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A METHODOLOGICAL GUIDE TO SCIENCE AND TECHNOLOGY AWARENESS (STA) IN EARLY CHILDHOOD CARE AND EDUCATION (ECCE) CURRICULA

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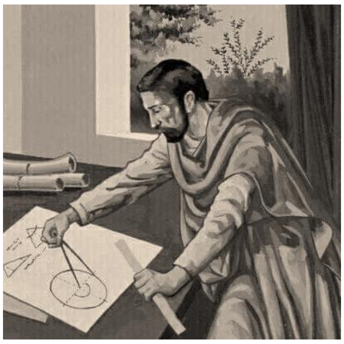

"*One only understands the things that one tames*," The Little Prince *by Antoine de Saint-Exupéry*

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INTRODUCTION

Today, the African continent is experiencing a shortage of scientists and accounts for only 2% of world research output, even though this is one of the key levers for promoting sustainable economic growth and long-term social progress on the continent. A joint report by UNESCO and the International Association for the Evaluation of Educational Achievement (IEA) also reveals that in almost all education systems (87%) more boys than girls aspire to enter a career in science. Today, 49% of students under the age of 14 are studying science, technology, engineering, the arts, and mathematics using dry and outdated methods, mainly by committing scientific concepts to memory and reading textbooks in class. In both developed and developing countries, it is important to recognize that there is a sense of disenchantment among secondary school and university students for scientific and technical fields.

Nonetheless, in 1957, the UNESCO Source Book for Science Teaching already stated: *"For scientific concepts to be truly assimilated, they must be the object of experiences and discovery rather than learned. […] Everywhere around the world, objects that are part of the scope of science are also an integral part of our environment: animals and plants, land and sky, air and water, light and heat, weight and centrifugal force […] In order to proceed to experiments and observations, countries need certain means which many of them lack, especially in primary education and the first cycle of secondary education […]."* Creating knowledge and developing skills through science and technology allows us to find solutions to current economic, social, and environmental challenges, while developing the tools needed to achieve sustainable development and build greener societies. Back in 1974, Senegalese historian and anthropologist Cheikh Anta Diop said: *"Africa must opt for a policy of scientific and intellectual development, no matter the price. Because its vulnerability for the past five centuries is the result of its deficiency in science."*

How science and technology are understood and appropriated must be improved. The curriculum, a key element of the education system, has its role to play in reflecting society's vision of its future and in creating opportunities to shape it by training future generations. The 1990 Declaration on Education emphasizes that "learning begins at birth," a notion reaffirmed in November 2022 by the adoption of the Tashkent Declaration at the end of the World Conference on Early Childhood Care and Education. The development of this methodological guide on Science and Technology Awareness in Early Childhood Care and Education (ECCE) also echoes the idea of "*making science more accessible, inclusive and equitable for the benefit of all*" from an early age, and of focusing on education quality in a context where countries are increasingly likely to include a year of preschool in the compulsory curriculum, thereby clarifying, supporting and guiding countries' pragmatic implementation of this roadmap.

In line with the International Bureau of Education of UNESCO (UNESCO-BIE) vision, the curriculum operationalizes and implements the vision and purposes of the educational system, from Early Childhood Care and Education (ECCE) up to the secondary level of education: the what, when, where, how much and how of learning, for which citizens and what kind of society, from a general definition of these elements to their implementation in the classroom and their evaluation. This creates a space for defining these kinds of learning experiences and provides the means, tools, and players to do this. Constantly changing societies require new knowledge, skills, and attitudes, and so the curriculum, its educational programs and implementation must be continuously adapted to afford children and youth the opportunity to respond to the evolving expectations of the future. In a dynamic, progressive, and living curriculum, Science and Technology Awareness (STA) requires integration into teaching and learning methods, so that, from an early age and throughout their lives, everyone may acquire the necessary knowledge, skills, attitudes, and values to build a sustainable future. In Commitment 6, the Transforming Education in Africa Declaration recommends focusing *"on foundational learning from an early age to raise learning levels by emphasizing teaching focused on Science, Technology, Engineering and Mathematics (STEM)."*

This methodological guide to Science and Technology Awareness (STA) goes beyond a mere listing of skills often described in basic education as "read, write and count". It is a call to think "out of the box" to transform ECCE and ECCE teaching, learning, and pedagogical practices, contributing to the whole child development and well-being, as well as to transforming Education. In the broader and cross-cutting context of the right to education which begins at birth and of the Convention on the Rights of the Child (CRC), in the 21st century it is more important than ever to use Science and Technology to establish guidelines for organising learning processes so that children and youth, boys and girls, can become active and aware citizens of their communities, countries, and the world. This involves:

- **Drawing on local knowledge to develop child-centred, play-based learning in the children's mother tongue that is inclusive, environmentally friendly, and gender-responsive**. ECCE thus constitutes a window of opportunity for reinventing a truly active kind of pedagogy to motivate and build confidence in young learners, boys and girls alike, to become aspiring scientists and work with science and technology more broadly, and to demystify science and technology, which are all too often viewed as elitist.
- **Discussing changes to the education system in response to societal changes by encouraging the reshaping of education based on local realities and challenges, and rethinking curricula by regions and for regions**. The area of Science and Technology may require local adaptations to better and more consistently respond to specific scientific and/or technological challenges which can only be identified and contributed to by local education communities.
- **Analysing and moving beyond a fragmented and siloed approach to education and to curricula, also moving beyond ownership of the ECCE curriculum exclusively by stakeholders in charge of early childhood education**, bridging the gap between time spent in and outside of school, between basic education and lifelong learning, between ECCE teachers and educators and those at other levels of education, between classes, cycles and disciplines, between knowledge, skills, and attitudes.

