WP 4: IDENTIFY & CO-DESIGN

Deliverable 4.3
White Paper on Equity-Focused Science Education Outside the Classroom
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# Acronyms

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<tr>
<td>SEOC</td>
<td>Science Education Outside the Classroom</td>
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<td>STEM</td>
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1 Executive summary

This White Paper introduces a set of action areas and strategies to develop equity-focused science education outside the classroom. The document targets decision-makers, funders and policy-makers in informal science education and aims to be a tool that helps integrate equity in their practice from a holistic approach. The White Paper is part of the Horizon 2020 research and innovation project SySTEM 2020: Science Learning Outside the Classroom, which seeks to bring understanding on aspects related to the scientific literacy of children and teenagers, as well as ideate, design and evaluate solutions to support informal science education.

The White Paper is informed by the outputs of a series of co-design sessions with international science education experts aimed at the ideation of strategies to support equity-focused science education outside the classroom. The co-design workshops involved more than 40 participants from 17 countries. The action areas and strategies for equity presented in the White Paper (Table 1) build on the contributions from these expert researchers and practitioners.

The analysis of the co-design outputs helped to define SySTEM 2020’s approach to equity in informal science education. SySTEM 2020’s understanding of equity permeates the action areas and strategies for equity and is based on the following key ideas:

- Equity is a process and a goal.
- Equity requires proactivity and commitment.
- Equity is a collective endeavour.
- Equity-focused science education requires a critical approach to the culture of science.
- Inequalities in informal science education need to be addressed from an intersectional perspective.
- Cultivating equity in science education outside the classroom requires a systemic approach.
Table 1. SySTEM 2020 Action areas and strategies for equity

<table>
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<th>Strategy</th>
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| **Framing** | Incorporate equity into the organisation’s values, vision and mission statements, as well as into the strategic plan.  
Involving the organisation’s board and staff in the definition of strategies at all levels.  
Include diverse stakeholders in decision-making processes. |
| **Embedding** | Bring diversity into the organisation.  
Form committees and working groups to steer work around equity.  
Make conversations around equity part of the institutional culture. |
| **Bridging** | Create welcoming environments.  
Strengthen the collaboration with formal education.  
Develop partnerships with societal actors from minority groups in science education. |
| **Involving** | Recognise the assets of the communities who do not engage in the activities offered at your organisation.  
Engage with a diversity of stakeholders.  
Support participation from the ideation to the assessment of programmes and initiatives. |
| **Designing** | **Broaden the range of literacies in informal science education.**  
Build on culturally responsive pedagogy.  
Support educators’ and learners’ critical agency. |
| **Assessing** | Develop a holistic approach to evaluation.  
Monitor progress towards the organisation’s goals around equity.  
Use multiple methods to collect evidence for equity. |
| **Sustaining** | Seek funding to support the organisation’s work on equity.  
Provide ongoing training on equity for staff and board members.  
Foster a diverse community through growth paths. |
| **Advocating** | Make the commitment to equity explicit.  
Raise awareness around the value of equity in informal science education.  
Think big and work towards a desirable future. |
2 Purpose and objectives of the White Paper

This White Paper presents a set of action areas and strategies to support equity in Science Education Outside the Classroom (SEOC). In particular, equity is approached from the perspective of informal science education organisations, providing tools for decision-makers to start working towards equity in their own contexts.

The White Paper provides a lens to look at different aspects related to equity in informal science education organisations. Equity is regarded as a transversal feature of science learning ecosystems. The ecosystem metaphor helps to conceptualize science learning as a complex and evolving network of interactions between different actors (such as audiences, learners, families and guardians, educators, coordinators…) in diverse environments (such as after-school activities, summer camps, science centres, museums, schools…), and which can be mediated by different tools and media. In order to tackle the challenges for equity in science learning systems, it is crucial to examine equity holistically, considering it from the individual as well as the societal perspective.

At the individual level, equitable science education ensures people have the opportunity to develop science literacies to the best of their capacities. This is strongly connected to organisational practices and it demands proactive efforts from informal science education organisations to actively support access, diversity and inclusion in all of its spheres.

At the societal level, equity contributes to the development of strong and resilient systems, in which everyone feels included. As global disruptions such as the Covid-19 pandemic have highlighted, educational ecosystems must be equitable in order to guarantee all learners can develop a broad range of literacies, avoiding divides based on socio-economic factors. This White Paper is a tool for informal science education organisations to advance in this direction.

The action areas and strategies to support equity in informal science education have been co-designed with international experts in equity and informal science education, including the SySTEM 2020 project partners. Through a series of five online co-design workshops that gathered more than 40 participants from 17 countries¹, a set of strategies for supporting equity-focused SEOC were formulated. After the first three workshops, the strategies for equity were grouped under key action

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¹ The co-design workshops participants were from Europe, U.S. and Israel.
areas. These equity key action areas were consolidated in two subsequent co-design sessions in which additional strategies were generated. The action areas and the strategies presented in the White Paper synthesise the consolidated insights from researchers and practitioners on equity in informal science education.

The following sections provide background information on central aspects of equity in informal science education, and introduce the SySTEM 2020 approach. Next, the action areas and strategies to support equitable practices in informal science education organisations are presented and described. Finally, some key ideas that permeate the White Paper action areas and strategies for equity-focused SEOC are discussed.

3 PART I: Equity in science education outside the classroom

3.1 Introduction

Scientific and technological literacy is increasingly recognised as a necessary skill to engage in active citizenship and help make informed decisions at the individual and societal level (Hazelkorn et al., 2015). From this perspective, developing equitable education that supports various groups of learners' meaningful engagements with science is key for ensuring citizens perceive science as an integral part of their lives and have the confidence, knowledge and skills to actively participate in societal debates.

