OPEN SCIENCE HUB

EMPOWERING CITIZENS
THROUGH STEAM
EDUCATION WITH
OPEN SCHOOLING

DELIVERABLE 4.1

Gender Equity Recommendations

Authors

Shaun Ussher and Brendan Owens (TCD)

Contributors

ULEI and IH

Disclaimer

Reference

Please cite this work as:
OSHub Consortium, 2020. OSHub: D4.1 Gender Equity Recommendation,
Trinity College Dublin, Dublin

Copyright Notice

Acknowledgement

OSHub has received funding from the European Union’s
Horizon 2020 Research and Innovation Programme
under Grant Agreement No. 824581

Document Identification Sheet

Project Ref. No.	824581
Project acronym	OSHub
Project Full Name	Open Science Hub: Empowering Citizens Through STEAM Education with Open Schooling
Document Name	OSHub.Network_D4.1GenderEquityRecommenda-tions_20200531.pdf
Security	Public
Contractual Date of Delivery	Month 8, 31.03.2020
Actual Date of Delivery	Month 8, 31.05.2020
Type	ORDP: Open Research Data Pilot
Deliverable number	D4.1
Deliverable name	Gender Equity Recommendation
WP / Task	WP 4 Design and Implementation / Task 4.9
Number of pages	48
Authors	Shaun Ussher and Brendan Owens (TCD)
Contributors	Kristen Seigel, Maria Vicente, Mairéad Hurley, Muiriosa Guinan, Ciaran Devlin, Mark Ball
Reviewers	Maria Vicente
Project Officer	David Monteiro
Abstract	This Gender Equity Recommendations presents the current literature and guidelines for best practice in diversity, equity and inclusion.
Keywords	OSHub, Open Schooling, Data Management, Diversity, Equity Inclusion, DEI, Gender, Best Practice

Revision History

REVISION	DATE	AUTHOR	ORGANISATION	DESCRIPTION
0.1	25 March 2020	Shaun Ussher	TCD	Initial Draft
0.2	28 March 2020	Shaun Ussher	TCD	Review by WP Leads
0.3	31 March 2020	Mairéad Hurley	TCD	Final Draft
0.4	30 April 2020	Brendan Owens	TCD	Further Revisions
1.0	29 May 2020	Brendan Owens	TCD	Final Version

List of Acronyms

ACRONYM	DEFINITION
GA	Grant Agreement
GER	Gender Equity Recommendation
CSA	Coordination and Support Action
DEI	Diversity, Equity and Inclusion
STEM	Science,Technology, Engineering and Mathematics
STEAM	Science,Technology, Engineering Art and Mathematics
ISLE	Informal Science Learning Environment
ILS	Informal Learning Space
HO202	Horizon 2020
MORI	Market and Opinion Research International
OSHub	Open Science Hub
PISA	Programme for International Student Assessment
TCD	Trinity College Dublin
ULEI	University of Leiden
WP	Work Package

Executive Summary

The OSHub.Network Gender Equity Recommendations (GER) is Deliverable 4.1 (D4.1) from the coordination and support action (CSA), OSHub.Network, grant agreement (GA) 824581.

This report introduces diversity equity and inclusion (DEI) guidelines with a focus on gender equity into the OSHub.Network consortium. The document describes the current literature surrounding DEI including a theoretical framework and the current state of educational equity in formal and informal learning spaces. This document provides a set of guidelines to help the OSHub.Network consortium implement diverse, equitable and inclusive practices throughout the project. Using this framework, each member of the OSHub.Network consortium can create an equitable space for all stakeholders involved in the project, including students, community members, researchers, families, schools and other stakeholders. The GER was influenced by current projects researching best practice methods for equitable learning funded under Horizon 2020 including Hypatia (GA 665566), SISCODE (Society in Innovation and Science through CODEsign, GA 788217) and SySTEM 2020 (Connecting Science Learning Outside The Classroom, GA 788317).

The purpose of this document is to put in place the definitions, explanations and details that will support any organisation who are initiating an Open Schooling project to adopt an equitable engagement strategy. This document addresses the following questions:

- What is the current understanding of diversity, equity and inclusion?
- What are the OSHub.Network guidelines for best practice diversity, equity and inclusion?

Additionally the document explicitly references the Covid-19 pandemic and offers advisories in section 4.1. The unpredictability of this situation in the medium to long term justifies that this document should be a 'living' one such that beyond the project deliverable it is augmented to remain timely and relevant during the course of the project for partners to use.

Table of Contents

Introduction

The Open Science Hub Network (OSHub.Network), and the associated network of community hubs – OSHubs, aim to inspire, empower and engage citizens – from school children to senior citizens – in STEAM (Science, Technology, Engineering, Arts and Mathematics) learning and research opportunities, grounded on collaboration with societal agents.

The OSHub.Network is developing a common methodological framework, that allows each OSHub to identify and analyse local needs, issues, opportunities and relevant actors, in order to address socio-economic, geographical, gender equity issues, and untapped growth potential. Inspired by the "Mission-Oriented Research & Innovation in the European Union" approach, developed by Mariana Mazzucato, OSHub.Network will define a set of Open Schooling Missions, aimed at addressing local relevant challenges linked to the UN's Sustainable Development Goals (United Nations General Assembly, 2015). These Open Schooling Missions will constitute the basis for the creation and development of open schooling projects, enabling real collaboration across communities. Through this approach with OSHub meditation, schools can be active agents for collaboration between civil society, enterprises, research institutes, and families.

Importantly, to ensure diversity, inclusion and sustainability, each OSHub location will be held accountable to a local management board consisting of representatives from local stakeholder groups across schools (teachers and students), families, research institutes and universities, enterprise, industry, media, local governments, civil society organizations and wider society. The board will be involved in all key processes and decisions regarding local OSHub programmes and initiatives.

By supporting local schools and communities with the tools and network to tackle relevant challenges, OSHub.Network aims to create local impact while simultaneously promoting an active global citizenship attitude. All resources, products and solutions developed by OSHub.Network will be fully based on Open Standards to expand the reach and impact of the project. OSHub.Network will create an online platform to share OSHub expertise, resources, and best practices with all OSHubs, their partners and the communities they serve. All OSHub.Network resources will also be shared on existing large online educational repositories, and relevant national networks and repositories.

In the long-run, we envision OSHubs as education brokers in their local communities, supporting local school networks to incorporate Open Schooling in their vision and organizational structure, leading to a sustainable high quality of education. In particular, OSHubs will facilitate the bridge between the needs and realities of schools and their local context and resources, as well as brokering and advocating for the implementation and maintenance of national/regional policies.

Purpose of document

This document describes a best practice equity plan to be adopted by OSHub.Network. It is to be used as a guideline and will require adaptation based on the individual circumstances of each OSHub. This equity plan consists of 5 parts, each part deals with a particular level of either understanding and/or implementation based on the current literature for best practice of diversity, equity and inclusion, with a primary focus on gender equity.

The document reads as follows:

1. Diversity, Equity and Inclusion – A strategic approach

This section of the document demonstrates the aims of this equity plan and aspires to provide a clear understanding of true diversity, equity and inclusion, including scenario exercises that illustrate examples of when and where these are not being met.

2. Issues in education practices

This section of the document highlights the current state of equity with regards to education and learning practices, particularly those in informal learning spaces (ILS). This section focuses on groups that may face exclusion and explores the reasons why. It also explores ways that the OSHub. Network can start to promote diversity, equity and inclusion, and the importance of doing so.

3. A Theoretical Understanding

This section gives an overview of some of the theory and criteria underpinning various types of group exclusion and inequality. It then proceeds to focus on gender, particularly theories around gender performance and the effect of gender performance on science identity.

4. Preparation and Implementation

This section highlights different parameters that can affect DEI at various levels. It also provides questions and focus points one should consider when attempting to adhere to best practice. This section provides advice on considerations during the time of pandemic requiring further awareness and flexibility to avoid exclusion.

5. Best Practice Guidelines

This section condenses the findings of the previous 4 sections, and should be used as a practical set of guidelines for the creators, facilitators and organisers of educational programmes across the OSHub.Network. This piece focuses on 9 particular points which are important to consider when working with diverse groups, such as those that will be involved in the OSHub.Network project, and should lead to more diverse, equitable and inclusive practices.

1. Diversity, Equity and Inclusion: A strategic approach

The following aims taken from the Erasmus+ Inclusion and Diversity Strategy in the field of Youth (European Commission, 2014) will act as a solid strategic foundation for DEI in OS Hubs.

1.1 The aims of the strategy

- Develop an understanding of underrepresentation in non-formal science learning, and create a coherent framework to support the OSHub.Network consortium in an effort to address this underrepresentation.
- Increase commitment to diversity, equity and inclusion from all actors involved in the OSHub.Network project.
- Reduce the number and complexity of obstacles for underrepresented populations and provide support to participants to overcome remaining obstacles.
- Support organisers, actors and stakeholders in developing quality projects that involve or benefit people with fewer opportunities.
- Identify opportunities to link with other initiatives that support underrepresented communities, cooperating with multiple stakeholders to provide information for inclusion-related policy and support at local, national and international levels.
- Provide a framework that utilises the local expertise and skills of the OSHub.Network project partners, as well as their local collaborators.

— Consistently apply a strong focus on diversity, equity and inclusion to all stages of the OSHub.Network project, including management, promotion, participant support, project selection and evaluation and dissemination of project outcomes.

1.2 Understanding Diversity, Equity and Inclusion

Diversity within society includes diversity of ethnicity, religion, gender, culture, sexual orientation, language, (dis)abilities (mental, cognitive, or physical), educational levels, social backgrounds, economic situations, and health statuses. When we are considering diversity, it is important to be aware of cognitive diversity as well as cultural diversity.

Equality ensures equal distribution of opportunities and resources to all parties from various backgrounds (Rawls, 2001). However, the more socially just concept of **equity** means treating each according to their individual circumstantial needs and to ensure that they have the appropriate methods of access to the opportunities of others and to ensure that all have a fair and equal outcome (Young, 1990). For equity to work effectively, it requires preliminary planning and foresight which is the core scaffold to a working DEI model.

Inclusion is at the core of diversity, allowing various identities that could potentially feel marginalised, to feel they genuinely belong, and are valued and empowered to consistently contribute. All actors involved in the practice should be equipped with the necessary skills to manage, recognise and empower those from diverse backgrounds to work together effectively. The encouragement of interactions between those from diverse backgrounds will ultimately improve the inclusiveness and the mentality of those who are typically seen in areas of low representation.

Inclusion and diversity strategies aim to celebrate diversity, to allow difference to be seen as a positive source for learning rather than a cause of competition or prejudice. The guiding principles of a successful DEI model are to recognise, respect and represent the differences amongst the participating population.

The following Section 1.3 contains a list of working scenarios resulting in a failure of DEI, inspired by the article *"Belonging: A Conversation about Equity, Diversity, and Inclusion"*(Burnette, K, 2019)

1.3 DEI Deficit Scenarios

SCENARIO A

A group of stakeholders in a co-creation workshop feel listened to, supported, included and everyone experiences equitable opportunities for participation.

> *However, despite these positives the group fails to innovate, reverting to ideas that don't serve the wider local community and the group is viewed externally as inequitable.*
>
> Why might this be the case?[1]

SCENARIO B

A management board is assembled, which (through various influential stakeholders) has the power to effect real change in the community. They are focused on diversity and inclusion and are confident that they have taken wider community needs to heart.

However, despite being so invested, their campaigns for change are not all positively received by the wider community.

