An Roinn Oideachais
Department of Education

Recommendations on STEM and the Arts in Education

March 2023

Context

The recommendations as set out in this document were informed by the STEM and the Arts Advisory Group (the Advisory Group) set up by the Department of Education's STEM Education Implementation Advisory Group (IAG) to guide national actions that enhance linkages between STEM education and the Arts across the education continuum. In the view of the STEM Education Implementation Advisory Group, STEM education is enriched and extended by an alignment between STEM and the arts.

STEM Education Policy Statement

The Department of Education published the national STEM Education Policy Statement 2017-2026 (Policy Statement) and STEM Education Implementation Plan 2017-2019[1] in November 2017. This comprehensive policy statement was informed by extensive research and consultation. At its heart is the vision, stated as follows:

> Ireland will be internationally recognised as providing the highest quality STEM education experience for learners that nurtures curiosity, inquiry, problem-solving, creativity, ethical behaviour, confidence and persistence, along with the excitement of collaborative innovation.

STEM Education is multi-faceted and goes well beyond the main disciplines that constitute the acronym STEM. The foundations for STEM education begin from birth. From the earliest years through their play experiences and family environment, young children engage with the world in ways that can promote learning related to Science, Technology, Engineering and Mathematics. Young children naturally engage in early STEM exploration through hands-on multisensory and creative experiences. By engaging in these experiences, young children are developing curiosity, inquisitiveness, critical thinking and problem-solving capacities which are built on through their experiences in early learning and care, primary and post-primary.

STEM education not only involves the teaching and exploring/experiencing these disciplines and subjects in isolation but also involves a cross-disciplinary approach. It builds on the content knowledge, skills and understanding developed in and across the four disciplines, while acknowledging that all STEM learning activities are underpinned by Mathematics. It also recognises the strong linkage between STEM and Arts education, which fosters design, creativity and innovation.

The policy sets out ambitions for the full STEM ecosystem (figure 1), including outcomes for learners, teachers and early years educators, for schools and early learning and care settings, and for society.

[1] https://www.gov.ie/en/policy-information/4d40d5-stem-education-policy/

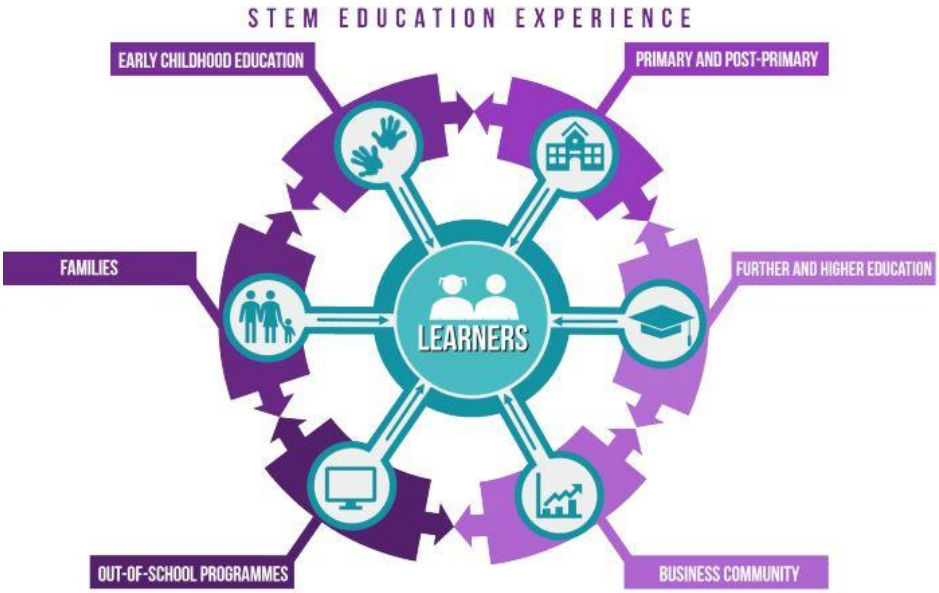

Figure 1 – STEM EcoSystem, STEM Education Policy Statement 2017-2026

STEM and the Arts education is a responsibility shared across government departments and agencies, education stakeholders, schools, teachers, early learning and care settings, early years educators, families, business and industry, and communities. It must have the voice of the children and young people at its centre. This report shows the need to bring together these key constituencies to build a coordinated approach to STEM and the Arts education

The continuum of STEM Education and key STEM skills from early learning and care to post-primary is identified within the Policy Statement and set out in figure 2 below.