In education, equity has been defined as “ensuring that there is a concern with fairness, such that the education of all learners is seen as being of equal importance” (UNESCO, 2017, p.7). In science education, several authors have also stressed an understanding of equity linked to supporting fair access, autonomy and full participation of all members of society (Dawson, 2014; Garibay & Teasdale, 2019; Philip & Azevedo, 2017). This approach places social justice and fairness at the centre of equity programmes and emphasises the need to guarantee everyone has equal opportunities to develop and perform at the best of their capacities.

Equity in formal and informal science education is still a challenge. Extensive research indicates that formal science learning remains a resource for certain groups, while other groups are marginalised.

2 To ensure a wide array of perspectives, the co-design sessions participants' areas of expertise dealt with science education, informal science learning, technology, assessment, diversity and inclusion, STEM, making, etc.
or excluded (Archer et al., 2015; Archer, Dewitt & Osborne 2015; Smith, 2011). In SEOC, a similar pattern arises and several studies have indicated that there is a particular profile for the learners who tend to engage in informal science learning activities (Barton Calabrese, Tan & Greenberg, 2016; Dawson, 2019; DeWitt & Archer, 2017; Feinstein & Meshoulam, 2014). These studies indicate that white male learners from well-educated, middle class families are the most likely youth to engage with informal science learning, a pattern reflective of historical privilege in science education.

Although there is a rising awareness of the historical marginalisation that certain groups have suffered in science education (and also in science), there is still a lot to do to compensate historical inequalities and support equitable science education, as recent research findings suggest (Brown, Roche & Hurley, 2020; Finlay et al., 2021; Roberson & Orthia, 2021).

When examining informal science education practices from an equity perspective, aspects related to access, diversity and inclusion are usually central [see for instance, the publication Learning science in informal environments published by the U.S. National Research Council (2009)]. While there is consensus on the importance of supporting access, diversity and inclusion, initiatives that uncritically focus on increasing only one of them have been challenged. For instance, efforts consisting in broadening access by offering the same programmes and activities to underserved communities have been criticised for falling into an assimilationist approach that disregards how dominant worldviews and cultures are reproduced in science culture (Bell, 2009; Garibay & Teasdale, 2019).

Framing science as a culture helps to understand why certain groups may feel excluded from it (Lee & Buxton, 2010; Stanley & Brickhouse, 1994). An important body of literature on equity in informal science learning has adopted a critical approach to examine scientific culture, understanding it as a set of practices, behaviours and identities, rather than just a body of knowledge (Adams, 2020; Dawson, 2018). In particular, some authors have highlighted that the spaces (formal and informal) where learners engage with science are not culturally neutral and tend to privilege worldviews that reproduce hierarchies, marginalising certain groups on the basis of aspects such as race, class, gender and nationality (Bang & Medin, 2010; Philip & Azevedo, 2017; Vana & Seebacher, 2020). These studies have brought insights into the values, as well as the structural inequalities that are reproduced in mainstream discourses about science. For instance, learning environments that reproduce stereotypes about science such as presenting scientific contributions as the result of individual work, portraying scientists as white males based in Western countries communicate the message that only certain people can do science. In this line, academics and practitioners have strongly argued against deficit-based approaches in science education that regard learners who do
not engage in science as lacking interest, without paying attention to their subjective experiences in science learning environments (Nasir & Vakil, 2017; Penuel, Clark & Bevan, 2016; Sturgis & Allum 2004; Vossoughi, Hooper & Escudé, 2016).

Recognising and addressing the fact that learners from historically marginalised groups face structural inequalities in science is key for envisioning solutions that support authentic equity in science education (formal and informal). In this regard, multiple authors have advocated for understanding equity in science education from a social justice perspective and embracing a relational view that supports horizontal relations (DiGiacomo & Gutiérrez, 2016; Dawson, 2014). Building on these views, some researchers have also claimed that informal science education should support learners’ empowerment by fostering their critical agency, helping them to connect science with their everyday lives and challenge societal injustices (Adams, 2020; Basu et al., 2009).

When looking at the challenges for equity in science education, numerous voices consider that education outside the classroom harbours strong potential for fostering diversity and inclusion (Barton Calabrese, Tan & Greenberg, 2017; Barron & Bell, 2015; Bevan et al., 2013). As several authors highlight, informal learning spaces provide opportunities to leverage local knowledge, giving learners freedom to choose and design their learning trajectories. Educators working in informal education environments are released from the pressures faced in formal education and thus, are in a unique position to adequate the activities based on the learners’ interests (Stocklmayer, Rennie & Gilbert, 2010).

This White Paper is a resource for decision-makers to unfold the potential of informal science education environments for fostering multiple images and ways to engage in science. To this purpose, the White Paper proposes a set of action areas and strategies to support equitable practices, and to increase access to science learning for diverse audiences.

3.2 System 2020 approach to equity in science learning outside the classroom

As numerous authors have noted, the meaning of the term “equity” in science education is not straightforward and diverse conceptualisations co-exist (Feinstein & Meshoulam, 2014; Philip & Azevedo, 2017). Depending on the approach, equity might be interpreted as instrumental for attracting a diverse science workforce and talent recruitment; as fair and equal treatment of all (ignoring the structural differences that mediate engagement with science and thus risking to
reinforce historical inequities that various groups face); or as part of social justice (Philip & Azevedo, 2017).