Why might this be the case?[2]

Answer A: All the participants come from the same background and thus this is not a **diverse** think-tank that widens participation and drives positive change

Answer B: The diversity of the management board is not a match for the diversity of the community at-large leading to misrepresentation, a negative impression of 'us v them' in some cases. Fundamentally, there is a failure to provide equitable avenues to join the board in the first place and thereby effect **equitable** solutions successfully.

SCENARIO C

During a co-creation workshop, a participant from an acutely underrepresented background voices a suggestion that could lead to a positive change particularly for those from a similar background, as well as ancillary benefits for other groups.

No one acknowledges this suggestion initially. Later the suggestion is voiced by other participants who have identified the ancillary benefits for those from their backgrounds.

Though the end result is of benefit to the participant who voiced the suggestion first, they themselves are not satisfied with the end result – why?[3]

Answer C: By failing to foster **inclusion** the group has alienated and appropriated their suggestion, reinforcing that those from their background continue to be consistently ignored or misrepresented.

2. Issues in education practices

2.1 The current state of representation in STEM

According to the ASPIRES report (Archer et al., 2016), 16% of 10-18 year olds in the UK reported an interest in pursuing a scientific career in later life, while those wishing to pursue a career in business, technology or art averaged at 55%, 50% and 45% respectively. In the report over 50% of students appeared to show an appreciation for the importance of science in the world today and noted that science was enjoyable in school across all age groups. However, a large decrease was seen when students were asked if they wish to become a scientist later in life. The 5-20% of those who reported an interest in pursuing a scientific career came from socially advantaged backgrounds, where someone with a scientific career was already present. Students from socially economically advantaged backgrounds appeared to be two and half times more likely to pursue a scientific career. High achieving, middle class males' students and students with high levels of family science capital were much more likely to aspire to a career in science and to be recognized by others as being scientifically capable (Archer et al., 2016).

According to the 2018 PISA survey (OECD, 2019), only 10% of those students recognised as living in socio-economically disadvantaged circumstances appeared within the top quartile of reading performance nationally. There was a large focus on male performance reported (which will be touched upon later), with more than 1 in 3 of males living in socio-economic disadvantaged circumstances not attaining a minimum level of proficiency in reading. Through the survey results, disadvantaged students generally showed that they were twice as likely to attend a school where a lack of teaching staff hindered instructions in lessons.

Further results from PISA 2018 show that girls outperform boys in reading across Europe, the differences between the two ranged from 6.4% to 21.5%. Males were noted to underachieve significantly more than females as indicated by an average of 26.3% and 16.9% respectively across Europe. The differences seen between females and males in subjects such as maths and science is much less, with the general proportion of underachievement greater in males. Some of the key survey findings showed that socio-economic background strongly affects pupils' performance and academic expectations in most EU countries leading to large performance gaps between those from socially advantaged and disadvantaged backgrounds. The survey seems to indicate an obvious disconnect between social and cultural status, performance in school, and science identity in educational spaces.

Informal learning spaces (ILS) have been an important addition to education over the last several decades. Using a multidisciplinary view of learning in combination with art and culture, ILS allow multiple access routes to an educational area. However in the majority, ILS have been recognised as being openly accessible primarily to those from a particular demographic. According to Ipsos MORI (2011), 69% of individuals have never visited an ILS. Out of those that did, only 19% claimed to visit museums and 12% claimed to visit science centres. Of those that expressed their attendance at ILS, 80% were noted as coming from an affluent and educated background, 69% were of white origin and 56% were female (European Commission, 2018). There is a lack of diversity in informal learning spaces, stemming from a lack of accessibility for individuals not typically represented in informal learning spaces to attend. Groups of people that are typically underrepresented usually come from ethnic, cultural, socio-economic, or gender minority groups (Lindley et al., 2019).

It has become evident that there are a number of factors contributing to an individual's engagement with science that are very heavily influenced by existing social inequalities such as class, gender and ethnicity, and by whether a young person has had opportunities to experience, do well in, feel connected with, be recognised in, and continue with STEM. According to ASPIRES, those who would consider themselves a "science-y person" or those who value themselves as a scientist, decreased as young people progressed through education. According to the report the largest decrease was amongst girls and especially those from underrepresented socio-economic backgrounds (Archer et. al, 2016).

In the same report three large factors surfaced that contributed to the accessibility of science learning for students. The first of these factors relates to capital-related inequalities. Here, we see that low science capital is correlated with low exposure to science, this was prevalent amongst those of minority gender, ethnic and socio-economic backgrounds. Coincidentally, the study reports low areas of representation in science media from these exact same groups (Archer et al., 2016).

The second factor is related to educational infrastructure and teaching practices, in which educational practices are structured around historical social inequalities. Boys have reported having greater support from teachers in STEM/STEAM subjects. Classroom practices have been noted as being more supportive of "feminine" qualities (being quiet, kind and attentive) (Dawson et al, 2019). However, this has resulted in girls not receiving as much attention, which is reflected in their perceived science identity. Educational gatekeeping has been damaging for the students in schools, regarding what subjects they can choose and what subjects a school can facilitate. Alongside subject choice, for the cohort surveyed for ASPIRES, there is a severe lack of guidance with 63% students from low socioeconomic areas reported not receiving any career advice.

The final factor noted in the report reflects the dominant social representations. Teachers expect more from males in the classroom, and masculine behavior such as being more aggressive, loud, or "laddish" (Archer et al., 2016) is more supported when it comes from males students compared to female students. Hence, subjects that appear to be masculine become unattractive to girls as they view those studying those subjects to be "less girly" as well as being unsupported by school culture. The longitudinal nature of the ASPIRES reports (Archer et al., 2016, 2020) samples has provided a clear window on changing perspectives of the self and the world around young people when it comes to establishing a science identity. Without improvements in diverse representation in STEM in the world around them, it appears that minoritised young people will be limited to a small and weak scaffold upon which to build their science identity.

2.2 What are the barriers?

Underrepresentation is born from certain exclusion barriers that particular groups may face. It is helpful to remember the following objectives that feed into the DEI strategic aims outlined in 1.1.

— Enable users to understand and identify when diversity, equity and inclusion is failing to be met
— Identify why they have failed to be met
— Identify what can be done in order to address and improve diversity, equity and inclusion in the future.

Examining the barriers an individual might face is essential to understanding their underrepresentation in particular fields. The following is an adjusted list developed by the Erasmus+ programme (European Commision, 2014) which identifies barriers that can exclude people from representation in employment, formal and non-formal education, democratic processes and society at large:

— **Disabilities:** (i.e. participants with special needs): young people with intellectual, cognitive, learning, physical, sensory, developmental, or other disabilities etc.
— **Health problems:** young people with chronic health problems, severe illnesses or psychiatric conditions etc.
— **Educational difficulties:** young people with learning difficulties, early school leavers, lower qualified persons, young people with a poor formal academic performance etc.
— **Cultural differences:** immigrants, refugees or descendants from immigrant or refugee families, young people belonging to a national or ethnic minority, young people with linguistic adaptation difficulties such as language learners and cultural inclusion difficulties etc.
— **Economic obstacles:** those with a low standard of living, low income, dependence on the social welfare system, people in long-term unemployment or poverty, people who are homeless, in debt or with financial problems etc.
— **Social obstacles:** people facing discrimination because of gender, age, ethnicity, religion, sexual orientation, disability, etc. people with limited social skills or anti-social or high-risk behaviours, people in a precarious situation, (ex-)offenders, (ex-)drug or alcohol abusers, young and/or single parents, orphans etc.
— **Geographical obstacles:** people from remote or rural areas, people living on small islands or in peripheral regions, people from urban problem zones, young people from less serviced areas (limited public transport, poor facilities) etc.

It is important to consider under-representation as relative, as the availability of opportunities is largely based on an environmental context. For example, not all people from minority backgrounds are underrepresented in a particular field, a person with a disability is not necessarily disadvantaged if the environment is adapted accordingly. The risk of exclusion exists because specific factors and obstacles vary across country and context. There can be multiple reasons causing someone to be regarded as under-represented or lacking opportunities, and similarly, there are myriad solutions that differ in an intersectional way.

As the Erasmus+ Inclusion and Diversity Strategy in the field of Youth (2014) notes, there also exist 'absolute exclusion factors'. These are when people's fundamental rights are violated, and they are always at a disadvantage regardless of how common the situation is in a particular context – e.g. those who are homeless. In the case of a group who are subject to absolute exclusion factors, particular special attention should be given (European Commission, 2014).

2.3 The importance of representation in education practices

Diversity, equity, inclusion and representation should be a prime concern across all fields of education. However, as mentioned previously there is an unequal representation of demographic involvement in education programs across Europe. Multiple rationales exist to pursue more accessible, equitable, diverse and inclusive practice when designing future educational programs.

Accessibility to information

Creating multiple and more efficient routes of access for people to enter learning spaces results in a large population of informed citizens. In an ever-growing complex world, citizens should have the opportunity and the understanding to access the knowledge they require in order to make informed decisions, think innovatively and act justly for the benefit of the individual and that of society. The pursuit of higher education has been a benchmark goal for many European states and is one of the largest influencers of global policy change. The higher proportions of students achieving higher education as well as attending ILS which can work in conjunction with the former, provides an increase in access to information, allowing Europe to contribute more to the growing knowledge economy (Fecher & Friesike, 2013)

Diversity and representation are just

Learning practices must be supported and actively seek a diversity of experiences from a variety of individuals and groups, leading to correct representation and support of the diverse society as a whole. This fosters an inclusive and diverse space which in turn allows for future diverse representation of ever-evolving cultures and society. Therefore, a focus should be placed in supporting, encouraging and representing diverse cultural practices centered around inclusive co-creation methodologies. In addition to the positive feedback loop (diverse representation leading to safe spaces, leading to more diverse representation), DEI also allows us to develop societal solutions with input from diverse voices. If we seek to understand and resolve problems in a culturally blended setting, we will achieve outcomes that better benefit the whole when consulting diverse members of the population.

The responsibility to provide equitable empowerment

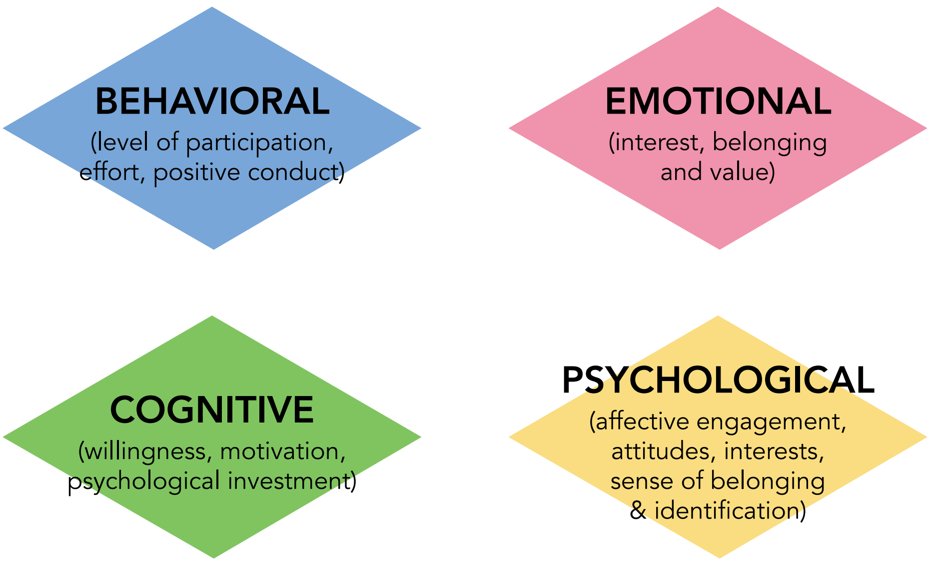
As educational institutions (both formal and informal), it is our duty to facilitate intellectual and social development for all of life's learners. One of the UN's Sustainable Development Goals is the provision of an accessible environment which allows individuals to better understand the complexities which surround them, leading to more inclusive and equitable lifelong learning opportunities (United Nations General Assembly, 2015). DEI frameworks allow us to identify minority and underrepresented groups and take decisive action to empower those that need it within the existing structural confines of the educational system.