Early Childhood themes, Primary priorities, Junior and Senior Cycle Key Skills							
Level 4	Senior Cycle key skills	Critical and creative thinking	Communicating	Information processing		Being personally effective	Working with others
Level 3	Junior Cycle key skills	Managing information and thinking; Being Literate; Being numerate	Communicating	Staying well	Being creative	Managing myself	Working with others
Level 2	Primary priorities	Develop thinking, learning and life skills	Communicating well	Be well		Engage in learning	Have a strong sense of identity and belonging
Level 1	Early childhood themes	Exploring and thinking	Communicating	Well-being			Identity and belonging

Figure 2 – Key STEM Skills from early learning and care to post-primary

The foundations for STEM and the Arts education begin from birth. From the earliest years through their play experiences and family environment, children engage with the world in ways that can promote learning related to Science, Technology, Engineering, Mathematics and the Arts.

What We Mean by STEM and the Arts Education

As identified in the *Review of Literature to Identify a Set of Effective Interventions for Addressing STEAM in Early Years, Primary and Post Primary Education Settings*[2], momentum to advance STEM and the Arts education nationally and internationally is growing. However, the *Review* notes that despite its growing popularity and the increase of STEAM-related initiatives, there is considerable 'divergence in conceptualisations, understandings, and/or a shared purpose of STEAM, in educational endeavours'[3]. The *Review* notes that the linkages between STEM and the Arts education are in the early stages of development.

The acronym STEAM is often used to highlight the positive effect that constructive relationships between the STEM disciplines and the Arts can have in education. However, that term is problematic, as it can be interpreted as presenting the arts in an ancillary or purely service role in respect of the STEM disciplines. It carries the risk of framing the arts in education entirely within its relationship to the STEM disciplines and ignoring the wider reach of arts education beyond its commonality with those disciplines. The Report therefore uses the term 'STEM and the Arts' to describe the field of educational endeavour under discussion.

For the purpose of these recommendations, the Report focuses on the transdisciplinary nature of STEM and the Arts, recognising that the individual disciplines has its own integrity, its characteristic way of processing knowledge and understanding, and its distinctive set of skills and techniques, ways of working and modes of processing experiences. However, many of these characteristics transcend the individual disciplines and cross boundaries between them. Like the Arts, the STEM disciplines are rooted in and shaped by creative, critical and original thinking. STEM and the Arts education builds on the content knowledge and understanding developed in and across its multiple disciplines.

STEM and the Arts education combines the individual disciplines and subject areas which enhance the understanding of all fields by immersing learners and educators in inquiry-based learning, problem solving, creativity and collaboration. It empowers learners to identify and tackle real-world problems as they integrate knowledge and make connections across the disciplines. Having a focus on the artistic processes such as performing, presenting, producing and creating within STEM and the Arts helps to increase learner focus, interest, engagement and confidence.

Within the domain of STEM and Arts education, learner engagement should include three interconnected areas of human engagement:

- Creativity, to include the roles of, for example, composer/ inventor/ discoverer/ designer

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[2] Leavy, Aisling, Carroll, Claire, Corry, Edward, Fitzpatrick, Michelle, Hamilton, Miriam, Hourigan, Mairéad, LaCumbre, Gary, McGann, Rory, O'Dwyer, Anne (June 2022), hereafter Leavy, in parenthesis.
https://www.gov.ie/en/policy-information/4d40d5-stem-education-policy/
[3] Review of Literature to Identify a Set of Effective Interventions for Addressing STEM and the Arts in Early Years, Primary and Post Primary Education Settings', Leavy, A et al, 2022

- Construction, to include the roles of, for example, technician/ player/ toolmaker/ craftsperson/ engineer/ maker
- Critical thinking, to include the roles of, for example, listener/ reader/ audience/ participant/ critic/ connoisseur

Arts education links all three areas and can provide a pathway to a more engaging approach to transdisciplinary learning.

Linking STEM and the Arts is a response to the presentation of these disciplines within the Primary School Curriculum, *Framework for Junior Cycle* and Senior Cycle as separate and distinct. The forms that linkages between STEM and Arts may take are still at an early phase of development.