The meaning ascribed to equity has implications for practice at many levels. Thus, before introducing SySTEM 2020 action areas and strategies to support equity-focused SEOC, it is important to highlight key ideas that underlie the SySTEM 2020 approach to equity in informal science education. These key ideas are summarised as follows:

**Equity is both a process and a goal.**

Equity is not a set of regulations to comply with, but something to actively build over time. Equitable learning environments need to be cultivated and nurtured so they are an intrinsic part of the culture of the organisation. From this perspective, equity is a set of principles, values and practices that permeate all processes in an organisation, at all levels and over prolonged timescales.

**Equity requires proactivity and commitment.**

Supporting equity requires recognising that education and science are political, and thus they are heavily influenced by the dominant worldviews and values that shape a given society. Informal science education organisations must be open and proactive about supporting equity, and avoid reproducing societal trends and hierarchies that create exclusion and inequality for historically marginalised groups.

**Equity is a collective endeavour.**

Equity is the result of a collective effort and thus, it requires the active participation of all stakeholders. In the context of informal science education, this means that organisations need to create opportunities to support the active involvement of the public, the learners, their families, science educators and staff, as well as other societal actors like civic associations, enterprises, funding bodies, governmental agencies and formal education. In particular, involving groups that have been historically excluded can support the empowerment and agency of these groups.

**Equity-focused science education requires a critical approach to the culture of science.**

Recognising that science as a culture has been dominated by Western values and worldviews helps to understand the challenges for access, diversity and inclusion in science education (formal and informal) that certain groups face. A critical view to the culture of science means acknowledging that science is not universal nor value-neutral. Looking at science from a cultural perspective brings
attention to the importance of recognising various ways of being and doing, as well as supporting different identities around science.

Inequalities in informal science education need to be addressed from an intersectional perspective.

The persisting inequalities in informal science education cannot be attributed to isolated factors such as gender, race, or class etc., but are the result of a complex mesh of overlapping identities and discriminations. The adoption of an intersectional approach to science education sheds light on the multiple inequalities that mediate learners’ engagements with science. This is key for developing strategies that support the participation and identity-building for diverse groups in science.

Cultivating equity in science education outside the classroom requires a systemic approach.

Informal science education happens in a broader socio-economic context and thus, it is affected by numerous aspects that exceed the organisation’s boundaries. A systemic approach to design in these contexts is one which is able to build synergies across actors, settings and time, paying attention to external forces and trends. Such mindset is key for designing and cultivating equitable systems that broaden access and inclusion in informal science learning.

The ideas presented above are an integral part of the SySTEM 2020 lens on equity in informal science education. These ideas on equity ground the action areas and strategies presented in the following sections.

4 PART II: Building equity in informal science education organisations

4.1 Introduction to SySTEM 2020 action areas for equity

This White Paper identifies a set of action areas to guide informal science education organisations’ work on equity. The action areas, as well as the strategies outlined for each of them, build on the outputs of a series of co-design sessions with 19 invited experts in informal science education from 14 countries, as well as a further session with 22 expert members of the SySTEM 2020 project consortium.
The adoption of a co-design approach to ideate strategies for equity-focused science education responds to the need to include multiple perspectives from relevant stakeholders. Previous SySTEM 2020 co-design sessions had involved learners, educators and coordinators from SySTEM 2020 partners, as well as civic and professional associations. At this point, it was considered important to also engage with researchers and practitioners external to the SySTEM 2020 project. In all the cases, the participants were in senior positions and had a wide experience in informal science education, and with aspects connected to access, diversity and inclusion, in particular. When selecting participants, special attention was paid to ensuring gender-balance, as well as including people from different contexts, geographical locations and fields of knowledge.

The co-design sessions were informed by the SySTEM 2020 research results published to date (in particular SySTEM 2020 deliverables D3.2\(^3\), D4.1\(^4\), D6.2\(^5\) and D6.3\(^6\)), the exploratory analysis of the data collected through the SySTEM 2020 map\(^7\), as well as the examination of science learning outside the classroom from a systemic perspective. These data was contrasted with results from top research publications in the field and used to elaborate background materials to share with participants before the co-design session discussions.

The purpose of the co-design workshops varied from the initial session to the final ones. All the sessions were held online. The first three workshops focused on issues connected to access, diversity and inclusion in SEOC. At this stage, the emphasis was on brainstorming and generating multitude of strategies based on the participants’ experiences. The analysis of the workshop outputs lead to the identification of a set of themes, which were referred to as equity action areas. These action areas were consolidated in the following workshops. In them, the participants generated further strategies to support equity around each of the action areas. The strategies included in the White Paper are the synthesis of the contributions made by the participants of the co-design workshops.

The equity action areas span distinct spheres of activity in informal science education. By highlighting these areas we seek to direct the attention of decision-makers in informal science education.

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7 Available at https://system2020.education/the-map/
education to a range of processes related to equity. The list of key areas aims to aid informal science education organisations adopt an equity lens to examine their activity.

The key actions areas are: framing, embedding, bridging, involving, designing, assessing, sustaining and advocating. Based on the discussions held during the co-design sessions, the groundwork for supporting equity at the organisations' level deals with framing and embedding. Framing refers to actively defining the meaning of equity in non-formal science education and in a specific organisation in particular, while embedding involves making all aspects connected to equity part of the institutional culture.

Bridging and involving stem from a systemic understanding that approaches informal science learning as an endeavour that happens across contexts and amongst multitude of actors. In particular, bridging environments alludes to connecting various environments to leverage their possibilities for supporting science learning. Involving is closely related to efforts for bridging. Here, the adoption of collaborative approaches is key to actively involve multiple communities.

Designing equity-focused learning environments involves taking into consideration and building on learner’s cultural resources to broaden their images about science. This action area stresses the importance of supporting learners' critical agency encouraging them to build science identities that recognise their values and worldviews.