3. A THEORETICAL UNDERSTANDING

In this section, we will explore some of the theory and criteria underpinning various types of group exclusion and inequality.

3.1 Exclusion and engagement

Learning is a collection of sociocultural processes; learning is indicative of engagement which happens on a number of different levels. There have been multiple arguments claiming for various proxies of engagement such as for motivation, enjoyment, frequency of participation and depth of involvement. Fredricks & McColskey (2012) and Godec et al (2012) have conceptualized engagement into 4 distinct categories:



These four areas must be carefully attended to allow particular individuals equitable access to the practice. Engagement does not evolve from nothing, it must be enabled, supported or constrained by the actors, opportunities and objects that surround them. Therefore, a connection between the person, the object or subject and the role they must play should be clear to support engagement. However, the current educational system creates a space where individuals find it difficult to engage with learning.

A collection of work from Dawson (2019) focused on groups of urban young people from ethnic, cultural and gender minorities and low socio-economic backgrounds that fell within an interesting and diverse cultural cross section. Within these cross sections we can examine exclusion criteria in the form of cultural imperialism, powerlessness, embodied exclusion, and symbolic violence and aim to understand what we may do to prevent it.

Female, ethnic minority, working-class young people remain underrepresented across various fields in post-compulsory STEM (Archer et al., 2016). Similar patterns have been noted by the same author regarding voluntary participation in informal science learning environments (ISLEs), such as science museums, galleries and learning centres. Archer et al., (2016) conclude that it is due to the confluence of dominant white, male, middle-class institutional cultures, along with social and economic exclusion, which combine to produce particular patterns of participation. ISLEs are spaces that can promote science learning and engagement in a revolutionary way that can be more relevant to a younger audience.

Crowley et al (2001) found that in ISLEs, parents pay more attention to boys than girls and engage in more scaffolding of their sons' learning than their daughters'. Moreover, evidence suggests that certain forms of exhibits are not gender-neutral but attract and retain boys' attention more than girls (Dawson, 2014).

With the OSHub.Network, we aim to promote spaces where everyday science learning practices help break down social inequities rather than reinforcing and reproducing them. To conceptualise the exclusions we face in today's world, we need to consider the tangible barriers such as fees, location, people in the area, access routes as well as the psychological, cognitive and emotional barriers that may obstruct individuals.

Initiatives that address tangible barriers, such as 'golden ticket' entries in which individuals of particular demographics gain free admission, expect minority communities to change their behaviors without expecting the science content or institutional practices/values to change as well. There also isn't one single barrier for the multiple different communities who are excluded. There are a plethora of interconnected exclusive practices all contributing to exclusion.

3.2 Understanding Exclusion

Cultural imperialism occurs when socially dominant perspectives and practices suppress or invalidate the views and experiences of minority groups. This is dismissive and harmful to the already underrepresented and marginalized groups and results in benefitting the socially dominant. This behavior rises from a lack of representation or negative representation in the space. An obvious example is when marginalized groups are referenced in history, but not acknowledged or represented to the same extent as the socially dominant. The dominant groups may present the marginalized in a way that appears they are burdened/struggling, displaying them as 'disadvantaged' and so may reflect negatively on the surrounding social groups.

Tokenism is another factor contributing to cultural imperialism. We must move away from representing or celebrating a group for a particular set time. Representation should be built into general practices with a focus on inclusion, not irregular earnest celebrations. A key access issue that many faces which is a prime contributing factor to exclusion is the non-fluidity of individualized literacy. Being unable to speak, read, or navigate in multiple forms of language (including semantic understanding) is detrimental to accessibility and engagement in cultural/science learning spaces. When all text is written in one language, referenced to one particular culture or exhibitions designed with prior knowledge in mind, then knowing how to interact with an exhibition or workshop is racialized, classed, and gendered in its approach to disseminating knowledge (Dawson, 2019; Kanter, 1977).

When a socially dominant group proceeds to recognise underrepresented groups in inequitable and exclusive ways (as indicated above), the minority group is not given a voice or an equitable share over how they want to be represented, leading to feelings of powerlessness. This occurs when the socially dominant group begins to represent those minority groups by speaking on issues such race/ethnicity, gender and class that describe experiences of being disrespected and having little to no autonomy over your choices.

- Underrepresented groups may feel as if they have **constraining choices**. Their perspective and voices may be controlled by the dominant social groups, as a result of a marginalised social status due to bias, racism, forced immigration, colonialism and other systemic factors. Marginalisation is linked to lower income and lower wages for labour, which in turn reduce an individual's time, money, and ability to make choices and participate in everyday informal learning (Dawson, 2019). As a result of having a constraint on involvement, those from minority groups often have **unheard voices**. This problem is twofold. First, the socially dominant group does not seek opinions from underrepresented individuals, and propagates a uniform, unchanging culture. Second, those underrepresented groups that are present may feel like they don't belong (as their opinions are not actively acknowledged) and they will be hesitant to lend their voices in a constrained social context. Voices aren't heard when some racialised, classed, gendered groups aren't listened to in socio-scientific consultations, or when they are not asked. An organisation cannot have the same people making decisions for long periods of time.
- **Symbolic violence** is a misrecognition of objective exclusion. Here the exclusionary domination or inherited disadvantages of marginalized populations that can be framed to resemble a choice to not participate. This can result in a personalised feeling of guilt from those not participating rather than placing a blame on those structural inequalities on institutional systems and society. Those who are impeded in participating may feel as though culture and science are created to be difficult and inaccessible to those who are not typically recognised as being involved, so those of us who are not seen in those circles waste our time trying to participate. (Bourdieu, P., & Passeron, 1977; Bourdieu, P. Eggleston, 1974; Browne et al., 2018)
- **Embodied exclusion** is that which is based upon a disconnect between groups of racialised/classed/gendered bodies and the somatic normalities that accompany them i.e. the bodies they imagine everyday science learners to have are old, white, educated and male. This can result in young people forming ideas similar to "Most scientists are men, so how could I be a scientist?"(Dawson, 2019). These suppositions can occur if the space attracts a large number of people from the same demographic, as the visitor bodies are all the same. There can also be a lack of diversity amongst those that represent the space, this can generate similar notions of "I don't fit in here"(Archer et al., 2016; Dawson, 2019).

These exclusive practices are not felt universally, they target specific groups of people based on issues such as gender, race, class etc. Structural inequalities run deep throughout our societies and although science centres and cultural institutions did not invent them, their practices naturally reproduce them and struggle to combat them.

3.2.1 Why does exclusion exist?

There are a number of reasons why practitioners do not address exclusive practices. One of the main reasons is due to a lack of awareness of the inequalities facing individuals around them. The first step is to recognise the barriers of access facing those groups you may want to reach. Failing to achieve this is detrimental to your cause and may lead to the false narratives proclaiming the exclusion is the fault of the excluded through their behavioural and attitudinal deficits.

The behavioral deficit implies that certain individuals cannot be seen as culturally, educationally or politically active, and that they do not participate in cultural practices like everyday science learning that we can see. Dawson (2019) explores the inaccuracy of this belief through a number of case studies with ethic groups, and their choices around participation in a number of "everyday science learning practices". The groups studied found these practices were in fact inaccessible, exclusive and off putting and typically, they chose not to participate. The "regular" participants of these everyday science and culture learning spaces were typically seen to lead rich political and cultural lives, therefore the minority groups felt their own culture and experiences were devalued and rendered invisible. Participants are not behaviorally deficient; they do not choose to do nothing over going to a science/cultural centre. They instead choose relevant community-based practices over exclusive, off-putting, and seemingly irrelevant everyday science learning.

The attitudinal deficit implies that people who don't participate in science learning are doing so because they don't "like" science, and it suggests that they would participate if they enjoyed science. This is false because those who enjoy science mostly have congruent access to science media, careers or hobbies. When we look at the science experience of marginalised people, we see how structural inequalities are rooted in parts of history such as colonialism which framed particular branches of academic or mainstream science as a culture distant to them (Schulz & Enslin, 2014).

3.3 Gender Equity and Inequity

Science has been celebrated across the world as an apparent means of producing the objective, unbiased truths of life. However, since women have been recognised in university and academia they have been severely underrepresented. Literature by Sinnes & Løken (2014) proposed that gender differences were thought to be caused by obstacles to participation in science; therefore it was thought that by removing these obstacles and inviting minority groups into mainstream science, equal numbers of men and women would pursue a scientific career (Allegrini et al., 2015).

As noted in the HYPATIA report many initiatives have been put in place to recruit more women to male-dominated STEM practices such as GAPP (Gender Awareness Participation Process: Differences in the choices of science careers) and Science: It's a girls thing! (Achiam and Holmegaard, 2017). These mainly focused on changing young girls' dispositions in hope that they might choose science. When women's disposition did not change, this was originally thought to be a result of essentialism (i.e. that by nature or nurture, girls develop skills and feminine characteristics that result in them not wanting to engage with STEM-like subjects) (Nash, 2000) This type of thinking is an example of behavioral and attitudinal deficits as described in Section 3.2. The historical discourse in science is not gender neutral – it has been dominated by males for centuries (Phipps, 2007). This is carried forward to today, with the current state of STEM is governed by rationales and characteristics of predominantly masculine symbolism. Thus, it is not enough to get a gender balance within STEM fields, there must also be representation and support throughout one's experience to ensure that the current culture is being challenged to allow for equity in the future.

Gender has been a primary focus for research in STEM participation, specifically research highlighting the lack of female representation throughout various fields. However, there have been fewer studies exploring how masculinity impacts young people's engagement with STEM. Despite the understanding of underrepresentation of women, there has been a spotlight placed on the epidemic of male underachievement in these sectors (Archer et al., 2016; Carlone et al., n.d.). Regardless of viewpoints arguing for improvements in gender equity, educational practitioners and policymakers continue to be concerned and vexed by the notion that boys are failing to achieve their educational potential. Within such debates, academics have highlighted how not all boys are underachieving, but the attainment and post-compulsory participation of some boys, especially working-class boys are considerably lower than others (Francis & Skelton, 2005). This illuminates the understanding that inequity in education is not a product solely of gender or socioeconomic status, but a combination of multiple factors that are specific and which vary among extended user populations.

3.3.1 Gender & Representation

Science initiatives both in and out of schools may be based on implicit presuppositions about who the science learner is. These suppositions work to attract and include learners with certain characteristics while excluding others. Assuming sex and gender are semantically interchangeable is an outdated paradigm. Gender should be approached as a complex category that individuals make recogniseable through their social and cultural engagement/performance rather than a translation of biological differences (Butler, 1990; Wedgwood, 2009). According to the Hypatia project (Achiam & Holmegaard, 2017), gender refers to the differences between genders that have been learned, that can change over time and have a wide variation, both within and between cultures. Therefore, gender does not correspond in a straightforward way to biological sex, nor is it a personality characteristic. Instead, gender is constructed and can be continuously negotiated across time, space and an individual's personality, interactions, communities, and cultures. Thus, gender is not only culturally embedded but a feature of one's individuality. Individuals adapt to the cultural context they participate in; therefore, one may not display performances of gender in one context in the same way as in an alternative one.