The vision statements and overarching principles found in *Aistear: the Early Childhood Curriculum Framework*[4], the *Draft Primary Curriculum Framework*[5], the *Framework for Junior Cycle*[6] and Senior Cycle, are supportive of opportunities for linking learning experiences across STEM and the Arts. The curricula support broad learning goals, sometimes described as 21st-century skills, competencies or capabilities. For example, the four themes of *Aistear*, (see figure 2 above) the key competencies in the *Draft Primary Curriculum Framework* (see figure 3 above), the eight key skills in the *Framework for Junior Cycle* (see figure 2) and the five skills for Senior Cycle (see figure 2 above), all support learning linkages and transdisciplinary experiences across STEM and the Arts. These curricular components go beyond the boundaries of specific subject or discipline knowledge and include the acquisition and cultivation of skills such as problem solving, creativity, critical thinking, innovation and communication.

Competencies in the Draft Primary Curriculum Framework
Being an active citizen
Being creative
Being a digital learner
Being mathematical
Being a communicator and using language
Being well
Being an active learner

Figure 3 – Competencies, Draft Primary Curriculum Framework

Meaningful and worthwhile opportunities for connecting creative learning experiences across STEM and the Arts in early learning and care settings, and in primary and post-primary schools support the holistic development of learners' knowledge, skills, dispositions, attitudes and values. The alignment of the STEM disciplines and the Arts can be mutually beneficial, providing early years educators, teachers and learners with opportunities to link

[4] https://ncca.ie/en/resources/aistear-the-early-childhood-curriculum-framework/
[5] https://ncca.ie/media/4456/ncca-primary-curriculum-framework-2020.pdf
[6] https://ncca.ie/media/3249/framework-for-junior-cycle-2015-en.pdf

learning experiences across the curriculum. Developing early years educator and teacher competence and confidence in recognising these opportunities for linkages in all learning environments, from early learning and care setting through primary and post-primary schooling, is essential. Initial professional education for early years educators Initial teacher education and continuing professional development are therefore crucial elements in any initiative linking STEM and the Arts.

Literature Review: 'Review of Literature to Identify a Set of Effective Interventions for Addressing STEAM in Early Years, Primary and Post-Primary Education Settings'

The Advisory Group acknowledged that while there are many STEM and the Arts interventions underway in all sectors of the education system, including the non-formal and informal education sectors, systematic evaluation in terms of their impact and effect remains at an early stage. As its first action, the Advisory Group commissioned a literature review to assess interventions at all levels.

Following a tender process carried out in October 2021 by the Department of Education, a contract was awarded to Mary Immaculate College, Limerick, whose research team was led by Dr Aisling Leavy.

A *Review of Literature to Identify a Set of Effective Interventions for Addressing STEAM in Early Years, Primary and Post-Primary Education Settings* (the *Review*) was undertaken to ensure any recommendations made by the group were founded in, and informed by, the available data and evidence.

The Literature Review

Following deliberations of the Advisory group and informed by the literature review, it was decided that the term 'STEM and the Arts' rather than 'STEAM' be used to describe the fields of educational endeavour under consideration. As previously noted, using the term STEAM carries the unintentional risk of framing the arts in education entirely within its relationship to the STEM disciplines and ignoring the wider reach of arts education beyond its commonality with those disciplines.

A key finding of the Review is that the area of STEM and the Arts is at an early stage of development. The review acknowledges that while STEM and the Arts can often be seen to make 'mutually beneficial contributions to teaching and learning' (Leavy et al., 9) there is 'still a level of ambiguity among practitioners and researchers as to what effective STEAM education entails'. (Leavy et al., 11)

The Review drew on national and international studies that considered STEM and the Arts interventions and it sets out key barriers and enablers for effective STEM and the Arts education within the formal, non-formal and informal education sectors

The Review also contextualises STEAM education within international education policy. It acknowledges that Ireland is one of the few nations with a STEM Education Policy Statement and that there are no comparable national policy reviews of STEM and the Arts education. It recognises that there are differing approaches to STEM and the Arts education. In Korea, for example, STEM and the Arts education is driven by science, technology and engineering, whereas in the United States STEM and the Arts tends to be driven from an Arts perspective. However, the Review also highlights that despite differing perspectives, 'STEAM education is considered a transdisciplinary endeavour focusing on hybrid creative and critical inquiry between the arts and science that involves innovative, problem and project-based, high quality experiences delivered in a collaborative and integrative manner.' (Leavy et al., 9)