Assessing and sustaining are action areas focused in the medium and longer term. Approaching equity as a process demands implementing structures that support continuous improvement. The adoption of a holistic approach towards the evaluation of the organisation’s efforts is key for assessing all areas that create exclusion. During the co-design sessions, the participants acknowledged that change is a process that takes time and hence, it is crucial to sustain the efforts for dismantling all situations and practices that exclude certain groups of learners.

Finally, advocating calls for considering the work of informal science education organisations as part of social justice endeavours. Participants to the co-design workshops agreed that informal science learning organisations needed to go beyond what is legally required. In particular, advocacy work was expected to raise social awareness on the value of equitable science education, as well as contribute to positive change.

In summary, the definition of these action areas for equitable informal science education aims to convey the following messages:
1. To have impact, work towards equity should also consider the organisation’s mission, values as well as all organisational processes. While this is a transversal message, the areas framing and embedding are the ones most directly related with it.

2. Equity is the result of a community endeavour and needs to be based on collaboration with diverse societal actors. Thus, bridging different environments and involving multiple stakeholders should be a priority.

3. Pedagogical practices in science education need to be reviewed from an equity perspective. This has strong implications for designing science learning programmes and activities.

4. Supporting equity requires iteration and perseverance. Thus, assessing and sustaining equity-focused actions should be regarded as integral in informal science education organisations.

5. Committing to equity demands thinking beyond a single organisation and actively working to dismantle the conditions that create inequalities in informal science education and society. This means that in addition to integrating equity in the organisation’s activity, advocating for equity needs to be part of informal science education organisations’ activity.

The following section elaborates on the action areas and presents a set of strategies to contribute to equity in each of the spheres of action.

4.2 SySTEM 2020 strategies to support equity

Working for equity in SEOC is a commitment to remove inequalities in informal science education, rather than sticking to a set of practical strategies. That said, strategies can also be useful to help guide everyday decisions.

In this White Paper, the strategies to support equity in SEOC have been organised around the following action areas: framing, embedding, bridging, involving, designing, assessing, sustaining and advocating. Each of the action areas unfolds into three strategies that support work in SEOC with an equity lens. The suggested strategies should not be regarded as exhaustive, but as a way to structure and reflect upon actions towards equity goals.

4.2.1 Framing

Framing equity refers to how concepts and issues around equity are taken into consideration in the organisational policy of an institution. The presence of concepts relating to equity in guidelines, policies and procedures is an important step for clarifying the approach and commitment to equity of an organisation. In this White Paper, the suggested strategies for framing equity in the context of
an informal science education organisation deal with the formulation of statements and plans, as well as the involvement of the organisation’s staff and external stakeholders in the strategy definition and decision-making.

**Strategies for framing equity**

- Incorporate equity into the organisation’s values, vision and mission statements, as well as into the strategic plan.

To truly advance work around issues connected to access, diversity and inclusion in informal science education, organisations need to develop a common understanding of equity from an intersectional perspective. This means taking into consideration the interconnection of overlapping social categorisations that create systems of discrimination and exclusion. This work requires analysis, but also envisioning what would be the ideal scenario to reach. While each context and starting point is unique, an important aspect of committing to equity deals with setting concrete goals, milestones and benchmarks that enable monitoring and review.

- Involve the organisation’s board and staff in the definition of strategies at all levels.

Working towards equity requires a collective effort of all the people involved in the organisation. Participatory approaches are more effective for supporting awareness and commitment than top-down strategies. Discussion sessions around the organisation strategies are a good opportunity to review all the organisation’s processes and identify areas that create exclusion from multiple points of view.

- Include diverse stakeholders in decision-making processes.

While internal reflection around the organisation’s strategies is important, in order to dismantle the power relations embedded in science education it is necessary to include diverse voices external to the organisation’s activity, especially from non-dominant groups. Such involvement enables identifying the tacit expectations, behaviours and cultural norms that create exclusion in science education. In this regard, actions like inviting community actors to influence the organisation’s thematic agenda and its activities can be a powerful way of supporting power-sharing and empowerment of non-dominant groups.

**4.2.2 Embedding**

To be actionable, the organisation’s vision and strategy around equity needs to move from the general to the particulars. In other words, the values that guide the work towards equity need to be embedded in the organisation’s daily activity. For this, strategies like bringing diversity, creating
stable working groups and making conversations around equity part of the institutional culture can help to embed equity throughout all of the organisation's processes.

**Strategies for embedding equity**

- **Bring diversity into the organisation.**

  An important step in working to engage different audiences is to embrace diversity internally across programming and staff. The people who work in science education are also role models for the organisation's audiences. Thus, organisations should examine hiring practices at all levels and, if necessary, update hiring policies to increase diversity and inclusion. Supporting champions, appreciating dissent and avoiding tokenism are essential to ensure diversity is a meaningful and valuable asset of the organisation’s strategy.

- **Form committees and working groups to steer work around equity.**

  Equity needs to be built on an everyday basis. Thus, it is important to form working groups that make proposals and monitor progress on equity. Creating dedicated-positions for strengthening work around equity might help to build and consolidate accountability structures. While the available resources that each organisation can dedicate might vary, it is crucial to invest time and means. Also, working groups and committees should be representative of staff from all levels of the organisation, and avoid the pitfall of being composed solely of staff members who are themselves part of minority groups who may feel they must take on increased emotional labour as advocates for diversity in the workplace.