Through the Hypatia project, Achiam and Holmegaard (2017) carried out analysis of school science curricula in 14 European countries, which showed two dominant forms of discourse. The first was a contextual science-from-issues approach that had a focus on human socio-scientific aspects of science. This approach was strongly linked to 'softer science' such as biological or social sciences which were represented as more feminin subjects. The second was a more abstract approach in which science is decontextualized into domains of discipline, more strongly present in the 'harder science' curricula such as physics represented as more masculine subjects. These general educational approaches resurfaced in multiple countries. However, a co-variation appeared between educational representation and curriculum formation. Countries exhibiting a larger socio-scientific perspective in a biology curriculum tended to also see a greater increase in socio-scientific perspective in the physics curriculum, which has led to more diverse representation among students studying these subjects. Conversely those who see a large abstract approach in physics also see this surface in biology (Corrigan et al., 2007).

Hughes (2000) pointed out that a society at large often places a symbolic association of abstract 'hard science' with the 'masculine' corresponding with a dissociation from the social world of human subjects. Furthemore, there is then symbolic association placed on 'softer' science to include biology with the 'feminine'. The Relevance of Science Education study (Sjøberg et al., 2010) has investigated this pattern across a number of industrialised western countries. The results show dominant patterns of discourse that have implications for the inclusion and exclusion of science learners in specific fields based on gender identity. It does not categorise those of a particular gender into one science or another, however it is important to recognise that these assumptions may perpetuate the essentialist stereotype of one's gender identity allowing participation in particular fields of science. Research on socio-cultural issues, including gender and identity, has emerged as a key focus for those exploring how people learn science (or not). Exploring girls' identity performance became a central aspect of understanding equitability around science learning. Research has described a multiple bind that undermines the science learning experience of women. It is important that we start to consider science learning experience through the lens of gender and sexuality as a spectrum, and these are issues that intersect with race, ethnicity, socio-economic class and more (Archer et al., 2012).

Studies across a range of science learning spaces suggest that everyone, including girls, are more engaged with, and better able to learn science when their identities, bodies of knowledge and behaviours are valued and reflected in a given space (Calabrese Barton et al., 2013; Dawson et al., 2019). However, a growing number of studies also document the extra work needed by women and girls to pursue studying science whilst being themselves, such as longer work hours (Francis et al., 2017; Thompson, 2014). Taken together, these two sets of studies suggest an urgent need to better understand how girls enact the identity performances they are invested in while learning science.

3.3.2 Theories of Feminism

The gender inclusion guidelines generated by the Hypatia Project (Achiam & Holmegaard, 2017) take a range of approaches centered around equality, essentialist and postmodern approaches. It is important to understand the concept surrounding gender theories in order to understand identity and how best to create an equitable practice. The Hypatia project examined 3 theories of feminism. When we use the term 'feminism' we use it as a definition of social, political and ideological movements that have aimed to establish economic, political, personal and social equality of all sexes:

- An equality feminist approach assumes that genders are similar in their engagement in science and that obstacles external to teaching situations cause girls to participate to a lesser extent than boys (Sinnes & Løken, 2014);
- An difference/essentialist approach reflects beliefs that by nature or nurture one can presuppose specific sex characteristics and skills that should be recognised and acknowledged in their own education situation (Schulz & Enslin, 2014);
- A postmodern approach challenges the notion that learners' experience is equal across genders, and that the individual differences between learners are important, regardless of whether they are caused by gender or not (Sinnes & Løken, 2014).

Equality Feminism

An example provided by the UK Institute of Physics (2013, p. 3) reported that "schools close doors to both male and female students by failing to challenge the external factors that drive them to make gendered choices” This implies that students make gendered choices of study subjects outside of the education system, and it is a shortcoming of schools to fail to challenge these external factors.

An Austrian strategy for gender diversity suggests that a gender-neutral selection of teaching materials, examples, and problems should be the basis of all subjects. Here, there is an implication that external factors such as textbooks, problems, resources etc. play a large part in gender inclusion. However as stated before, simply removing tangible barriers is not sufficient to ensure inclusion of a broad diversity of learners. It is difficult to imagine that a teaching practice founded in equality feminism (i.e. simply based on removing obstacles) could counteract the exclusion effects of masculine or feminine subject presuppositions (Allegrini et al., 2015).

Difference Feminism

A study of teacher opinions on gender-adequate teaching found that teachers tend to treat students differently based on their sex. This may indicate that teachers have an essentialist perception when it comes to gender. The Institute of Physics (2013) makes reference to “the differences between girls and boys and the teaching styles that suit each”. Other reports have noted that the inclusion rate of males and females is not the same, and that equitability can be created by ensuring over half of visiting scientists, physicists, engineers and experts are female, for all projects, in addition to replicating this in print material, on the web, and in social media (Fidler, 2014).

Approaches like this seem to reflect a strong distinction between the needs of different genders. There is evidence to suggest that science appeals to genders differently. The problems we face are related to the relative invisibility of specific genders in scientific knowledge, making their marginalisation more prevalent (Ryan et al, 2004).

Difference feminism does not question the status of science itself. Those who operate using a different feminism approach would probably not question the dominant discourse of the scientific subjects that they were teaching – whether that discourse was based on an internal disciplinary logic or an external socio-scientific logic (abstract/physical or hard/soft). The inclusion and exclusion effects of each science subject would thus remain unchanged, wherein the exclusive behavior and inaccessibility is born from the innate differences in those of a different gender.

Postmodern Feminism

A postmodern feminist approach was taken by the Hypatia project. In their work, an example from a French policy document outlines the collective unconscious as a direct source of discrimination, bias, and gender stereotyping, which must be challenged from a young age (Ministère de l’Éducation Nationale, 2010). Thus, the diversity which is specified by policy and set out in existing practices remains a necessary but insufficient condition for real equity between genders (having a greater effect in later life). This must be accompanied by strong policy initiatives to all stakeholders in the educational community and the partners of schools

Gender inequity is not due to biological differences or individual choices; it is inherent to our larger societal structure. Knowing that gender is socially constructed provides an opportunity to examine how and why past and present societies have influenced what is deemed ‘proper’ gender behavior. It also allows each person to understand where these societal constructs were born and how behavior can be perceived through their gendered experiences.

From a postmodernist perspective, science is not assumed to be objective, rational or dispassionate. Like any other endeavor, it is assumed to be governed by the social, cultural and societal context in which it is practiced (Sinnes & Løken, 2014). This encourages a diverse educational practice that provides opportunities for science learners to participate in discourse in a variety of legitimate ways.

If science is represented in a way that offers one gender limited, stereotypical ways of being science participants, those individuals may likely be alienated by science. Female-friendly approaches to science allow girls the choice of opting out of or engaging with the established gender normalities that sanction science culture. The advantage of a postmodernist point of view is not only to address the many problems inherent in different feminist approaches, but also to counteract the imbalance of participation between those of a multi-facet gender approaches. It may be that science initiatives that are based on postmodern feminist approaches would encourage all learners to value their own experiences and interests and reflect on their personal relevance for science learning. This practice may help establish an increased awareness of all types of marginalised gender groups.

Postmodern feminism also addresses the structural intersection of gender and science, as it challenges the association between masculinity, objectivity and science (Sinnes & Loken, 2014). These approaches don't assume that science is objective, rational, or dispassionate, and recognize that it is influenced by social, cultural and societal context. Recently science educators are encouraged to take a postmodern feminist approach to teaching and are potentially able to counteract the exclusion mechanism of 'gendered subjects' that is strongly framed in terms of an abstract, internal disciplinary logic. The existence of gender inclusion guidelines for educators is evidence that the call for national policies for gender inclusive teaching practices is beginning to be heard.

3.3.3 An intersectional view of gender

In order to create a consortium of best practices for gender equity, we must first come to terms with what gender is and what has contributed to today's understanding of gender. We will draw upon a number of different theories, the first of which is the conceptualisation of **gender as a 'performance'** (Butler, 1990). We can integrate with Collins' view of intersectionality (Collins, 1993), showing gender as culturally entangled and intersecting with other social axes such as race, ethnicity and social class. We can, in turn, view gender as an analytical lens that is inseparable from these other social constructs. As noted previously, gender (along with other social identities) is produced through discourse. These are not fixed components or inherited biological traits; they are dynamic and continuously processed.

We will also take into consideration Butler's gender relational construct (Butler, 1990). Here, we accept that masculinity and femininity exist co-dependently, one is not rationalised without the other. Gender identity cannot be prescribed, it is not a symbol or product of biological development. Although, it can prescribe a range of gender performance that may be judged more authentically through biological reasoning such as aggressive/submissive behaviour, rate of emotional development or intrapersonal skills, it is important to be aware of generalisation when discussing these. Gender is a socially constructed 'performance', it is a set of acts, it is not what we are but what we do that determines gender. Butler (1990) suggests that gender is a powerful 'illusion' – it is not 'real' and yet it has very real effects. We do not consider that one gender acts in a homogenous manner, but rather we can look at social identities and inequalities that intersect with gender, ethnicity and class, all of which are in a state of flux and have boundaries that are continuously being contested.

If we accept that masculinity and femininity exist co-dependently, and that genes exist on a diverse intersectional spectrum, we may also need a reference point to denote what we consider masculine or feminine. To function as a reference point, we will examine Connell (1998)'s notion of **hegemonic**

masculinity which denotes 'those dominant and dominating modes of masculinity which claim the highest status and exercise the greatest influence and authority'. Hegemonic masculinity is organised around the subordination of others such as those more feminine, and it seeks to maintain its position of dominance by excluding, marginalising and disparaging those less powerful social groups or by attempting to present itself as the only 'normal' or 'natural' way to be male (Connell, 1998; Connell & Messerschmidt, 2005)

Lastly, we will look at **Bourdieu (1977)'s "concept of field"**. This allows us to investigate the reproducibility of social inequalities in educational environments through talking, thinking and behaving – privileges that are typically held by those in socially advantageous groups. Bourdieu describes privilege and domination being reproduced through interaction of capital, habitus and field.

- **'Capital'** refers to the available resources that an individual can use for beneficial outcomes in a social situation. These resources can fall within economic, cultural and social capital. Capital is not universally valued at the same degree, as the value of one's capital may vary based on its recognition as symbolically legitimate within a specific context. Possessing relevant resources can afford some privilege, wherein having other resources deemed less valuable within a dominant system such as education may offer limited advantages.
- **'Habitus'** refers to an internal cognitive mix of dispositions developed through lived experiences, such as the particular social environment in which one grows up. Habitus is shaped by a complex system of socioeconomic, ethnic, and cultural factors.
- **'Field'** is the context in which capital and habitus are understood. Field is not the physical setting, but the set of rules, regulations and relations that confine the capital and habitus. Bourdieu's field is a "network, or configurations, of objective relations between positions" (Bourdieu, 1977).