The enablers identified in the international context are reflected throughout the research at a national level. The enablers, in the formal, non-formal and informal education sectors, include: promotion of student-led learning, thus promoting agency, creativity and the opportunity to develop both Arts and STEM understanding; the importance of teacher professional development for both Initial Teacher Education (ITE) and Continuous Professional Development (CPD); a constructivist approach to teaching and learning; access to relevant courses, technology and expertise; connections with stakeholders in formal school settings non-formal and informal settings; interdisciplinary teams; play-based approaches; children's natural curiosity and agency; and meaningful, equal integration of the arts-based elements of the intervention. (Leavy et al.134)

The Review details potential barriers to STEAM education, including: 'limited time and resources within pressurised formal curricula and informal courses; lack of support for STEAM at management levels in schools and education settings' 'the absence of shared understanding regarding the meaning of integrated STEAM education; a lack of understanding of how to teach integrated STEAM; an absence of opportunity to collaborate with colleagues across STEM and the arts disciplines; limited, poor or a lack of initial teacher education and CPD that support the implementation of authentic STEAM education.' (Leavy et al.138-9,140)

These key barriers and enablers, across all settings from early learning and care to post-primary and in informal contexts, have provided the Advisory Group with the robust research and evidence base for the development of the recommendations. The *Review* concludes by highlighting 'unequivocally that STEAM education has transformative potential for learners, in their pursuit of knowledge, skills and dispositions and for their essential participation and engagement as global citizens of the 21st Century.' (Leavy et al., 142)

The recommendations are grouped around three key areas for action, relating to learners, to teachers and early years educators, and to policy and research. It is the aim of the Advisory Group, through these recommendations, to support access, to inspire learning, foster creativity and prepare learners for subsequent engagement and success in and across the disciplines of STEM and the Arts. The recommendations also aim to promote opportunities

for early years educators and teachers to engage with STEM and the Arts in their formative preparation and in their subsequent professional development. Finally, the recommendations propose initiatives in research to explore the opportunities and challenges presented by STEM and the Arts education in Ireland.

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Recommendations

The promotion of STEM and the Arts learning within the education system is a key priority for the Government and is reflected in multiple strategy documents, such as the STEM Education Policy Statement 2017; Action Plan for Education 2021[7]; Ireland's National Skills Strategy 2013[8]; the Digital Strategy for Schools to 2027 the Arts in Education Charter 2013[9]; Creative Youth Plan 2017[10]; Literacy, Numeracy and Digital Strategy (in development); Second National strategy on Education for Sustainable Development to 2030[11]; and the National Artificial Intelligence Strategy for Ireland 2021[12].

These recommendations are made to ensure that learners have equality of access to opportunities for STEM and the Arts learning experiences in early learning and care settings settings and in primary and post-primary schools, to build leaders', early years educators', teachers', parents' / guardians' and learners' knowledge (knowing what), skills (knowing how) and values (knowing why), in and across the disciplines. Progress can be achieved through conducting education-based and STEM Education research; ensuring the professional preparation of early years educators and teachers; the provision of experiential and inquiry-based teaching and learning; and the use of innovative teaching, learning and assessment modalities to include technology-enhanced learning. These recommendations recognise the need for early introduction of STEM and the Arts programmes to encourage the development of attitudes to and interest in and across the disciplines.

Specifics of all these recommendations will be considered for inclusion in the STEM Education Implementation Plan 2022-2026. Their inclusion will also be assessed against available resources within the Department of Education and the Department of Children, Equality, Disability, Integration and Youth. Development and implementation of the recommendations requires input from all stakeholders including the learners. Delineation of responsibility and timelines will be detailed in the Implementation Plan.

Key areas for action

The **key areas for action,** as set out by the Advisory Group, build on, and are additional to, the extensive actions identified in the STEM Education Implementation Plan 2017-2019. They are:

1. Support learner access to, and experiences of, STEM and the Arts
2. Development of STEM and the Arts Research
3. Support capacity building through Initial professional education of early years educators, Initial teacher education and continuing professional development

These areas will be enacted by implementing the recommendations set out below.