- **Make conversations around equity part of the institutional culture.**

  Equity doesn't happen by itself, but people can make it happen. For this, it is necessary to cultivate a culture in which access, diversity and inclusion are appreciated and considered essential. Overcoming views that regard equity issues as an afterthought, only considered at the very end of a programme or initiative is crucial. Some ways to make discussions around equity part of the regular activity include:

  - inviting experts to discuss access, diversity and inclusion in science with internal and external audiences.
  - Engaging community groups, external consultants advisory boards to get external feedback and advice.
  - Developing protocols and supporting transparent communication about equity issues.
4.2.3 Bridging

Taking a proactive stand towards equity from a systemic perspective requires identifying which groups do not engage with science, what their cultural influences and reference points are, and exploring the possibility to build links between the two. Cultivating welcoming environments around science inside and outside the organisation, as well as establishing and strengthening collaborations with formal education and various societal actors are proactive measures that organisations can take. Generating multiple connections is key for building a network of collaboration that leverages the opportunities of different environments to increase access to informal science education.

Strategies for bridging

- Create welcoming environments.
A welcoming environment is one in which people feel safe, comfortable to express themselves and valued. In informal science education, a first step to create a welcoming environment consists of highlighting and understanding the many barriers that prevent people’s access and participation. While some internal analysis might be useful, it is better to avoid relying on guesses and get feedback from those groups who do not tend to take part in the organisation’s activities. Another way of expanding the opportunities for participation is to run informal science education activities at the spaces where the target groups congregate and involve the audiences you wish to reach in the planning and development of such activities, rather than just expecting them to be interested.

- Strengthen the collaboration with formal education.
While one of the strengths of informal science education lies in its potential for offering learning experiences that differ from the ones people might have at school, a close collaboration between formal and informal education environments is key for equity. The connection to schools enables informal science education organisations to reach diverse learners, in particular those who might not engage in science learning in their free time. Although many informal science education organisations are visited by learners during the school time, it is important to look for ways for improving the collaboration between formal and informal education. Some practices that can help advance in this direction include supporting knowledge sharing through educators’ exchanges, as well as developing programmes and activities with links to the school curriculum.

- Develop partnerships with societal actors from minority groups in science education.
Building a network of opportunities for engaging in informal science education is not enough to increase access. Unless specific actions targeting historically marginalised groups in science are developed, existing inequalities may be reinforced. To avoid reproducing the dominant trend it is
crucial that informal science education organisations form strong connections with communities who have been traditionally excluded from science. Establishing formal and informal partnerships with organisations and leaders of underserved communities can help understand their needs and identify opportunities for action. For instance, co-developing activities with the communities and running them in their spaces can be a mutually beneficial output of such partnerships. Sharing resources and collaborating with organisations in different fields (like for instance, sports or crafts) can also help bridge diverse learning environments and promote transdisciplinary thinking. The development of structured Science Technology Engineering and Mathematics (STEM) learning ecosystems that feature links between science education, research and innovation, governmental actors, business and industry, and learners can also contribute to make science more accessible and diverse, and rooted in local relevance.

4.2.4 Involving

A hallmark of equity-oriented informal science education environments is diversity. While this doesn’t mean that everyone should engage in informal science education, it does mean that everyone should have the opportunity to access and participate in a meaningful way. A first step for engaging other actors in informal science education deals with developing empathic understanding. This initial awareness and understanding of the main challenges for supporting access, diversity and inclusion in informal science education will help design initiatives that engage diverse stakeholders representative of minority groups, traditionally excluded from science. The adoption of participatory approaches is also a powerful way to cultivate equity-oriented environments that foster ownership and agency.

Strategies for involving

- Recognise the assets of the communities who do not engage in the activities offered at your organisation.

Identifying who does not show up at your organisation’s science learning activities is key for understanding the ways in which informal science education is not accessible nor inclusive enough. From here, it is necessary to develop empathy, or in other words, a deep understanding on the reasons why certain communities do not engage in informal science education, as well as the assets these groups have and that have been traditionally unrecognised. Initiatives like the community listening sessions, targeted communication strategies and the adoption of an assets-based approach that enable building on the interests, knowledge and resources of minority groups can help support access, diversity and inclusion in informal science education.
• Engage with diverse stakeholders.

Expanding the range of groups, particularly those who have been traditionally underrepresented in informal science education, needs to be oriented towards developing long-term relations based on trust, in which people feel comfortable to contribute. The creation of environments that enable participation is challenging because there are many tacit assumptions and power relations that hinder authentic involvement. Teaming up with champions and actors whose work aligns with your organisation’s agenda towards equity, as well as supporting and co-developing community-led programs are ways to support meaningful engagements with diverse stakeholders in informal science education.

• Support participation from the ideation to the assessment of programmes and initiatives.

While participation in informal science education can happen in different ways, the participatory actions geared towards equity have to successfully bring in diverse populations and engage with them through joint reflection, critique and collaboration. When ideating actions for fostering the participation of stakeholders in informal science education it is important to remember that participation can happen at very different moments of the organisation’s activities (for instance, during the development, implementation and assessment of the informal science education programs and activities). Community participation in decision-making can be encouraged by involving diverse stakeholders in, for instance, board committees and advisory groups. The adoption of activist research approaches that focus on supporting empowerment and transformation is also a powerful way to involve local stakeholders. For instance, inviting audiences as co-researchers in inquiries that critically discuss dominant representations of science can help break stereotypes and trigger more diverse and inclusive imaginaries around science.

4.2.5 Designing

Designing for equity in informal science education means cultivating inspiring learning environments where the learners’ cultural resources are recognised as valuable. For this, it is necessary to expand what is considered “science” and the literacies that have been traditionally associated with it.

Equity-focused informal science education demands that everyone involved has critical agency, especially the educators and the learners. Setting the conditions for supporting learners to become critical agentic actors should be an important mission for informal science education organisations.
Strategies for designing for equity

- Broaden the range of literacies in informal science education.