With its future-oriented, innovative vision of issues related to curricula, and to contribute to an education in sustainable development that is equitable and inclusive of all, this guide provides strategic orientations for developing an environment favourable to quality learning in science and technology, starting from ECCE, while unlocking the potential of every single child.

1. THE NEED FOR A METHODOLOGICAL GUIDE TO SCIENCE AND TECHNOLOGY AWARENESS IN CURRICULA

The reasons for publishing a methodological guide to Science and Technology Awareness in curricula can be summarised using two key points:

The first has to do with the process of discussing and transforming education policy starting in Early Childhood Care and Education (ECCE). Countries can enhance their ownership of the process and increase the internalisation of the analysis of their ECCE curricula, which have a focus on Science and Technology Awareness (STA). Having a methodological guide would help improve national analytic capacities and promote the more efficient and contextualised development and implementation of high-quality ECCE, the role of which is to develop emerging skills that will remain relevant during later studies and in lifelong learning.

Second, this guide is a practical approach to curriculum development for ECCE in secondary schools, with a focus on the specific area of science and technology education. It also allows for the analysis of the learning progress in this area as early as in ECCE. Although the foundation and concepts in science and technology can be adjusted and adapted based on the learners' age and the level of their education cycles, they remain consistent in their emphasis on asking questions, critical thinking, and problem solving, with the same learner-centred pedagogy and a teaching/learning process that places learners first. Providing a methodological guide helps share concrete illustrations of this potential progressive implementation from an early age.

a) Transforming curricula and learning from an early age

There is growing international and regional consensus on the importance of transforming education, including by modifying curricula, and on the necessity to develop or strengthen scientific literacy, and to target emerging 21st century skills.

An overview of the critical analysis of the status of STA in ECCE in 18 countries in West and Central Africa made it clear that Science and Technology Awareness is present in all countries, usually explicitly included in a specific area, or, less frequently, implicitly incorporated into other activities. However, it also reflects the rather disparate nature of the entry points of these curricula, and deficiencies and challenges in ECCE curricula (UNESCO-IBE, 2023) were revealed and require a more thorough analysis to enable a true transformation: weak linkage between development milestones (language, cognitive, social/emotional, psychomotor) and presented activities; the lack of a "methodological scenario" to help teachers and educators apply STA; no prioritisation in the selection of themes and/or activities for STA; lack of information about the profile, skills and knowledge of pedagogical content required of ECCE teachers and educators; the supply of teaching and pedagogical materials.

However, curricula cannot be transformed through only one part of the system or at only one school level. These processes of change, often complex, require the mobilisation of a large number of players and significant resources. An in-depth transformation of curricula often requires reviewing the educational purpose and approaches, as summarised in the table of international trends in curriculum reform.

FROM	TO
Teaching	Learning
Transfer of facts	Student construction of knowledge
Memorization of information	Analysis, synthesis, evaluation and application of information
Focus on knowledge	Development of knowledge, skills, values and attitudes
Summative assessment of academic achievement	Authentic and formative assessment of competency
Learning by rote	Applied learning/learning in context
Categorized knowledge (traditional subjects)	Integrated knowledge (broader learning areas)
Schooling	Lifelong learning
Focus on inputs	Focus on outcomes and processes
Didactic teaching	Participatory, activity-centred approaches that incorporate interactive methods
Assumption that there is one "learning style"	Recognition that there are several "preferred learning styles"
Curriculum as product	Curriculum as both a process and a product

<u>Source</u>: UNESCO-IBE, "International Trends in Curriculum Reform," Training tools for curriculum development, Resource Bank, 2017

This transformation also means reviewing curriculum governance structures, curriculum development financing, and the implementation of reforms of curricula, training, material and human resources, and interactions between various levels of government and of education [1].

In order to transform curricula, Science and Technology Awareness (STA) in ECCE curricula must contribute to cultivating and demystifying scientific and technological literacy from an early age, to placing greater emphasis on the quality of STA teaching/learning processes, to making informed choices about the priorities outlining the scope of the impact of STA on the overall vision of education and, finally, to unleashing the potential that appears during the unique window of opportunity of ECCE.