[7] https://www.gov.ie/en/collection/b1330-action-plan-for-education/
[8] https://www.gov.ie/en/publication/69fd2-irelands-national-skills-strategy-2025-irelands-future/
[9] https://www.gov.ie/en/publication/b2f7f6-arts-in-education-charter/
[10] https://www.gov.ie/en/publication/0ef32-creative-youth/
[11] https://www.gov.ie/en/publication/8c8bb-esd-to-2030-second-national-strategy-on-education-for-sustainable-development/
[12] https://www.gov.ie/en/publication/91f74-national-ai-strategy/

Recommendations

Support learner access to, and experiences of, STEM and the arts

The transdisciplinary approach of STEM and the Arts education provides an opportunity for learners to understand better and to prepare for our changing world and to help design solutions to the problems facing it. It promotes the development of learners' agency, knowledge, problem-solving skills, design thinking, collaboration, creativity, resilience and confidence.

The provision of equitable access for all learners to experiences of STEM and the Arts within formal and informal settings is necessary to promote the development of critical and creative thinking skills. It is important to promote and broaden participation in STEM and the Arts for all learners through inclusive practices that support representation from the whole of society.

Specific actions

- Identify opportunities for linkages between STEM and the Arts in curricula, through NCCA's ongoing curriculum and assessment work across early learning and care , primary and post-primary education,
- Implement and support pilot and research project(s) within early learning and care settings/primary/post-primary schools, to explore cross-curricular linkages between STEM and the Arts and to examine the effectiveness of the initiatives to contribute to desirable learning outcomes for learners.
- Support Creative Youth school programmes and artist-residency schemes to include as wide a range as possible of creative practitioners, incorporating STEM, creative technology, design thinking and other practices across the disciplines of STEM and the Arts.
- Work with relevant stakeholders in the development of teaching resources for STEM and the Arts
- Engage with STEM and the Arts communities of practice to provide the opportunity for early years educators, teachers, informal STEM and the Arts practitioners and other stakeholders to collaborate and share ideas.
- Ensure access nationwide to meaningful STEM and the Arts career awareness activities. Evaluate the provision already in place to assist in making informed decisions on how to progress in this area.

Support Early Years Educator Initial Professional Education, and the Continuing Professional Development of Both

Early years educators, teachers and their initial educators should should view the arts and the STEM disciplines as equal, and should understand the potential of the linkages between STEM and the Arts.

Given the relatively early stages in the development of linkages between STEM and the Arts education, early years educators and teachers require targeted support to implement STEM and the Arts education in early learning and care rooms and school classrooms. In addition to other supports, relevant professional development is required to enhance their professional knowledge, skills and teaching practices.

Promoting an awareness that each discipline has a 'discourse community with its own language, texts, and ways of knowing, doing, and communicating within it'[13] has implications for teacher and early years educators knowledge. Teachers require foundational content knowledge and pedagogical content knowledge across disciplines (what and how to teach), and access to modules in ITE/professional development that demonstrate how to integrate in rich and authentic ways without compromising any of the disciplines involved.

In addition, Initial Teacher Education and Initial professional education programmes for early years educators play a vital role in preparing future educators to teach within STEM and the Arts programmes. While further research is required to strengthen the evidence base in support of high-quality initial professional education, it is acknowledged that learning to teach is complex (OECD, 2019). Initial Teacher Education (ITE) should be seen as 'the first step in the continuum of teacher learning and should be understood as a system of multiple actors and artefacts' (OECD, 2019 p.11) which inducts them into a career-long commitment to teaching and learning from ITE through to induction to Continuous Professional Development.

Specific actions

- Explore and develop opportunities for linkages between STEM and the Arts in Initial Teacher Education and Initial professional education programmes for early years educators.
- Further develop the expertise of support services by upskilling advisors and building expertise in order to support teachers and early years educators to enhance the linkages between STEM and the Arts.
- Include a component on STEM and the Arts in Continuing Professional Development for early years educators in the National Síolta Aistear Initiative (NSAI). This could form part of the existing plan for a CPD programme in STEM education for early years educators
- Encourage national and local providers to develop specific CPD initiatives linking STEM and the Arts disciplines within national curriculum programmes for example TAP and primary school summer courses

Stem and the Arts Research

The Literature Review highlights that the literature focus related to STEM and the Arts education is at an exploratory, early phase. There is significant scope for innovation and creativity regarding research focus, design, and implementation of STEM education interventions. There is a need for research, projects and initiatives to be undertaken at a national level in both the formal and informal sectors.