Upon entering an informal science learning environment, learners and audiences are assumed to have a certain set of "literacies" - the tacit skills and knowledge needed in order to participate. These literacies act as a barrier to engagement for some. Becoming aware of all the implicit assumptions present in informal science education programmes and activities is essential for understanding why people might not feel comfortable or welcomed into informal science education spaces. Some initiatives that can help broaden the range of literacies and break the stigma around not knowing how to act in an unfamiliar setting consist in using plain language in the signage, and reformulating how the staff and audiences are expected to act in spaces like exhibitions. For instance, some science centers and galleries have mediators who have conversations with visitors rather than just signage, and some places invite audiences to physically interact with exhibitions by touching, leaving a mark or adding their work to the display.

In terms of learning design, transdisciplinary education programmes offer greater opportunities for expanding the range of literacies than those exclusively focused on the traditional disciplines associated with science. Adopting a transdisciplinary lens allows including and supporting manifold practices and skills, as well as questions and interests of other learners and publics that fall outside the traditionally dominant groups.

- Build on culturally responsive pedagogy.

Recognising the value of learners’ previous knowledge, skills and cultural background is crucial for designing equity-focused informal science education programs. Providing educators tools and resources that help them design science learning activities from a culturally responsive approach can help them develop awareness, as well as incorporate equity-oriented approaches and principles in informal science education.

Making the learning materials available in different languages, making them accessible online and in hardcopy, as well as open for re-use and adaptation can help increase access and inclusion. The selection of tools for learning is also an important choice since open and free tools might enable learners to continue experimenting and learning on their own. Outputs from research and innovation projects like the SySTEM 2020 Design Principles and Methods Toolkit for Supporting Science Learning Outside the Classroom⁸ (SySTEM 2020), the Equity Practice Briefs of STEM Teaching

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Tools⁹, The Science Capital Teaching Approach¹⁰, the Hypatia Project Toolkit -innovative activities to engage teenagers in STEM¹¹- (Hypatia project), as well as the YESTEM Equity Compass¹² (YESTEM), for instance, can offer a solid foundation to build on when designing informal science education programmes and activities.

- Support educators and learners’ critical agency.

A key trait of equitable systems is that they foster their stakeholders’ agency. The role of informal science education is not to compensate for knowledge deficits of "scientifically illiterate" people, but to co-create with learners and audiences environments in which they can develop insights and resources to transform their reality. This approach involves critical agency from educators and learners, as well as from other science education stakeholders. From the educators’ side, critical agency refers to the capability to leverage the available resources for designing informal science education engagements that pay attention to the challenges experienced by groups that have been historically marginalised from science. From the learners’ side, critical agency means that learners can incorporate and make links to their cultures, as well as to diverse ways of being and doing when engaging in informal science education.

The creation of environments that consider learners as active agents and foster transformative learning is key for supporting equity-focused informal science education. Raising awareness and supporting different forms of literacy in science education can help balance power relations and support diverse groups’ critical agency in science. Participatory approaches to science and innovation based on co-design and co-creation involving learners of minority groups in science are also powerful ways of fostering learners’ agency and empowerment.

4.2.6 Assessing

Building equity-focused learning environments is both a process and a goal. Therefore, it is important to revisit the goals and the impact of the actions undertaken to support access, diversity and inclusion on a regular basis. In this light, equity-assessments should be formative and holistic. This approach requires examining programmes and activities, but also organisational practices to identify

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9 Available at http://stemteachingtools.org/tgs/Equity
10 Available at https://discovery.ucl.ac.uk/id/eprint/10080166/1/the-science-capital-teaching-approach-pack-for-teachers.pdf
11 Available at http://www.expecteverything.eu/hypatia/toolkit/
any area that might create exclusion. In order to achieve this, it is necessary to develop mechanisms to monitor progress, as well as defining what data would be used for assessing equity.

**Strategies for assessing equity**

- Develop a holistic approach to evaluation.

For informal science education organisations, implementing a holistic evaluation approach is key to gaining an overall view of how internal processes impact access, diversity and inclusion. This means that in addition to assessing learning programmes and public-facing activities, other areas like communication and signage, opening times or fees, as well as front-line services like security or catering need to be assessed.

Involving all staff in the equity assessment is a good way to ensure everyone is aware of the value of equity, as well as to identify aspects that might not be noticed otherwise. The adoption of a co-research approach with the organisation’s audiences and learners, especially those from (historically) marginalised groups in science, helps to foster involvement and empowerment. Framing assessment as a participatory and collaborative endeavour is also a good way to increase transparency and accountability.

- Monitor progress towards the organisation’s goals around equity.

A systemic understanding of equity requires approaching assessment as a complex web of interrelated aspects that change over time. While goal-setting is an important first step towards increasing access, diversity and inclusion in informal science education, it is necessary to monitor progress towards these goals, and to be open and adaptable to adjusting the goalposts as new challenges for equity emerge.

While assessing equity in informal science education might seem challenging, quite frequently the most difficult is to actually make time for monitoring and assessing. Thus, finding ways to create safe spaces for dialogue whilst also integrating assessment as part of the organisation’s activities is essential. Identifying situations and tasks that might draw on the assessment results (for instance planning new activities or services) can be a good way to make the benefits of assessment obvious, showcasing equity as an integral practice rather than an add-on.

- Use multiple methods to collect evidence for equity.