ECCE is often a fragmented and isolated subsection of education systems, with little focus on program content, teacher and educator training, and pedagogical approaches, and is often subject to fragmented reforms. Responsibility for ECCE is frequently shared by different ministries and/or ministerial directorates that work independently of one another. There are diverse ways of organising ECCE, with private sector structures (for-profit/non-profit), community structures, and public structures (sometimes integrated into primary schools). Finally, depending on the country, ECCE can cover different age ranges, often with two separate groups of 0-3 and 3-6 years of age. Many of these interventions have demonstrated their limited ability to improve the quality of ECCE learning outcomes and to improve the efficiency and resilience of its contribution to the entire system.

[1] See UNESCO-IBE publication, Step-by-step guide "Curricular reform and transformation processes: what constitutes successful curricular reform? How can it be planned and carried out?"

In order to contribute to a quality education, Science and Technology Awareness must be incorporated into ECCE curricula, with possible flexible adaptations depending on the resources (human, financial, and material) available in the various types of structures and depending on the learners' development milestones, while ensuring a focus on the educational purpose of STA and the development of target skills. Moreover, after curricula are transposed, they should result from the interpretation of institutional or official texts such as Orientation Laws and the Curriculum Orientation Framework (COF), encompassing the ECCE up to the secondary level, making it possible to reinforce the progression of learning through the different educational levels. This Curriculum Orientation Framework can also define the general and specific principles linked with areas of learning - including science and technology - so that educational levels are linked together in a relevant and appropriate manner. Science and Technology Awareness in countries must be flexible and contextualised, accounting for the curricular approach in the country, national and local possibilities and potentials, materials available in the environment, as well as the real (and future) professional qualifications and skills of ECCE teachers and educators.

Developing or revising the ECCE curriculum that is more specifically STA-focused requires a participatory and collaborative approach through the involvement and contribution of different ministries and players along the pedagogical chain - from curriculum developers and designers of teaching materials to inspectors, educational advisers, teachers, teacher trainers, school principals and local education communities - and specialists in science and technology education, scientists and engineers, since this field is evolving rapidly as discoveries and innovations impact our daily lives. This complex, dynamic process also makes it possible to account for all curricular documents governing practices and activity content, training programs for teachers and trainers, the methods of teachers/trainers and of their trainers, and assessment models.

This transformative process, which aims to develop a high-quality, equitable, and inclusive curriculum, is a precondition for creating a holistic, systematic, and transformative vision for ECCE curricula, of which Science and Technology Awareness (STA) is a key area of learning that is innovative, concrete, and full of promise for the entire education system. It is necessary and possible to incorporate high-quality ECCE in this curriculum transformation.

b) Foundations and concepts of Science and Technology Awareness (STA)

Multiple reports mention the possibility of strengthening the independence of societies through science. The science-based search for knowledge and understanding helps provide solutions to the economic, social, and environmental challenges we face, and provides us with knowledge that enables social progress. Capacity building in the basic sciences and engineering is key to developing the necessary human resources for this social and economic development, and to allowing for the transfer of scientific knowledge. In a "traditional" approach to science and technology, it is difficult to learn about this area from an early age. However, Science and Technology Awareness (STA) can feasibly be included in Early Childhood Care and Education (ECCE) by defining and clarifying its scope and by explaining its epistemological and pedagogical foundation through curriculum transposition - the process of adapting content produced in a given context to the context in which a school curriculum was designed. In our context, this transposition involves adapting and simplifying scientific knowledge so that it can be turned into learning content for educational programs, textbooks, and lesson planning.

Science and Technology Awareness (STA) must allow for real-life collective and spontaneous activities of discovery, while accounting for children's cognitive skills, by promoting simple modelling and problem-framing activities (Ledrapier, 2010):

- discovering or encouraging discovery/exploration/research: discovering a new phenomenon or the variation on a phenomenon, encouraging learners to solve a problem, especially by thinking about the "how" and only later about the "why."
- modelling: this does not mean understanding a model or modelling in the scientific sense of the word, but rather helping learners participate in developing a model using three modelling activities: explaining or formulating explanatory hypotheses, predicting, and modifying a system of interpretation (Ledrapier, 2014).
- problem-framing: helping children to experiment and develop and encouraging the ability to analyse and observe during manipulation and experimentation activities, to build creatively, to define a problem, and to listen to others who are participating in the problem solving.

By referring to the epistemological meaning of STA, one realises that among collective activities it includes questioning, exchange, communication, and argumentation. STA is first and foremost about encouraging curiosity, a sense of wonder, questioning, and supporting already existing skills among the young children-explorers, children-engineers, and children-creators. On the one hand, STA creates awareness of the learners' potential, of their thoughts, ability to understand and conceptualise, their ability to create, their perceptive and intellectual curiosity. On the other, it creates an awareness of the world and the surrounding environment. The goal is to contribute to the children's maximum development potential by emphasizing their relationship with the world.

STA does not mean teaching science to children, but rather fostering scientific literacy, teaching them a scientific approach and way of thinking based on cause and effect. While the acquisition of scientific and technical knowledge, or science literacy, is not the ultimate goal of STA learning at this level of education, this knowledge can take the form of a simple and adapted explanation of familiar physical and natural phenomena, with the progressive acquisition of a scientific vocabulary, for example, through repetition by the teacher. Mathematics awareness is usually treated separately from Science and Technology Awareness (STA), but the acquisition of basic mathematical concepts (e.g. length, weight, geometric shapes) can be encouraged through interdisciplinary STA activities.