Specific actions

Studies will be undertaken to:

[13] Zygouris-Coe, V. (2012). Disciplinary literacy and the common core state standards. *Topics in Language Disorders*, 32(1), 35-50. https://vocablog-plc.blogspot.com/2012/03/what-is-disciplinary-literacy-and-why.html

- Determine what constitutes STEM and the Arts education at early learning and care, primary and post-primary level in Ireland to include an understanding of the opportunities, how and why barriers prevent access to STEM and the Arts education, and how to incorporate STEM and Arts education and experiences into the early learning and care room and school classroom.
- Identify programmes in the informal and non-formal sectors that engage young people in STEM and the Arts and determine how synergies between in-school and out-of-school experiences and practices should be explored and disseminated.
- Determine ways of embedding evaluation into formal and informal STEM and the Arts programmes to determine the level of achievement and impact of project objectives, and their effectiveness, efficiency, inclusivity and sustainability.

Monitoring:
Implementation of the recommendations should be closely monitored and a rigorous evaluation process should be put in place. This will allow for the assessment of the appropriateness, efficiency and effectiveness of each of these recommendations, as well as providing the information to inform the future direction of the recommendations.

Implementation of the recommendations will take time to effect change, especially given that the linkages between STEM and the Arts education are in the early stages of development. The Advisory Group recommends that that there should be an annual review, with a three-year and five-year marker, to ascertain the impact from early learning and care to post-primary.

Background to the Recommendations

The STEM and the Arts Advisory Group (the Advisory Group):

The terms of reference for the group are as follows:

Within the context of informing the development of quality education provision and of advising the STEM Education Implementation Advisory Group, the Advisory Group will:

1. Undertake a Literature Review of STEM and the Arts learning; scope and outcomes of the review to be set out and agreed by the STEM and the Arts Advisory Group
2. Identify opportunities for partnerships and linkages between the Arts and STEM.
3. Develop suggested actions for inclusion in the second STEM Education Implementation Plan, 'Embedding' and present to the STEM Implementation Advisory group for consideration.
4. STEM and the Arts Advisory Group will make recommendations to the STEM Education Implementation Advisory Group on the above.
5. STEM and the Arts Advisory Group will oversee and promote the implementation of actions relating to STEM and the Arts from the STEM Education Implementation Plan

Group Membership

Jane O'Hanlon, Chair	Poetry Ireland, ETAI & TAP
Aidan Clifford	ETAI, CDETB, CDU, Council of Europe EPAN, TAP
Derek Grant	National Council for Curriculum and Assessment
Gary Granville	Professor Emeritus, School of Education, NCAD; Creative Ireland, Expert Advisory Group
Mary Shine Thompson	Arts and Education consultant
Lindsay Deeley	Science Communication and founder of Toodelou
Eithne Kennedy	Dublin City University Institute of Education
Kate Delaney/Stephen Ryan	Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media (Kate Delaney replaced Stephen Ryan in December 2021)
Karen Murtagh	Department of Education
Maeve Price	Department of Education

As part of its remit, the Advisory Group was tasked by the Department of Education's STEM Education IAG with developing recommendations to ensure that learners have access to opportunities for STEM and the Arts learning experiences in early learning and care settings, primary and post-primary schools.

The Advisory Group commenced work by commissioning a '*Literature Review to Identify a Set of Effective Interventions for Addressing STEM and the Arts in Early Years, Primary and Post Primary Education Settings'* in order to inform the recommendations. It is agreed that STEM and the Arts is 'at an early exploration phase and still not fully assimilated in terms of a common purpose, vision, and the implementation of an agreed and equitable pedagogy'. It is further agreed that while there were interventions underway in Ireland, little was understood on how effective these are effecting change. Following analysis of the report the

group agreed that there is a requirement to support multiple interventions addressing different segments of the ecosystem to effect the change required.

It was agreed by the group that success of the recommendations would result in easily identifiable:

- ***Ecosystem alignment**:* Interventions targeting one barrier or level of the STEM ecosystem are aligned with other elements of the ecosystem.
- ***Curricular alignment**:* Curriculum coherence, articulation and implementation across transition points provides continuity for learners and scaffolding for extra-curricular interventions.
- ***Equity alignment**:* All learners have equitable access to STEM and the Arts education opportunities both in formal and informal settings.