A potential barrier to implementing assessment is the preconception that assessment must be carried out using sophisticated, validated instruments. While using validated instruments might be beneficial, it is important to beware of implicit biases inherent to the instrument, as well as restrictive
approaches that limit the assessment to what is possible to measure. Supporting the self-assessment of staff and audiences can be a good way to raise awareness on issues related to access, diversity and inclusion and contribute to build an institutional culture around equity. Tools like the SySTEM 2020 Design Principles and Methods Toolkit for Supporting Science Learning Outside the Classroom, the YESTEM Equity Compass, as well as checklists to self-assess your programmes (see for instance the Self-Assessment and Program Planning for STEM in Out-Of-Schools) can support evaluation efforts with limited resources.

When defining metrics and indicators of diversity, equity and inclusion in evaluations, planning, programme assessment and accountability mechanisms, it is important to attend to counterfactuals, that is to say, pay attention to the silences and absences (who is not participating, what topics are not included). Taking a step back and critically reviewing the metrics can help identify cognitive biases like relying on the information available at hand or using data to confirm already existing beliefs, for instance. A good practice to prevent biases is to inform the selection of metrics by participatory sessions to identify what would be relevant evidence of equity in your organisation. Using multiple sources to continually gather information is also a good way to increase reliability and reach strong conclusions that are informed by evidence.

4.2.7 Sustaining

Equity is a process that needs time, meaning that any strategy followed to make a positive impact on informal science education needs to be sustained over time. For this, aspects related to access, diversity and inclusion need to be considered a strategic priority, instead of an additional effort dependent on the economic wealth and the resources available at the time. Nurturing equity over time requires capacity building from all staff, and from informal science educators, in particular. Senior management can support and promote equity-related professional development opportunities for all staff as an effort to foster diversity over extended time frames.

Strategies for sustaining equity

- Seek funding to support the organisation’s work on equity.

Cultivating equitable learning environments requires investing time and resources. Allocating stable funding for equity can help increase the impact of these actions since results can be observed in the medium and long-term. Diversifying the sources of funding (for instance from grants, sponsorships, 

internal budget…) can help ensure some resources to be allocated towards equity actions. Besides securing funding, it is also key to motivate staff to commit to equity. For instance, a strategy to support equity efforts might include incentives for teams to embed equitable practices since this might require additional work to revise and reconsider current assumptions and practices - these could include recognition or awards, or financial incentives such as increased budget lines to cover extra costs. In addition, developing partnerships and collaborations with external actors (other informal science education organisations, civic associations and enterprises, government bodies, funders) can be a good way to join forces and share efforts for supporting equity in informal science education. Tools like the SySTEM 2020 map\textsuperscript{14} can be a valuable resource to identify like-minded organisations to collaborate with.

- Provide training on equity for staff and board members.

Capacity building on equity is strongly connected to the creation of a culture of equity. Providing training on equity for staff and board members is valuable, but it is not enough. It is also necessary to actively support staff and leadership to take time to attend the training. To maximise the impact, the training should be carefully designed and connect to the experiences and needs of the staff. Some good practices include asking staff in advance what challenges for supporting access, diversity and inclusion they face in their practice and to follow up after the training sessions. In addition to seminars and workshop sessions, it is good to consider other formats based on peer-to-peer learning and mentoring.

- Foster a diverse community through growth paths.

Creating and supporting an equitable environment means that all members feel valued and have opportunities to develop at the best of their capacities. This is important not only for the learners, but also for the organisation's staff. It is difficult to convey the idea that science is for everyone if only certain groups hold certain positions and roles. From this perspective, the development of professional growth paths is a good way to support diversity and commitment. For instance, recruiting learners from minority groups in science as facilitators can bring new insights into the organisation, enable more fluid communication with audiences, and support learners' identity building around science outside formal education.

\textsuperscript{14} Available at https://system2020.education/the-map/
4.2.8 Advocating

Advocacy for equity in informal science education organisations should be considered an important part of the work, as it contributes to social justice. Advocacy work in informal science education involves a clear commitment to supporting access, diversity and inclusion, as well as raising awareness on the positive impact that equity has for the whole society. Being ambitious and envisioning desirable futures around equitable informal science education is also important. For this, it is recommended that informal science education organisations address equity challenges from a systemic perspective, as described in the following strategies.

Strategies for advocating for equity

- Make explicit the commitment for equity.

In addition to framing and embedding equity in the mission, values and strategies, organisations need to make public their commitment to supporting access, diversity and inclusion in informal science education. This means, for instance, being transparent and setting a calendar for reporting on the impact of the actions for developing equity-focused informal science education.

Building networks of collaboration around equity goals is also a good way to make the commitment for equity explicit. This can be achieved by teaming up with municipalities and other like-minded science education organisations, developing national initiatives with local champions, as well as involving and working together with community leaders, especially youth leaders, for supporting the access, equity and inclusion of minority groups in science education outside the classroom. Being part of international communities is also important. Joining online networks like the SySTEM 2020 map, and equity-focused groups like ECSITE’s community of pioneers15 are ways to share and learn, as well as identify potential collaborators in an international arena.

- Raise awareness about the value of equity in informal science education.

Within science education and communication, equity is not a separate task, to be performed if the circumstances allow. As a community, we can advocate for a deeper commitment to access, diversity and inclusion in informal science education to benefit all of society, and not only the groups that have been historically marginalised. Evidence-driven examples of how efforts towards equity lead to societal benefits are valuable resources in dissemination actions. In particular, using

15 Further information about ECSITE’s community of practice around equity can be found at https://www.ecsite.eu/activities-and-services/resources/new-framework-tool-equityecsite
evidence-based arguments help to formulate convincing proposals for advancing work towards equity.