To represent the wide scope of science and technology more accurately, we have included the table below containing the conceptual framework of the critical analysis of the status of science and technology conducted before this guide (UNESCO-IBE, 2023), with the addition of a possible application in STA. These are content elements selected for an adapted incorporation into preschool curricula and teacher training programs, while trying to avoid curriculum overload.

Conceptualising Science and Technology *with respect to their use and function in a country's socio-economic development*	**Possible applications in Science and Technology Awareness (STA)** *with respect to the life of the students and that of the educational community in which they grow*
The **biological sciences** are a branch of natural science that study living organisms, their structure, function, evolution, and interaction with their environment. Biology explores a vast variety of levels of organisation, from molecules and individual cells to ecosystems and the biosphere as a whole. It includes fields such as cell	▪ Awareness/exploration of basic biological processes (e.g. stages of birth, reproduction, and growth in living things), the identification and classification of living things, nutrition for growth, organ function in the human body (breathing, digestion, circulation, nervous system), and biodiversity conservation and ecosystem ecology

biology, genetics, molecular biology, physiology, and ecology.	▪ The ability to make observations, to conduct experiments, to initiate problem-solving, as well as critical thinking, logical reasoning and creative skills used to interpret experimental results
The **chemical sciences** are a branch of natural science that deals with the study of the composition, structure, properties, and transformation of matter. Chemists concern themselves with atoms, molecules, chemical reactions, and the interactions between different substances. Chemistry plays a vital role in many scientific and technological fields. It includes organic and inorganic chemistry, analytical chemistry, and computational chemistry.	▪ Awareness/exploration of the composition, structure, and states of matter (e.g. water), varied materials (e.g. paper, tissue paper, finger painting, modelling clay), and chemical reactions (e.g. the decomposition of a piece of fruit). ▪ The ability to conduct chemical experiments, to initiate problem-solving, as well as critical thinking, logical reasoning and creative skills used to interpret experimental results
The **physical sciences**, also called the "sciences of nature," or "physical and natural sciences," are a branch of science that deals with the study of nature and the behaviour of matter and energy. Physical sciences rely on observation, experimentation, modelling, and the formulation of mathematical laws and theories to describe the physical phenomena that surround us. Physics includes mechanics, thermodynamics, astrophysics, and electromagnetism.	▪ Awareness/exploration of movement and equilibrium, energy-related phenomena, light and reflection, electrical objects and circuits (e.g. light bulbs), the stars, celestial bodies, planets, and stars (e.g. eclipse, time/calendar) ▪ The ability to make observations, to initiate problem-solving, as well as critical thinking and logical reasoning skills
Life and earth sciences (LES), also called biological and geological sciences, are a multidisciplinary field that deals with the study of processes and phenomena related to life on Earth, as well as the structure, history, and dynamics of our planet. They encompass biology, geology, ecology, palaeontology, and other related fields. .	▪ Awareness of living things, their structure, functioning, evolution, and interactions with their environment, Earth's changes (e.g. erosion) and its impact on living conditions (e.g. climate, soil, water, light), on the evolution of species over time (e.g. extinction process), and on the interactions between organisms within a species and across species ▪ The ability to make observations and conduct experiments
Technology refers to all knowledge, tools, methods, and processes used to solve practical problems, improve activities, or satisfy human needs. Technology is often based on scientific principles and can be applied in different fields. It includes engineering technology, medical technology, energy and environmental technology, transport technology and information and communication technology.	▪ Awareness of the use and manipulation of technological engineering tools and equipment in their everyday environment (e.g. solar/wind/hydraulic energy, medical equipment such as thermometers, communication tools such as computers, means of transport for people or goods such as cars, motorcycles, airplanes, and boats), energy storage technologies, energy management systems, emission reduction technology, water treatment systems, waste management technologies, etc.). ▪ Ability to communicate and collaborate as part of a team and to effectively convey one's ideas

c) Methodology, goals, and expected results of the guide

This guide is a methodological tool that will help guide and support countries in reforming existing ECCE curricula by incorporating and strengthening areas of activities focused on Science and Technology Awareness (STA). It proposes steps to be followed and lists suggestions for educational strategies in order to transform curricula in the most consistent manner possible.

As such, it is intended for national teams participating in the process of transforming curricula, from their development to implementation and evaluation. Normally, these teams include ministries and/or directorates in charge of the different levels of education, including ECCE, the Secretary General of the ministry/ministries, technical curriculum committees, administrative and technical staff (designers, administrators, directors, department heads, etc.), teachers and educators, educational supervisors and inspectors, general management at the central and decentralised levels, and trainers of trainers. Other potential players such as civil society and scientific associations/clubs, centres for scientific research, and universities may also be included.