To summarize, the field determines how resources (capital) are perceived and valued in relative terms and it is the field that governs the way in which particular behaviours are recognised as legitimate. One needs the 'right' capital to provide them leverage and whose habitus 'fits' with what is expected and valued in the area. Habitus relates to the field as a fish relates to water. The habitus of the fish fits better with living in the field of the water than it does to the field of land. Similarly if Person A has capital that includes good boxing coaches, good boxing gloves, a great gym, a dietitian and a habitus of determinability, efficiency, precision, a good pain threshold, and if Person B also had a capital consisting of a great gym, a dietitian, a private tennis court, great coaches, and a habitus of determinability, efficiency, quick, and hard working they are almost equally matched. However depending on the field they are in, the right capital and correct habitus is needed i.e. Serena Williams has tremendous capital and habitus to be a world champion as does Katie Taylor, however if Serena Wiliams was to box Katie Taylor or Katie Taylor was to play tennis against Serena Williams, the field has a significant effect on the outcome.

3.4 Contributing to gender performance and identity

To consider the conditions that activate gendering (i.e. the 'girling', 'boying' or 'othering' of bodies) and how it relates to scientific identity and performance, post-structural intersectional feminist approaches must be considered. This investigates the affordance and the limitations of girls' performances in a particular space. This might be understood for both science learning and girls' agency in the science learning space. Gender performances draw on, recreate and/or resist social norms of what it means to be female or male. Acts, gestures and enactments are generally construed as performative in the sense that the essence of identity that they otherwise support are fabrications manufactured and sustained through corporeal signs and other discursive means. (Butler, 1990)

Intersectional feminist theories allow us to think about gender as inextricably linked to other aspects of identity and performance. Intersectional approaches to gender consider the influence of race/ethnicity, social status, ability, and the multiple experiences that shape an individual's life when analyzing gender identity. We can use the idea of intersectionality as pointed out by Dawson (2019) as a kaleidoscope to frame that shifting in relationships between the different aspects of one identity/performance and the relationship with the surrounding world (Archer et al., 2016; Carastathis, 2014; Godec et al., 2012).

It also reminds us that not all performances are equally available to all persons in space. Local, global socio-historical, political, and structural inequalities of racism, sexism and class oppression influence identity performances that affect bodies and communities in space and time. Therefore, some individuals of particular age, shape, colour, history or demeanor encounter problems that other bodies would not, given a specific space or structural framework.

Lastly, we must note that the way different groups of people read identity performances (i.e. peers, teachers or researchers) can be just as important as the way that performances are enacted. Notably, we must understand how performances are accepted or rejected in a specific context. Investigating how one reads a performance lets us consider how they might be read or misread across time and space (Francis & Paechter, 2015). For instance, identity performances can be misread in ways that are racist and/or sexist in different cultures. Puwar (2004) touched upon examples of bodies that are less accepted in particular spaces marked by sexism, racism, or colonialism. Therefore, people create alternative readings of themselves, the people around them and the specific spaces they are in. As Mohanty (1989) has argued for the educational context, "teachers and students produce, reinforce, recreate, resist, and transform ideas about race, gender, and difference".

OSHub.Network is proposing to take an intersectional approach when investigating science and social identity amongst learners. **Science Identity** (Carlone & Johnson, 2007) refers to an individual's interest in, along with the feeling of, and being recognised as scientifically capable by others. Science identity, like gender identity is inextricably linked to our culture, circumstance and environment.

4. Preparation and implementation

The following section will address contexts in which a diversity, equity, and inclusion plan can be implemented. A special emphasis will be placed on gender equity in relation to the OSHub.Network. This will then lay the groundwork for a set of best practice guidelines.

4.1 Review the landscape

As a result of research carried out through the Hypatia project, Achiam & Holmegaard (2017) showed that planning and implementation cannot exist in a vacuum. Instead, science educators, centres, schools, institutions, and industry should work together within their complex environments to address constraints and conditions in their work. The Hypatia project also demonstrated how a planning strategy should be based around recognising the various constraints and conditions that may influence a given project. Conditions may be explicit—such as a clearly defined mission statement that defines a range of possible activities. Constraints may be implicit—such as having an established way of doing things that remains static and so influences the way in which an education programme is designed. Some conditions may originate at levels beyond the immediate control of the educators, but even simply acknowledging their existence can help counteract them, if not control them. For example, a government may incentivise careers in biotechnology over the other sciences leaving careers in those areas with less profile, funding and perceived appeal.

Identifying and understanding specific levels of constraint should be thought of as an analytical tool to guide reflection when it comes to designing and implementing science education activities.

The framework of the Hypatia project took into consideration a number of constraints outlined below that will have a bearing on the OSHub DEI strategy (Achiam & Holmegaard, 2017). Amongst theses, a number of advisory statements have been added in the context of Covid-19 impact.

4.1.1 Societal and cultural level

These are conditions and constraints that originate outside of the institution. Many museums and science centres are dependent on government subsidies. These subsidies are often given on specific conditions that the institutions must adhere to during their activities. Formal educational activities can be strongly influenced by those who devise the curriculum, for example government ministries. Education activities carried out by industrial and community actors should be co-created with reference to social responsibility issues that play out at the intersection between society and institutions.

Additionally, the Covid-19 global pandemic adds a new lens to this constraint category. Issues such as equitable access and knowledge of digital tools for all students and/or educators has been exacerbated by the trend for formal, informal and non-formal programmes to move to an online space. The most underserved communities in every nation are the most impacted during the pandemic and in turn most in need of care and consideration.

4.1.2 Societal and cultural level

The conditions and constraints which take effect here depend on the particular institution in question. The type of institution will have a defining influence on the kinds of activities undertaken (e.g. an industrial institution may offer education programmes with the aim of recruiting workers for its workforce). These conditions are often (but not always) beyond the control of institutional educators. In institutions, scientific disciplines may be more or less explicitly present. Therefore, some discipline-specific conditions and constraints may be of concern in that institutional context. The discipline is located between the institutional and the interaction level, with the overarching discipline being determined institutionally, while the dissemination of disciplines is determined at the interaction level.

The global pandemic has thrown a spotlight onto all institutions whose remit is to engage the public when it comes to recalibrating under trying circumstances. While institutions directly experience the negative effect of societal constraints resulting from the situation, there is a need to actively avoid placing institutional survival above the needs of underserved communities. Behaviours and actions altered during this time of contemplation could be seen as an opportunity to steer engagement towards the most underserved communities within reach of those institutions like never before (Dawson & Streicher, 2020).

4.1.3 Interactional level

This is the level in which educators influence the engagement of individual learners. The engagement of learners is dependent on the chosen activities. For example, science cafés work to promote conversation, though they constrain some types of hands-on learning. Conversely, an open science experiment encourages hands-on learning, but constricts other forms of interactions. A large proportion of these constraints manifest at this level under control of the institutional educators.

Once again, the pandemic further constrains this level. For example, conversations no longer happen ‘in person’ and learning no longer directly ‘hands-on’. While the world is hopeful for harsher constraints to be eased or lifted altogether, the staging of this in various national contexts are not predictable in the long term at the time of writing. In the meantime engagement must consider DEI closely in methods of interaction that are open to some and currently closed to others.

4.1.4 Individual level

At this level, the constraints manifest themselves in relation to learners' individual knowledge, values, and experiences. A learner with a strong sense of empathy may prefer group work, while someone who struggles socially might find group work difficult. Preferences strongly co-determine the activities in which a learner can participate and should be considered and addressed by the institution. This is also the level in which the constraints of a teacher or facilitator are considered. These could include constraints relating to time, equipment. and resources. Facilitators can help learners to develop skills, explore new topics, and can also frame culturally sensitive topics in an equitable and supportive way.

4.2 Set the scene

For each OSHub, a number of steps can be taken to ensure that best practice is followed concerning diversity, equity, and inclusion. These steps can be shared within an organisation, for convenience, in the form of a presentation, a workshop, or a self-guided activity. The following suggestions can be seen as a set of 'stepping stones' to help build upon the existing knowledge within a community and to deliver that knowledge in the most equitable way possible.

In order for these stepping stones to be used to create an equitable framework, they need to be embraced and adopted by everyone in the organisation. The "Three R's" highlighted here can be a useful shorthand for these stepping stones:

- **Recognise:** Integrate and articulate the life experiences of all involved.
- **Respect:** Validate the equitability of the programme through all involved.
- **Represent:** Reproduce DEI successes with parity across the network and beyond.

The following questions for self-reflection can help deepen an understanding of these stepping stones:

Recognition

Build equitable knowledge:

- *What potential barriers stop an individual from accessing a given opportunity? Which routes could someone take to get around those barriers?*
- *Are they visible to a novel individual?*
- *How do we learn more about under-served groups?*
- *What does the space/practice afford these groups?*
- *Are there organisations or spaces in which underrepresented families feel comfortable?*

Articulate and develop equitable experience from an underrepresen-ted standpoint:

- *What does empowerment look like for a person of this background?*
- *How do we develop spaces to grow, experiment and experience equity in this manner? What are the factors of informal learning that influence development?*

Respect

Identify evidence of research practice supporting equitable experiences:

- *How do we build capacity for participatory methods?*
- *How do beliefs and learning from stakeholder's impact learning spa-ces to offer support? How do we conceptualise and evaluate equity?*
- *Is there intervention among stakeholders or a historically disconnec-ted form of informal learning? What contributes to sustained repeat engagement?*

Understanding pathways, one might navigate for greater learning:

- *What is an equitable pathway?*
- *How do we learn/create and use youth-directed tools and pathways to promote equity?*
- *How do youth equity pathways into ILScontribute to their cience capital?*

Represent

Support connections across and through different settings:

- *How can we understand an informal learning ecosystem from the perspective of multiple actors? How can we bridge the resource gap to make it more equitable?*
- *What would a holistic, accessible pathway look like?*

In the context and aftermath of Covid-19, the above questions should be reflected on again thro-ugh that particular lens.

4.3 Maintain focus

4.3.1 Reaching out

Organisations should be consciously reaching out to reduce obstacles for a variety of target groups. Allowing organisations to open up and create access routes for those of underrepresented commu-nities will make everyone feel welcome, connected and comfortable in their learning spaces.

- Do you make a conscious effort to reach out to a variety of groups, and who?
- What do you do to get young people with fewer opportunities on board?
- How does this reduce obstacles for that particular group?
- What way do you respond to the needs of the particular group?
- Are extra efforts needed to ensure equitable opportunities for all?

4.3.2 Keeping a centered goal

Whatever form of exclusion you are trying to overcome in your project, whether it be youth, gender, race etc., the target group must be placed at the center of the project. The goals should be conceived by them, the methods should be co-created, and the process and results should be impactful to them. The projects should be based on the strengths of the target group and their active contributions. The following are questions organisers may ask themselves.

- Do you understand participants' needs?
- Is this true participation?
- Is your approach tailored?
- Is your approach supportive?
- Is everyone included?
- Have you done a robust risk assessment?

4.3.3 A large diversity of participants

The diversity of our society should be reflected within the projects that we present. This requires special attention from organisers and those implementing activities.

- Is everyone adequately prepared (e.g. relationship building)?
- Are the groups truly diverse?
- Does the project allow for social and intercultural competence?
- Is there adequate language support?
- Have you made room for reflection?
- Is DEI reflected in the organisers and facilitators?

4.3.4 Non-Formal Learning

- Are the objectives clear and tangible for all?
- Are the methods appealing?
- Is peer learning encouraged and fostered?
- Is the project manageable for all participants?
- Have you made room to document learning?

4.3.5 Looking at Impact

Designing and organising inclusive, diverse, and equitable projects involves keeping an eye on its long-term impact to result in greater social gain from the community. A project should be seen as a part of a longer-term social change.

- Does wide participation extend beyond the project?
- Is your approach strategic?
- Is the experience motivating?
- Do you envisage a follow-up?
- Is there a dissemination plan?