Committing to equity involves adopting an activist stand and challenging discriminatory views and practices. Taking a proactive role and dismantling authoritative representations and stereotypes about science is essential in order to raise awareness about current existing inequities in science and society and work towards a more equitable future.

- Think big and work towards a desirable future.

When setting long-term goals around equity, envisioning a desirable future rather than a possible one will ensure an ambitious vision. Breaking this vision into long, medium and short-term goals can help understand and define what really needs to happen to realise the ambition of equitable science education systems. Committing to equity means understanding the limitations of current legal and political frameworks and going the extra mile, that’s to say going beyond legal compliance, looking at equity as an institutional priority rather than an external imposition.

To generate impact, work around equity needs to be conducted from a systemic perspective that enables including multiple perspectives (this means identifying who are the key actors and their motivations), identifying interconnections among actors, defining boundaries for the interventions and spot influences and trends in the overall informal science education ecosystem. The adoption of a systemic mindset is a valuable tool for guiding decision-making since it helps focus the attention on the aspects that have greater potential for leveraging change in the system. This is particularly relevant for the design of equity-oriented services and programmes.
5 Conclusion

In informal science education, work towards equity requires a holistic understanding in order to consider how organisational processes and external factors impact aspects connected to access, diversity and inclusion. The action areas identified in the White Paper (framing, embedding, bridging, involving, designing, assessing, sustaining and advocating) seek to raise awareness of the importance of considering equity as a lens to look at the activity of an organisation as a whole. Below, there is a summary of the key ideas conveyed by the strategies for equity-focused science education outside the classroom.

Working for and towards equity requires commitment. While it is crucial that organisational leadership commits to support equity-focused informal science education, equity cannot be framed as a top-down process. The adoption of a transversal approach to equity brings the opportunity to involve a diversity of actors consisting of staff, audiences as well as external stakeholders. Several of the strategies for equity emphasise the fact that equity goes hand in hand with meaningful participation of stakeholders, especially of those groups that have been historically marginalised or excluded from the culture of science.

The design of equitable pedagogy for informal science education needs to be based on the recognition of the diverse ways of being and doing in science. Broadening the range of science literacies, as well as ensuring that pedagogical practices are culturally responsive and foster learners’ critical agency is key for supporting diversity and inclusion in SEOC.

Equity is a process and a goal that requires perseverance. Effort and resources invested in supporting equity must be sustained over time. Informal science education organisations should identify their strengths for supporting access, diversity and inclusion and build on them. Baby steps, even if small, are powerful ways of advancing equity-focused SEOC.

Cultivating authentic equity in informal science education requires awareness of the structural inequalities that mediate learners’ access to and engagement with science, as well as making equity an institutional priority. This means that informal science education organisations should also engage in advocacy work. Advocating for equitable science education outside the classroom highlights the importance that informal science education organisations become opinion leaders, raising awareness of the underlying worldviews and systems that contribute to inequities in society, in education, and in science.
6 Glossary

Access is a key concept related to equity and highlights the need to ensure people have the ability to enter, approach and make use of for instance, content, tools, environments and services. Access is also closely connected with accessibility, which is associated with standards and regulations to ensure the physical and cognitive access to products and services. In educational equity, educational institutions and policies are expected to guarantee all learners have opportunities to access and benefit from education.

Co-design is a design-lead approach that promotes the active involvement of stakeholders without professional design training in the design process. Co-design processes build on people’s creativity and expertise over their own life to ensure the final solutions meet their needs and are usable.

Critical agency refers to the ability of people to critically examine their living conditions and take action to transform their circumstances. To develop critical agency individuals and groups need to first develop critical awareness on the systems of privilege and exclusion that dominate current societies.

Diversity is a fundamental aspect of equity and it alludes to the recognition of the varied range of characteristics (based on race, ethnicity, gender, sexual orientation, socioeconomic status, age, physical abilities, cultural background, education and more) that make an individual or group different from one another. When discussing equity, diversity refers to different social identities, with special attention to those groups that have been (historically) marginalised.

Equity refers to social justice and fairness. In education, equity means treating everyone according to their needs to guarantee they have opportunities to develop and perform at the best of their capacities. While equity seeks to ensure fair and equal outcome, equity does not imply equality. In fact, equity advocates acknowledge how aspects such as gender, race, physical and cognitive abilities, as well as cultural and socioeconomic status impact people’s opportunities. The recognition of these differences is key for developing equitable practices in which individuals are treated according to their needs.

Inclusion refers to the process of removing barriers limiting the presence, participation and achievement of all people. Inclusive learning environments are those in which all learners, regardless of race, age, gender, disability, religious and cultural beliefs and sexual orientation - feel respected, supported and valued.
Intersectionality is a framework for analysing how different social categorisations such as race, class, gender and religion overlap creating systems of advantage and disadvantage. Intersectional approaches call the attention on the interconnected nature of factors that impact people’s social and political identities, developing a more complex understanding of societal systems of oppression and discrimination.

The term Learning Ecosystem uses an ecological metaphor to highlight the interrelations between different actors in a learning environment. From this perspective, learning and education work as a system composed by individuals, organisations, tools, content, activities, among other elements. In this system, various stakeholders connect, interact and adapt. Like biological ecosystems, learning ecosystems are complex and constantly evolving. Recent conceptualizations have described learning ecosystems as systems that feature regional or local partnerships between formal and non-formal education, government, business and community, and which are both learner-centred and learner-driven.

Systems thinking is an approach to design that looks at systems as more than the sum of their parts. A systemic perspective looks at the relations and interactions between the multiple elements and actors that are part of a system, setting boundaries and exploring them through multiple perspectives. This approach has gained popularity as it supports problem-solving in complex situations with many interconnections.
7 References