The methodological process for drafting the guide underwent four main stages: planning, reflection, and exploratory studies based on "A Critical Analysis of the Status of Science and Technology in Early Childhood Care and Education Curricula"; an additional literature review on the subject to support it with empirical data; a workshop for outlining the general content and orientation of the draft guide with the contribution of international and national experts, inspiring and feeding into the discussion of experience and practice, and institutional, scientific and pedagogical profiles as a factor for contextualising the guide; and, finally, the successive stages of editing and review.

As part of a systemic and transformative approach, the goals of this guide focus on three major pillars:

- **Providing an overview of the guidelines for an educational project focused on science and technology by promoting the specific dimension of Science and Technology Awareness (STA)** starting in Early Childhood Care and Education (ECCE), in conjunction with other levels of education and the language policy adopted for the entire education system. This means defining a strategic and endogenous vision of the level of scientific and science literacy which a country wishes to inject into its broader plans for society.

- **Defining and establishing appropriate and inclusive education strategies, guidelines for teaching and learning activities, a consistent and appropriate pedagogical approach**, relevant content for teacher training, indications for teaching materials, pedagogical materials, and evaluation methods for Science and Technology Awareness (STA) in order to support the development of three types of skills that interact with one another: emerging and unconstrained skills; learning skills such as perseverance, curiosity, and motivation; social personality skills such as self-image, self-confidence, social skills, and social consciousness.

- **Shed light on learner-centred educational approach, on quality learning in Early Childhood Care and Education (ECCE), and on the development of emerging skills** to better meet the needs of young learners' overall development and unleash their full potential through the lens of the specific area of STA. While avoiding the risk of over-schooling, this means that whatever the entry point - a field, theme, or centre of interest in science and technology - the most important thing is to focus on/prioritise the development of emerging, age-appropriate skills (promoting children's physical and motor development, self-awareness, harmonious relations with others, oral and written expression, and discovery of the world around them).

This guide is part of a dynamic to produce the desired effects of controlled, deep, and lasting change for the benefit all citizens that supports sustainable development and economic, cultural, social, and human prosperity. Various dimensions can be impacted in the medium and long term: schools and education communities may be more likely to explore and expand partnerships to improve and support STA; the planning and increased use of more active, learner-centred and innovative learning experiences, and increased dialogue for mutual support and collegial sharing of best practices by players on the ground to build on learners' past experience more effectively, ensuring continuity of learning.

2. PREREQUISITES AND METHODOLOGICAL FRAMEWORK

There are a few prerequisites for countries which would like to revise or develop ECCE curricula while strengthening STA. Countries may reference the procedure described in this section, while making sure that it links up with other curricular processes.

There are two main stages: first, conducting a diagnostic evaluation of existing curricula, taking care to include those in ECCE; next, planning curriculum reform by devising a consistent, relevant roadmap that is appropriate to the national context.

a) Curriculum diagnosis with a focus on Science and Technology Awareness (STA)

The diagnosis creates a reference and analytical framework for initiating and managing the recommended curricular changes. It is intended for all stakeholders affected by transforming the curriculum, a complex process which must include ECCE: education policy decisionmakers, members of a steering committee for curricular reform, ECCE administrators, professionals in the field, designers of pedagogical programs and materials, trainers, etc. In the specific case of a diagnosis focused on Science and Technology Awareness (STA), additional experts who are familiar with various scientific and technological concepts, fields and instruction may also be part of the process.

This diagnosis will help verify the relevance of a curriculum to the new needs of society, identify and provide proof of risk factors and protective factors with an impact on learning quality, gather field data on the gaps between the recommended curriculum and the curriculum as interpreted and implemented, inform political decisionmakers and technicians about objective data, use this analytical framework for relevant and committed monitoring, and, finally, develop strategic and pragmatic recommendations in light of other countries' experience, the latest research, and international standards. On this last item, the international PISA or TIMSS studies pay particular attention to science, because scientific literacy is "that which prepares students for current and future challenges in their daily and professional lives, involving both science and technology," and mathematical literacy promotes "mathematical reasoning and the ability to formulate, use, and interpret mathematics to solve problems in a wide range of real-world contexts."

A diagnostic evaluation (internal or external) is a rational process[2] conducted with the goal of providing an exhaustive and accurate overview of the current curriculum (the curriculum prescribed, interpreted and implemented) via four stages: (1) a preparatory and participatory stage, when the objectives, process, criteria, and indicators for each aspect of the study are shared with all stakeholders, (2) the design of the tools of the study (e.g. questionnaires, semi-structured interviews, and a table for observing and analysing classroom practices), (3) a critical reading of various documents (official texts, Curriculum Orientation Framework (if available), curricula (STA or general), sample instructional tools and teaching guides, initial and in-service training modules for teachers/educators, etc.) and the procedure for evaluating the education system, and (4) a study and/or consultations on the ground (at the central and decentralised levels, in rural/urban settings) that collect and analyse representations, uses, and classroom practices.

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[2] *UNESCO-IBE publication: Step-by-Step "Practical Guide to Diagnostic Studies Conducted for the Purpose of Curricular Transformation."*

While analysing the actual conditions and problems encountered during implementation, new needs, and the desired orientations, this diagnostic must also systematically integrate various levels of analysis:

- The ECCE curriculum as part of the national Curriculum Orientation Framework (COF) to the extent that the COF *"always positions itself upstream of the educational programs that it guides"* (Jonnaert, 2015)
- The area of science and technology (or benchmarks) throughout the various levels of education
- The specific area (if it exists explicitly) of Science and Technology Awareness (STA) in ECCE or implicit benchmarks.