4.3.6 Holistic Approach

It is important to justify the relevance of the project in relation to the larger societal context – how it makes connections with any wider work and the considerable impact that it will have among all the stakeholders involved.

- How will you connect stakeholders meaningfully?
- How will you facilitate solid co-working amidst diversity and difference?
- Have you established strategic partnerships for innovation?
- Have facilitators/ organisers taken part in DEI training?
- Does everyone know what exactly they're doing and the levels of commitment?

5. Best Practice Guidelines

The following section is a guide to best practices for implementing diversity, equity and inclusion, particularly related to science learning outside the classroom. The interactions with science learning must be grounded in the personal experiences and existing identities of those participating. Science learning goals call for equity to be at the forefront. Ultimately, all experience matters and all individuals can contribute to STEM learning and discovery.

The following are a list of best practices recommendations taken from SySTEM 2020 (GA 788317), SISCODE (GA 788217) and HYPATIA (GA 665566) projects funded under Horizon 2020 and STEM Teaching Tools created by the NHF (Award #1238253) that focus on next generation science standards (NGSS).

5.1 Recognise

5.1.1 Be Accessible:

Making science accessible allows individuals to engage in science learning regardless of their background, experiences, prior knowledge, or skill level. The concepts and practices that we explore with our audience should be representative, relatable, relevant and tangible. Accessibility improves for individuals with regards to their physical, cognitive, financial or emotional needs.

1. Leveraging students' interests enables us to build upon prior experiences, knowledge, interests, and identities. Recognise the importance of the facilitator-learner relationship. We should know our audience and be able to use their innate curiosities as a motivational learning tool.

   Example: When beginning an exercise use icebreakers to open up conversation about the participants as individuals. Have topics that are based around personal opinion and simple expression. An exercise such as stating their name, hobby and their preferred pronouns.

2. Understanding the interests of each participant allows facilitators to segue into new topics in a railroad-style manner, ultimately supporting the participants' culture in a responsive way.

   Example: If working on an exercise relating to light play, we can relate it to the importance of light and shadow in film, this is what allows special effects to look so real, an example is the T-Rex scene from Jurassic park.

3. Self-documentation and mapping can help define the assets of each learner and identify anchors for what learners want to investigate. A larger option of relatable science will foster grounds for more meaningful experiences.

   Example: Give enough time for 'talk' before and after an exercise, make sure participants are able to understand the task and that they can relate it to their experience. This requires some flexibility from the mediator. Give lots of time for talk during the task so you can use it as an informal assessment, alter the task so the parts that relate most to the individual are the parts that they focus on.

4. We must consider the cognitive, physical, behavioral, neurological, and emotional barriers that may be present in learners who enter an informal learning space (ILS). Equitable science learning environments must be versatile with multiple ways of knowing, doing, expressing, and understanding.

   Example: Tasks and instructions should be simple, there should be multiple avenues for one to complete and explore the task. Organisers should be provided with information about any special needs that participants may have, activities should then be designed to play to those individuals strength as well as providing facilitation for those particular needs.

5. Every task will generate unique obstacles for each individual learner. Be conscious about the task and the instructions; the design should work to the learner's strengths. Be sure to build on prior interests, use multiple representations, and continually document student progress using varied assessment tools.

   Examples: Marble machines are used as an open-ended activity with simple *instructions. Participants are asked to explore materials and create a path for a marble to travel around a vertical peg board. Prior to the task some real--world examples of art, science and engineering are provided, multiple materials and methods are demonstrated throughout the task with individuals.*

5.1.2 Be Engaging:

Student engagement is a major determinant of effective learning and instruction. To ensure that individuals are engaged, we must increase their motivation to be involved. Individuals may be motivated by fostering strong emotional ties and empowering exploration. Understanding a participant's personal interests is the best place to start.

1. Scientific fields move quickly, causing some historical science to seem boring, outdated, and most importantly, disconnected from society. Contemporary science projects lend weight to the relevance of science in our lives, and help learners appreciate the importance of scientific understanding and transdisciplinary contributions. Focusing on relevant phenomena and identifying authentic design problems can engage students in a way that historical, abstract, or broader global concepts may not. It provides a local responsibility, agency, and relationship throughout development of a program, enabling learners to foster a deeper relationship with their community.

   Example: Current issues such as climate crises, epidemiology, mental health and big data are all issues that affect us all. Activities should be framed with current events in mind regardless if the activity is art or science based.

2. Relevant socio-scientific topics can promote greater engagement and allow learners to become emotionally invested in the concepts and practices that are being discussed. Emotional readiness is a powerful driver of learning. When designing practice, it is important to think about how certain emotions may be evoked and what you can do to address them. It is vital to address that particular topics may be triggering for some learners leading to a strong negative and potentially damaging emotional response. It is therefore imperative to understand the audience and leverage their own ideas and passions.

   Example: If working with particular groups it is important to have a strong relationship with their current understanding, history and culture. If a group is deeply connected to a particular culture, the activities should leverage that connection. For instance for those that live in a highly rural area, an activity centered around nature may strike a chord with that group.

3. Engaging in scientific literacy is more than acquiring scientific knowledge. It should be based around the learning process and how a learner comes to understand and apply concepts. Activities should support open exploration and personal discovery, allowing students how to build knowledge based on their first-hand experiences. Independently figuring out how something works can be engaging and rewarding.

Example: Again, if working with a group from a rural area, agriculture may be an important part of their culture. Learners may have a diverse knowledge of agricultural science; a facilitator can use this real-world knowledge in activity related to environmental and sustainability issues as agriculture is an important node in the sustainability debate.

4. Controversial topics should not be discouraged. We must often navigate conflicting arguments and different perspectives to converse about issues in our daily lives. Similarly, controversy is a core part of scientific enterprise and research. Scientific controversies are disputes that unfold within the scientific community, such as competing hypotheses. Scientific understanding progresses through skepticism, using argumentation and debate to work towards a consensus. Socio-scientific controversies can occur as individuals disagree on what topics to explore, what methods to use, or how knowledge should be applied.

   Example: It is important to create a safe space for individuals to voice their opinions and topics should be introduced with a logical, correct and informative context. If discussing topics that enforce opinion try to create a physical spectrum against a wall from agree at one end to disagree at the other end. If participants feel uncomfortable speaking out, use an online voting tool such as mentimeter. If a discussion is based on research be sure it is backed up by the correct relevant information and data.

5.1.3 Build Diversity:

Our learning environments should always function within and reflect the diverse, complex, and multicultural nature of our society. Building diversity in science education involves providing access and opportunities to people of different demographics (ex. socio-cultural background, economic background, gender, sexual orientation, etc.).

1. To increase engagement and diversity in STEM, underrepresented people must be able to envision themselves in scientific positions. We must expose learners to culturally diverse professionals. Scientific ways of knowing have been pervasive across diverse cultures throughout human history. All cultures have crafted and contributed to science. However, it is western, educated, industrialised, rich and democratic (WEIRD) individuals that are largely recognised as scientists, of whom many are white men. It incorrectly narrows the image of who is capable of doing science. We must be representing science through a lens of multiple cultures, genders, socioeconomic classes, education statuses, and abilities.

   Example: When organising any activities practical examples and facilitators should represent a broader society. Move away from the dominant examples in these fields and opt for more that are typically not represented. In STEM fields individuals typically underrepresented include, transgendered, eastern, African, low socio-economic status, and mixed-abled individuals.

2. Draw upon that which is valued and deemed relevant by local populations, such as their historical and contemporary interests, cultural values, and analogous practices of data collection and experimentation. The learning one receives must be scaffolded onto their preexisting knowledge. Some local cultural groups have direct communal or religious responsibilities, and their learning and lives may be dependent on this. We must be able to facilitate navigation within and across multiple branches of knowledge that simultaneously encourages cultural connectivity without erasing or assimilating one into the other.

   Example: If organizing an activity in a richly rural area agricultural practices may resonate heavily the local participates. Therefore, the practice should be framed in a way to leverage this pre-existing knowledge. If a socio-scientific project is being run in an area with highly religious affiliations, it should acknowledge particular topics may challenge pre-existing beliefs.

3. Linking the multiple aspects of research, society and enterprise is important to understanding the behaviour of the science field and how it develops with research. Today it is more important to move away from superficial conceptual representations and instead show science, enterprise and society's mutual influence over one another to promote student engagement, activism and social responsibility of scientists.

   Example: In an activity map out the different levels of effect the particular project may have on individuals, groups, communities, institutions, enterprise society as whole. Examine the issues from a multiple stakeholder perspective.

5.2 Respect

5.2.1 Be Inclusive:

It is important to recognise that those who feel more comfortable are those whose existing cultural practices are more closely reflected in the learning space. Creating a non-formal science learning space means being able to help those of diverse backgrounds and cultures feel welcome, wanted, and supported, ultimately resulting in their meaningful engagement within these environments.

1. Engaging a diverse audience means making room for diverse interests and activities. The range of topics, the type of activities, the tools and the participation formats matter as some groups might get the idea that „science is not for them" if they cannot find anything that resonates with their interests. We must provide multiple access routes for learners to understand and become engaged. When providing instructions to a group, do not assume any group engages in a uniform, particular behavior, share values, or share their worldview, even if they appear to have come from the same background. There is always variation among groups, and individuals will change over time.

Example: Use examples that coincide with the audience shared values, whether it be current topics that relate to them, cultural keystones of music, art, or fashion. There may need to be several examples. Speak with participants one-on-one during facilitation to make sure they are comfortable engaging.

2. To allow science learning to be diverse, equitable and inclusive in a natural way, we must treat it as a series of cultural accomplishments. Science and science learning can enhance the social identity of every learner involved. The more individuals that build a stronger science identity, the more diverse the field can become.

   Example: Ask the participants if they can think of examples that relate to the activity you are trying to explore. Using writing tools such as post-its and fast, timed thinking games provides motivation for expression of opinion.

3. Create an environment and activities in which learners have the opportunity to participate and contribute in different ways. Activities that foster collaboration, as well as support various skills, create opportunities for the meaningful participation of all learners. Aim to make this as natural as possible, move away from tokenistic representation or activities.

   Example: 'Think, Pair, Share' is an excellent tool to foster discussion in a group. Individuals can reflect on their experience and pass it to a partner, who then presents it to the group. This way the feeling of ownership is reduced, opinions can be shared, and a group can learn from each other.

4. While best practices recommend that you know in advance about your participants' special needs, sometimes this is not possible. Thus, you need to be flexible and be able to adapt the activity, the materials, the tools and even the outcomes based on your participants' unique needs.

   Example: Preparation is key, gather as much information about participants beforehand, make sure your activity plays to their strengths and there is a back-up activity for those finding it difficult to participate. This could be an individual needing to work in a room by themselves due to the environment being over-stimulating. It could be a task that is too complicated and so you need a bridging activity that reactivates their attention, such as a blind drawing task.

5.2.2 Inspire & Motivate:

There can be a false assumption that learners are responsible for their own learning, both inside and outside the classroom. However, it is also the job of the organisers, facilitators and the environment to be inviting and encouraging for each learner to have active involvement.

1. Support learners' active involvement in their learning tasks, these activities must be relevant and based upon the prior knowledge of each participant. Support should be reinforced for all learners throughout an activity.

   Example: If you are facilitating a group that is tactile and high energy, those learners may need to temper those behaviors in a formal learning setting. Allow for a hands-on activity in a busy environment as it may play to their strengths. One suggestion is Tinkering. Also consider facilitating through empowerment by allowing individuals who are typically underrepresented in fields to feel as though they belong by giving examples of people and situations that they identify strongly with.