Moreover, the diagnosis will account for the specific context into which it is integrated, the expected objectives and results, the theory of change, the reference criteria and evaluation indicators. These criteria may include:

- *The concepts and guiding principles of science and technology*, including, for example, a list of concepts taught in the many different fields of science and technology, the progression of ECCE learning and with other levels of education, the level of complexity and sophistication of the presented concepts, the degree of relevance and timeliness of the concepts, the extent to which the curriculum is connected to the environment (family, social) of the child (e.g. pharmacopeia)
- *Pedagogical approaches,* including, for example, the type and number of available activities, the degree of interaction and engagement of learners in activities facilitated through the application of language policy, a consistent pedagogical approach (e.g. Skills-Based Approach) in science and technology throughout all levels of education, the adaptation of the pedagogy to the children's level of development (e.g. play-based learning and experiments in ECCE)
- *The resources and materials proposed and used*, including, for example, diversity, the availability and accessibility of teaching materials for STA activities, the use of pedagogical guides and online resources to facilitate and support STA learning
- *An evaluation of learning*, including, for example, the diversity of tools, methods and practices used to measure learners' acquired skills and to identify remedial action
- *The major training areas of teachers and educators,* including both their knowledge of scientific and technological content, their pedagogical knowledge of content (how and what children learn in informal and formal contexts), their educational strategies for organising and implementing STA activities, and expected and actual professional attitudes.

For triangulation, the data from the field study are cross-referenced with those from the literature review in order to present relevant and contextualised diagnostic results, complementing recommendations and suggestions with ideas for action. Various stakeholders involved in transforming curricula then appropriate the results, with a final validation that will serve as the basis for a roadmap for planning the implementation of this curriculum reform.

b) Roadmap development: drafting, implementation, and evaluation

The findings of the diagnostics phase help develop a strategic roadmap in a collaborative and participatory manner (including, for example), laying out a vision for the curriculum reform and the operationalisation and planning of the stages of work necessary for its implementation.

Strategic pillars of the roadmap

In this roadmap, the vision must be incorporated explicitly with a consensus among the various stakeholders, including, among others, the learners themselves, in order to hear their views on the teaching of science and technology, the authorities and/or national institutes in charge of science, engineering, and the environment, CSOs concerned by informal and non-formal activities related to science (association, clubs, etc.), and union representatives of various sectors. Fundamental questions must be raised and addressed during the initial phases of the drafting of the roadmap and throughout the curriculum transformation process.

- ✓ What is the general vision of the education system - and, more broadly, what is the social project - to which the area of science and technology should contribute?
- ✓ How can the area of science and technology be linked with the national development plan (or a similar national strategy)?
- ✓ What should be the status of Science and Technology in the curriculum orientation framework, no matter the level of education, from ECCE through secondary school (and even higher education)? What are some of the risks and benefits?
- ✓ What curriculum transformation would make it possible to achieve this status of science and technology in the education system, starting from ECCE?
- ✓ In what manner can this curriculum transformation, particularly from the perspective of the area of science and technology, help bridge the skills gap between actual skills and desired skills?

Operational pillars of the roadmap

Similarly, the operationalisation (what? when? how? where? and how much?) consists of simultaneously identifying and defining key elements such as: alignment of the science and technology curriculum; capacity building for curriculum designers and stakeholders, specifically on incorporating ECCE into their work; design/revision of the curricula and supporting tools/materials; experimentation with developed curriculum tools; institutional and technical validation of the curriculum; the generalisation of the new STA-oriented curriculum; and, finally, the evaluation of the new curriculum.

- **This alignment must be conducted from one cycle and one level of schooling to the next, from Early Childhood Care and Education (ECCE) to primary school, secondary school, and throughout people's lives.** With a possible additional step before deconstruction, depending on the history of the curricula and programs, this alignment between STA and the fields of science and technology in the levels of education helps create a common, consistent language for discussing levels of learning, pedagogical approaches, and the tools and resources necessary for moving towards the pre-defined vision and ensuring that learners will develop high-quality knowledge and skills.

- **The skills of curriculum designers and other players along the curricular chain need to be enhanced so that they can appropriate (and understand resistance to change) and incorporate the design, implementation, and evaluation of relevant and high-quality ECCE STA curricula into the education system.** This includes understanding basic content in the field of science and technology, determining different types of materials and activities with clearly identified educational and pedagogical intentions, using methodological references to analyse existing curricula or to use the results of a diagnostic evaluation, adopting techniques for adapting curricula,

- **Work on the design and revision of innovative curricula and methodological guides for ECCE** is conducted by teams selected based on specific criteria, including a requirement for experienced teachers and educators to be included given their expertise as field practitioners. This process requires identifying and establishing the preparatory elements for the actual drafting of the STA curriculum. This involves:
  - Defining the subareas of learning, by considering the expanded scope of potential STA foundations and concepts (see preceding section)

- Constructing target profiles for the end of ECCE, depending on the number of years of ECCE
- Selecting and organising a list of themes and/or key centres of interest
- Identifying skills and learning objectives generally or specifically by subarea and/or by considering the interdisciplinarity of these subareas
- Selecting types of activities and teaching/learning content
- Developing pedagogical processes adapted to STA and/or ECCE (experimentation, scaffolding, observation, play, etc.)
- Defining procedures and tools for a formative evaluation of STA learning (e.g. identifying the Zone of Proximal Development)
- Developing pedagogical and instructional resources that optimise the teaching/learning process and support pedagogical processes
- Identifying the key skills of teachers and educators to support STA in a relevant and appropriate manner

- **The new curriculum must be tested (generally or with a focus on sequences of activities or complex situations related to STA)** during at least one school year in a sampling of early childhood education establishments (3-5 years) preselected based on relevant criteria (urban, rural, or suburban environment; age of establishment, etc.) Similarly, the teachers/educators who will serve as testers will also be selected based on criteria (experience, seniority, specific expertise) before undergoing training. Particular attention will be paid to follow-up and evaluation of the testing, and it will be the subject of a report that will present areas for improvement in the curriculum.

- **After incorporating the observations and suggestions explicitly presented in the testing report, adjustments will be made before the technical validation** of the new curriculum, which will lead to its finalisation. Depending on the type of problems identified and the changes made, another targeted testing process could be launched. Institutional validation, with the publication of official texts authorising its generalisation, for example, will be necessary.

- **Generalisation may happen progressively or comprehensively, at various scales (regional, national)** depending on the political choices and available resources. All documents relevant to this new curriculum will need to be printed and distributed. This generalisation also involves:
    - Launching training for teacher/educator trainers
    - Updating in-service training for teachers/educators and pedagogical advisors, school administrations, and inspectors, who provide local support
    - Updating inspection standards and tools for STA
    - Updating initial training programs for teachers and educators
    - Developing a framework and assessment tools for STA learning

- **Curriculum evaluation (internal or external) is an important and essential element of any national education system.** It allows decisionmakers and other stakeholders to determine the extent to which the initial objectives of the curriculum transformation process have been achieved. This is an objective evaluation of various impacts: on the methods used by teachers and educators, on pupils' learning, on learners' attitudes in connection with their own development and environment, on the foundations that serve as the basis for other levels of education. The criteria for evaluating curricula can be based on those outlined by the OECD Development Assistance Committee (DAC): relevance, coherence, effectiveness, efficiency, impact, and sustainability.
    - To what extent is curriculum implementation - and specifically as regards STA - aligned with the strategic guidelines contained in the roadmap/COF?

- To what extent did curriculum implementation meet the expectations of learners, field practitioners and the education community?
- To what extent is the curriculum consistent with the country's education policy?
- What are the synergies/complementarities of STA with the area of science and technology in primary and secondary education?
- What mechanisms/resources have been provided to guarantee curriculum implementation?
- What are the factors (internal and external) that have facilitated or negatively affected curriculum implementation?
- What are the most significant results/outputs obtained thanks to the new curriculum?
- What are some of the favourable factors, necessary conditions, and obstacles and risks to continuing or revising the curriculum?

3. COMPONENTS OF AN ECCE CURRICULUM WITH A FOCUS ON SCIENCE AND TECHNOLOGY AWARENESS

In this third and last section of the guide, the presented rubrics contain the components of an ECCE curriculum that will be developed by the designers and managers of the curriculum, with a particular focus on Science and Technology Awareness. As part of a pragmatic approach, the next section will share additional specific tools and illustrations of these items. It is important to contextualise, maintaining a flexible and adaptable approach, while reflecting and capitalising on local cultures and traditions.

a) Exit profile and target skills

General ECCE exit profile (3-6 years of age)

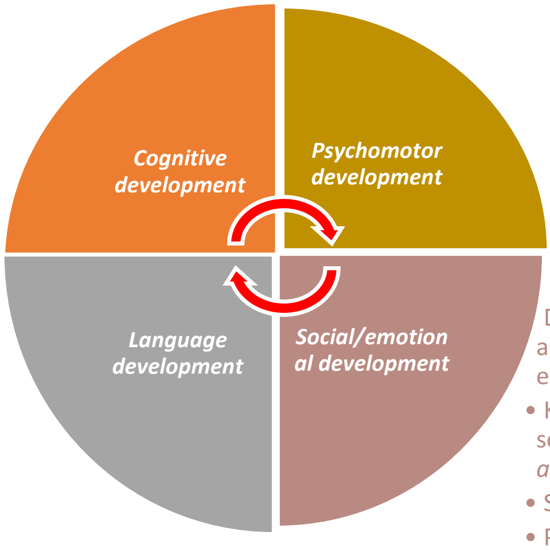
The exit profile determines the educational aims for pupils at specific establishments. The general exit profile for ECCE is based on the educational aims as expressed in official texts (orientation law, Curriculum Orientation Framework if there is one[3]). It is an important milestone that allows different players along the curriculum chain to guide their actions to be implemented across the various dimensions of the curriculum and to establish new foundations for their pedagogical interventions. There are two types of exit profiles, **a general profile and a specific profile which can reflect what is expected of learners in Science and Technology Awareness (STA).** Nonetheless, in the approach described in the previous sections, these two profiles shall not be treated in silo, but rather viewed as closely intertwined and interdependent, based on the child's overall development (psychomotor, language, social/emotional and cognitive).