2. Guide instead of directing. Guiding is about encouraging the person to find their own way and supporting their process, while direct instruction is about showing them the way and helping them to keep on a prescribed path. You can guide a learner's process of knowledge building by asking questions, offering alternatives, giving constructive feedback, etc. The most important factor is that you inspire learners to find their own way!

   Example: Guiding requires supporting by recognising achievements and asking questions to provoke a deeper sense of learning. We can probe a learner's knowledge and future ideas through questions like "Why have you added this piece?" / "Do you have a goal for the next piece?" / "I have never seen that done before, what made you think of that?"

3. Classroom talk fosters a participatory shift. Discussion opens up opportunities to learn for both the student and for the facilitator, and builds stronger connections between members of the learning community. Allowing time for public thinking and discourse can result in deeper reasoning and helps a learner to relate their thinking to other ideas. It is important to understand the power of the environment and the structure that we create for discourse both physically and emotionally.

   Example: Talk refers to open discussion between groups/individuals. To allow for more talk, lend more time before and after an activity commences to allow learners to informally discuss the activity. Reflection tools are also a great way to issue this type of conversation. Practical tools like zine design is also an effective reflection tool.

4. One way to foster self-confidence is to adapt a 'fail forward' or 'fail better' attitude. We must recognise and appreciate the process of failure, as it enables us to reshape our practices and constantly improve. In turn, this will increase communal collaboration and provide learners with opportunities to share and build upon their thinking. 'Fail forward' environments can improve ability, reasoning and argumentation. Reflecting on their failures allows each participant to understand their problem-solving workflow, while engaging in an open, empathetic and equitable process.

   Example: Implement a time and space to explore failure as a group. Talk about why we fear failure, why it is important, and how failure is relative and based on one's point of view. Agree to welcome failure into practice. A blind drawing exercise in which participants look directly at an *object or person and draw them quickly using multiple colours without looking at the page is one way to show that by 'mistakes' we can create something beautiful.*

5.2.3 Build community:

Bringing people together who share common interests (or different interests) will lead to a richer learning community. Innovation stems from collaborative working spaces, where diverse ideas can be readily shared without consequences.

1. Encourage collaboration. To encourage people to share and collaborate, you need to create a structure, as well as a culture, that enables such exchanges and that makes working together easy. Similarly, it should be easy to ask for and offer help.

   Example: Group exercises can be structured by providing a time limit and roles to each objective. Methods such as De Bono's Six Hats can be used to structure roles. We can use voting systems with graphs, polls, dots and post-its.

2. To support communities in implementing a new initiative, you must rely on trust between teachers, schools, community project officers, and all stakeholders. There must be accessibility to cohesive training for staff, and support from principals and researchers in a non-hierarchical fashion. Community hierarchy can cause resources to be unfairly distributed, and negatively affect teachers and students in certain areas. Community leaders may openly share resources and seek out experts, while working with other teachers to identify learning and equity problems. The community must implement shifts from an individual to a whole community-based teaching approach.

   Example: Underrepresented communities who typically don't engage in informal science learning must have the correct access to resources, there needs to be active communication from organisers to schools, community centers, parents and other stakeholders. A website, newsletter or messaging platform to contact and update participants (or their guardians) is needed to keep individuals engaged.

3. In informal learning communities, learners might change roles based on their different expertise. By acknowledging that knowledge is unevenly distributed and not prioritising one person's knowledge over another, everyone can learn from everyone. This sets the basis for horizontal relationships in which everyone can contribute.

   Example: Creating a structure for workshops and projects where individuals can experiment and explore new roles is important. Individuals should be free to show off their expertise as well as experience situations from other individual perspectives. Drama-based activities are a low risk way to get individuals to see from other people's perspectives.

4. Spaces can act as third teachers to inspire, trigger curiosity, and support exploration and making. In community building, using the space as the third teacher means designing the spaces in a way that supports encounters, and encourages learners to experiment and take on new challenges. You should cater activities in the chosen environment based on the needs of the learners. For example recognize that some spaces will privilege students that are fast, active, and have a full range of motor abilities. You should always strive to provide accommodations to ensure that spaces can be equally accessed by all students.

   Example: The environment that activities takes place in is a key component of the learning experience. The environments should make participants feel comfortable as well as promoting confidence for risk and exploration. 'Knowledge Rooms' are a great example of this space (Streicher et al., 2014).

5.3 Represent

5.3.1 Support identity building:

Learning is deeply connected to individual identity, and all learning environments are inherently social and behavioral. In an educational context, social interactions allow people to get feedback and resources, while also impacting their self-perception, abilities and scientific successes.

1. Connect learners to communities. The greater number of bonds that a learner has with different communities involved in science, the more opportunities they would have to find roles in which they can see themselves. Within this framework, there is also a responsibility on each organization to be representative of groups from all backgrounds, particularly those from underrepresented backgrounds.

   Example: Provide equitable representation in your programming for those of underrepresented audiences. Have twice as much female, transgender, eastern, African, representation or those from lower socioeconomic backgrounds. Give those representatives a platform to explain their stories and speak informally with participants.

2. Acknowledging learners' achievements in non-formal education is also a way to support them in building their science identities. Recognizing learners' achievements outside the classroom may create opportunities for long-term engagement by helping them access educational opportunities in other contexts and demonstrate relevant skills for professional practice. Recognition can take many shapes, ranging from using digital badges as credentials to more standardized certificates for accreditation.

   Example: Incorporate individual's expertise and experience into activity practices. In community projects people may engage with different aspects or stakeholders in the community. Empower those individuals to take charge of communicating with those groups or educating the group on their own expertise.

3. Personal development (PD) opportunities should be highly selective and specific to leverage one's needs and should not be vague and overwhelming. PD should be designed around addressing local, relevant, and emerging problems.

   Example: Projects and activities should be grounded in the development of the learners. This may need some pre-organisational research into what the participants' needs and wants are.

4. An individual's knowledge is based on their everyday experiences. People naturally develop intuitive knowledge that shapes their scientific learning. Science education can be overwhelmed by the concept of 'correctness' at the expense of supporting deep conceptual understanding. Approaching learners' ideas as misconceptions can be like "starting again". Facets of an individual's conceptual understanding of phenomena can come from deeply personal experiences. This is their expression knowledge, and it must be respected as much as possible. A participant's knowledge should be used as a starting point, and their current knowledge should be leveraged in order to proceed equitably.

   Example: It is important that we build upon what people know and believe. Don't paint misconceptions as 'wrong' but as the first stepping stones of learning. Instead of telling an individual the misconception of 'Humans only use 10% of our brain' is false, we can use their current knowledge to leverage their understanding of neurology by responding with "What does that 10% represent?" / "What do you think happens when we use 100%?".

5.3.2 Promote autonomy:

Becoming autonomous takes time. It requires an understanding for one's particular needs and those of their community and can be drawn from reflecting on their previous experiences. Both learners and educators require a specific set of skills and their sustained growth and improvement can't be taken for granted. The development of lifelong learning skills is strongly related to becoming an autonomous science learner.

1. Science learning is not only about hard scientific skills, but also about being able to communicate, collaborate, be creative or engage in critical thinking. Transversal competencies have been increasingly recognized as key skills in very different knowledge domains, since people require them for successful learning and collaboration. We can foster these through group work, active problem solving, and presenting achievements.

   Example: Activities should focus on the transdisciplinary. We can achieve this by incorporating craft, debate, and hands-on exploration. In the Science Gallery Dublin activity 'Mindlab', students are encouraged to ideate, research and craft a prototype of an innovative tool, or initiative that helps solve a specific problem.

2. To self-assess, learners need to be aware of their process and the outcomes of their work. Good self-assessment involves identifying concrete stra-

tegies that could be improved, as well as highlighting accomplishments. In science learning activities, you can support self-assessment by asking students questions, suggesting specific strategies to pay attention to, and by encouraging them to reflect by documenting their learning processes.

Example: Reflection is an essential part of any learner's journey. Providing reflection tools such as a voice diary, a reflection book or a zine are great ways to provoke self-assessment in an informal fashion.

3. Risk-taking is about experimenting and being ready to face the unexpected. It is also about making mistakes and understanding what went wrong. Quite often, learners avoid taking risks as the possibility of failure creates anxiety. You can reduce this anxiety by asking learners to focus on the process rather than the final outcomes.

   Example: Risk-taking coincides with our perception of failure. Practices such as blind drawing or Tinkering activities in which learners are not given a defined goal to reach, but rather are encouraged to explore are great activities with low risk. Learners discover the importance and enjoyment of exploration and taking risk will become part of this exploration. It is important that they are supported in the risk they take; facilitators should have consistent encouragement and be prepared with alternative routes of guidance.

4. Discussion is a powerful equity tool if used correctly. It allows participation beyond those who 'raise their hands' in learning. Productive talk involves sharing and clarifying one's own thinking, active listening, deepening one's own reasoning, and thinking together. Talk allows us to think explicitly and publicly, so our ideas can be considered, interpreted, reinterpreted and refined. For an equitable, inclusive and fair discussion, learners must have the skills to engage correctly, construct explanations, and identify arguments that are constructed from evidence. Explanations are constructed and conclusions are drawn using multiple resources (observations, data, existing models, and other representations of reality).

   Example: Take time to examine the meta-cognitive development of the learners. Reflect on what type of discussion you have had, the conclusions you have come to and why you think they have developed. What allowed an individual to make that hypothesis and what affected them to take that into consideration. This allows learners to think about what effect their environments and peers have on their learning as well as how they can effectively communicate in the future.

5.3.3 Evaluate:

Evaluating your practice is a central part of growing and improving. Evaluation is about setting goals, monitoring your progress, and learning about what works and what needs to be improved. It also helps you to reflect, individually and as a team, about how well you are meeting the overarching goals of the science learning programs at your organization. Consistent evaluation is needed to allow the system to adapt accordingly to the needs of all of its users.

1. Goal setting is a process that includes: (a) Defining the criteria, (b) creating commitment, and (c) designing routes to reach those goals. In science learning outside of the classroom, both equity and inclusion should be strongly considered when defining goals for learning. The adoption of participatory techniques for defining the activity are also powerful ways to support engagement, discussion and ensure that your goals are useful, viable and feasible.

   Example: The most equitable and inclusive way for goal setting is through a co-created method. The SISCODE project aims to create tools for co-creation best practice. This means involving all stakeholders in the project design, from analyzing the issues needed to be tackled to gathering research on who is involved, to how the project is carried.

2. Formative Assessment (FA) is assessment for learning rather than assessment of learning. This allows teachers to gain information about students' existing knowledge to inform their practice and provide effective instruction. To conduct informal, conversational assessments, teachers may elicit, recognise, and use student thinking and engagement during instructions. The teacher recognizes learners' responses and continues to use that information to inform the next step, whether it be further instructions or an explanation.

   Example: Similar to reflection, assessing someone's learning can take the shape of self-evaluation tools to monitor their progress and confirm that they are using the best learning strategies available to them. This would mean facilitators should be ready to alter the learning strategy based on the assessment outcomes.

3. Taking the time to reflect and learn from what you have done, as well as assessing the impact of your outcomes, is a great way to inform future actions. Reflection should be done individually and as a group, and you should highlight your successes as well as those aspects that didn't work particularly well. Strategies like de-briefing, sharing best practices, and revision and iteration of the activities/programs can help you embed reflection as a critical work habit.

   Example: Reflection can happen on multiple levels and just as it is important for the learner to reflect on what they have done it is also important for the facilitators and organizers to reflect upon their practice using similar tools such as 'Stop, Start, Continue'. This can also take the shape of a more formal evaluation plan in which questionnaires and interviews will be used to gather data and track progress.

Bibliography

— Achiam, M., & Holmegaard, H. T. (2017). Informal science education and gender inclusion. In L. S. Heuling (Ed.), Embracing the other. How the inclusive classroom brings fresh ideas to science and education (pp. 32-40). Flensburg: Flensburg University Press.

— Allegrini, A. Henriksen, E. K., Dillon, J., & Ryder, J. (2015). Gender, STEM studies and educational choices. Insights from feminist perspectives. In Understanding Student Participation and Choice in Science and Technology Education (pp. 1–412). Springer Netherlands. https://doi.org/10.1007/978-94-007-7793-4 Archer Ker, L., DeWitt, J., Osborne, J. F., Dillon, J. S., Wong, B., & Willis, B. (2013). 2018 UCL Institute of Education ASPIRES 2 1 Triple Science Policy Briefing. www.ucl.ac.uk/ioe-aspires. Archer, L., Dawson, E., Seakins, A., DeWitt, J., Godec, S., & Whitby, C. (2016). "I'm Being a Man Here": Urban Boys' Performances of Masculinity and Engagement With Science During a Science Museum Visit. Journal of the Learning Sciences, 25(3), 438–485. https://doi.org/10.1080/10508406.2016.1187147 Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science Aspirations, Capital, and Family Habitus. American Educational Research Journal, 49(5), 881–908.

— https://doi.org/10.3102/0002831211433290

— Belonging: A Conversation about Equity, Diversity, and Inclusion. (n.d.). Retrieved March 31, 2020, from https://medium.com/@krysburnette/its-2019-and-we-are-still-talking-about-equity-diversity-and-inclusion-d d00c9a66113

— Bourdieu, P., & Passeron, J. (1977). Theory, Culture & Society (T. P. Mike Featherstone (Ed.)). SAGE Publications Ltd.

— Bourdieu, P. Eggleston, J. (1974). The school as a conservative force: Scholastic and cultural inequalities | Brunel University. In Methuen (Ed.), Contemporary research in the sociology of education (pp. 32–46). https://brunel.rl.talis.com/items/EFC8148B-A294-F89A-836F-E20E9DF6EBE1.html Browne, K., Nash, C. J., & Gorman-Murray, A. (2018). Geographies of heteroactivism: Resisting sexual rights in the reconstitution of Irish nationhood. Transactions of the Institute of British Geographers, 43(4), 526–539. https://doi.org/10.1111/tran.12255

— Burnette, K 2019, Belonging: A Conversation about Equity, Diversity, and Inclusion, <https://medium.com/@krysburnette/its-2019-and-we-are-still-talking-about-equity-diversity-and-inclusion dd00c9a66113>

— Butler, J. (1990). Gender trouble, feminist theory and psychoanalytic discourse. In L. Nichlson (Ed.), Feminist/Postmodern (pp. 324–340).

— https://books.google.ie/books?hl=en&lr=&id=HuAoe4phOgEC&oi=fnd&pg=PA324&dq=Judith+Butler+(1990)+%22Gender+Trouble%22&ots=wgzw0Sizmp&sig=TsEtv97qQcUbgmf3k4dNU_DfixI&redir_esc=y#v=onepage&q&f=false

— Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a Future in Science. American Educational Research Journal, 50(1), 37–75.

— https://doi.org/10.3102/0002831212458142

— Carastathis, A. (2014). The concept of intersectionality in feminist theory. In Philosophy Compass (Vol. 9, Issue 5, pp. 304–314). Wiley-Blackwell Publishing. https://doi.org/10.1111/phc3.12129 Carlone, H. B., Haun-Frank, J., & Webb, A. (n.d.). Assessing Equity Beyond Knowledge-and Skills-based Outcomes: A Comparative Ethnography of Two Fourth-grade Reform-based Science Classrooms. Journal of Research in Science Teaching, 48(5), 459–485. https://doi.org/10.1002/tea.20413 Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. Journal of Research in Science Teaching, 44(8), 1187–1218. https://doi.org/10.1002/tea.20237

— European Commission (2018). PISA 2018 and the EU – Striving for social fairness through education (research note).

— Collins, P. H. (1993). Toward a new vision: race, class and gender as categories of analysis and connection. Race, Sex & Class, 1(1), 25–45

— CONNELL, R. W. (1998). Masculinities and Globalization. Men and Masculinities, 1(1), 3–23. https://doi.org/10.1177/1097184X98001001001

— Connell, R. W., & Messerschmidt, J. W. (2005). Hegemonic Masculinity. Gender & Society, 19(6), 829–859. https://doi.org/10.1177/0891243205278639

— Corrigan, D., Dillon, J., & Gunstone, R. (2007). The Re-emergence of Values in Science Education. Sense Publications.

— Cronin, C. and Roger, A. (1999), Theorizing progress: Women in science, engineering, and technology in higher education. J. Res. Sci. Teach., 36: 637-661.

— Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. Psychological Science, 12(3), 258–261.

— https://doi.org/10.1111/1467-9280.00347

— Dawson, E. (2014). "Not Designed for Us": How Science Museums and Science Centers Socially Exclude Low-Income, Minority Ethnic Groups. Science Education, 98(6), 981–1008.

— https://doi.org/10.1002/sce.21133

— Dawson, E. (2019). Equity, Exclusion and Everyday Science Learning. In Equity, Exclusion and Everyday Science Learning. Routledge. https://doi.org/10.4324/9781315266763

— Dawson, E., Archer, L., Seakins, A., Godec, S., DeWitt, J., King, H., Mau, A., & Nomikou, E. (2019). Selfies at the science museum: exploring girls' identity performances in a science learning space. Gender and Education. https://doi.org/10.1080/09540253.2018.1557322
— European Commission (2014) Erasmus+ Inclusion and Diversity Strategy – in the field of Youth. Directorate General for Education and Culture.
— Fecher, B., & Friesike, S. (2013). Open Science: One Term, Five Schools of Thought. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.2272036
— Fidler, P. (2014). UK science and discovery centres: Effectively engaging under-represented groups. Bristol: UK Association for Science and Discovery Centres. P9
— Francis, B., Archer, L., Moote, J., de Witt, J., & Yeomans, L. (2017). Femininity, science, and the denigration of the girly girl. British Journal of Sociology of Education, 38(8), 1097–1110.
— https://doi.org/10.1080/01425692.2016.1253455
— Francis, B., & Paechter, C. (2015). The problem of gender categorisation: addressing dilemmas past and present in gender and education research. Gender and Education, 27(7), 776–790. https://doi.org/10.1080/09540253.2015.1092503
— Francis, B., & Skelton, C. (2005). Reassessing gender and achievement: Questioning contemporary key debates. In Reassessing Gender and Achievement: Questioning Contemporary Key Debates. Routledge Taylor & Francis Group. https://doi.org/10.4324/9780203412923
— Fredricks, J. A., & McColskey, W. (2012). The measurement of student engagement: A comparative analysis of various methods and student self-report instruments. In Handbook of Research on Student Engagement (pp. 763–782). Springer US. https://doi.org/10.1007/978-1-4614-2018-7_37
— Godec, S., King, H., Archer, L., Dawson, E., & Seakins, A. (2012). Examining Student Engagement with Science Through a Bourdieusian Notion of Field. In Handbook of research on student engagement (Springer S). Springer Science + Business Media. https://doi.org/10.1007/s11191-018-9988-5 Hughes, G. (2000). Marginalization of Socioscientific Material in Science–Technology–Society Science Curricula: Some Implications for Gender Inclusivity and Curriculum Reform. Journal of Research in Science Teaching, 37(5), 426–440.
— https://doi.org/10.1002/(SICI)1098-2736(200005)37:5<426::AID-TEA3>3.0.CO;2-U Ministère de l'Éducation Nationale. (2010). Programme de sciences de la vie et de la terre en classe de seconde générale et technologique. Bulletin officiel spécial n° 4 du 29 avril 2010. France. Nash, K. (2000). Equality and difference. In L. Code (Ed.), Encyclopedia of feminist theories (pp. 174-176). London: Routledge.
— Institute of Physics. (2012). It's different for girls. The influence of schools. London: Institute of Physics. Ipsos MORI. (2011). Public attitudes to science 2011. London: Department for Business Innovation and Skills. Kitzinger, C. (2004). Feminist approaches. In C. Seale, G. Gobo, J. F. Gubrium, & D. Silverman (Eds.), Qualitative research practice (pp. 124 – 140). London: Sage.
— Kanter, R. M. (1977). Men and Women of the Corporation (A. S. W. M. V. C. . M. 1998 (Ed.)). Excerpts in Working in America;
— Lindley, L., Clemens, S., Knibbs, S., Stevens, J., Leia, &, & Mori, B.-I. (2019). Omnibus survey of pupils and their parents or carers: wave 5.
— OECD (2019), PISA 2018 Results (Volume I): What Students Know and Can Do, PISA, OECD Publishing, Paris, https://doi.org/10.1787/5f07c754-en.
— Phipps, A. (2007). Re-inscribing gender binaries: Deconstructing the dominant discourse around women's equality in science, engineering, and technology. Sociological Review, 55(4), 768-787 Puwar, N. (2004). Thinking About Making a Difference. The British Journal of Politics and International Relations, 6(1), 65–80. https://doi.org/10.1111/j.1467-856x.2004.00127.x
— Rawls, John, Justice as Fairness: A Restatement (Cambridge: The Belknap Press of Harvard University Press, 2001).
— Ryan, M. K., David, B., & Reynolds, K. J. (2004). Who cares? The effect of gender and context on the self and moral reasoning. Psychology of Women Quarterly, 28(3), 246-255.
— Schulz, D. J., & Enslin, C. (2014). The Female Executive's Perspective on Career Planning and Advancement in Organizations. SAGE Open, 4(4), 215824401455804. https://doi.org/10.1177/2158244014558040 Sinnes, A. T., & Løken, M. (2014). Gendered education in a gendered world: Looking beyond cosmetic solutions to the gender gap in science. Cultural Studies of Science Education, 9(2), 343–364. https://doi.org/10.1007/s11422-012-9433-z
— Sjøberg, S., Schreiner, C., & No>, <camilla Schreiner@naturfagsenteret. (2010). Svein Sjøberg and Camilla Schreiner: The ROSE project. Overview and key findings The ROSE project An overview and key findings 1. http://www.ioste.org/
— Streicher, B., Unterleitner, K., & Schulze, H. (2014). SISSA-International School for Advanced Studies Comment SOCIALLY INCLUSIVE SCIENCE COMMUNICATION Knowledge • rooms-science communication in local, welcoming spaces to foster social inclusion. http://jcom.sissa.it/
— Thompson, J. (2014). Engaging Girls' Socio Historical Identities in Science. Journal of the Learning Sciences, 23(3), 392–446. https://doi.org/10.1080/10508406.2014.888351
— Wedgwood, N. (2009). Connell's theory of masculinity – its origins and influences on the study of gender. Journal of Gender Studies, 18(4), 329–339. https://doi.org/10.1080/09589230903260001 Young, I (1990). Justice and the Politics of Difference (Princeton: Princeton University Press, 1990)

OPEN SCIENCE HUB

EMPOWERING CITIZENS
THROUGH STEAM
EDUCATION WITH
OPEN SCHOOLING

DELIVERABLE 4.1

Gender Equity Recommendations