[3] *UNESCO-IBE publication: Step-by-Step "Practical Guide to Diagnostic Studies Conducted for the Purpose of Curricular Transformation."*

Based on the latest knowledge on overall child development and at the end of the cycle, the learner must be able to (non-exhaustive list):

- Use reasoning skills, critical thinking and problem solving by using knowledge (*to question, establish cause and effect, understand the world around them*)
- Introduced to new knowledge linked to areas of learning, including a basic understanding of scientific and technological concepts
- Demonstrate imagination (new ideas, creating, symbolic games etc.) Know how to take initiative depending on tastes and interests

- Exercies motor skills (fine and gross) with ease in gestures and movements
- Demonstrate interest in motor activities, manipulation, discovery, and exploration
- Gain awareness of motor abilities and their limitations through risk taking
- Develop coordination, dissociation and balance to better synchronise movements



- Express themselves to name, tell, explain, and question
- Interact verbally and non-verbally
- Develop phonological awareness (*syllables, rhymes, phonemes/graphemes, etc.)*
- Demonstrate understanding (*of themselves and of their social/cultural environment*) in different situations

Demonstrate openness to others and create links with them (sharing, empathy)
- Know how to work with others to solve conflicts *(with the support of an adult)*
- Self-esteem/respect for others
- Participate and contribute to group life
- Gradually learning everyday rules
- Express and regulate emotions *(with the support of an adult)*

Specific Exit profile "Science and Technology Awareness" at the end of ECCE (3-6 years)

As we have seen in the previous sections and on the basis of these broad foundations and concepts in science and technology (biological sciences, chemical sciences, physical sciences, life and earth sciences, engineering technology, energy and environmental technology, transport and mobility technology, etc.) and their possible adaptation to STA with the relevant contextualisation for learners, the learner, at the end of the cycle, must be able to (non-exhaustive list):

- Understand that the world is divided into two categories: living things (bacteria, protists, fungi, plants, animals) and non-living things (e.g. the four elements: fire, air, water, and earth)
- Describe the characteristics of the natural environment, e.g. by showing interest in tree species (bark-leaves-fruits) growing in the vicinity and recognizing their use in everyday life, while also showing interest and curiosity about any living elements encountered during outdoor excursions
- Initiate simple sensory experiences, encouraging curiosity and scientific exploration

- Encourage the understanding of natural phenomena through observation, classification, and experimentation
- Have some familiarity with the human body (e.g. anatomy of a skeleton, the main organs, the muscular system, the nervous system, the skin)
- Explore the characteristics of living things, including, for example, their needs (of our human body for health growth and development, or food - including where our food comes from - sleep, the dangers of sun exposure, safety)
- Have some familiarity with physical phenomena, such as meteorological phenomena (tsunamis, tornadoes, cyclones) with a specific pedagogical intent focused on explanation (e.g. observing waterways which are seeking a pathway to bigger waterways all the way to the ocean, or the weather and meteorological phenomena - this may be of little value for landlocked regions without access to the sea)
- Have some familiarity with technological phenomena, such as satellites or the new race to the moon
- Have some familiarity with matter/changes in the state of matter (e.g. water as a solid, liquid, or gas)
- Have some familiarity with simple technical objects (e.g. the wheel, gears, the light bulb, etc. and their uses in everyday life)
- Manipulate objects by using the concepts of colour, space, and shape
- Recognize the characteristics of geometric forms, knowing how to group and classify objects, put them in order, add new ones, take some away
- Use the reference points of the day and concepts, for example the Earth's movements in relation to the Sun, which give us the times of day, and the Earth's orbit around the Sun, which gives us the seasons and the year when there is a complete rotation (birthdays)
- Have a notion of time (e.g. explain the life cycle of an individual: infanthood, childhood, adolescence, adulthood, old age and/or position our era in time, from prehistory to the modern day, describe human evolution from Australopithecus to homo sapiens)
- Have a notion of space (e.g. where does the child live, where does the child come from, or address, city, province, country, continent, planet, solar system, galaxy, the universe, interest in all these “places” where we live)

Target skills and learning objectives in STA

Skills are intricately linked with the defined exit profile (both general and specific) and describe those skills which learners must acquire to continue to progress through the education process (which is why it is necessary to align STA skills and knowledge from ECCE all the way through secondary school).

These skills must be adapted to the child’s development, as can be seen from the latest research in neuroscience on the early years of life. The brain’s ability to establish neural networks and long connections between these networks signals its ability to develop more complex skills and abilities, in which **these are progressively integrated thanks to repeated experiences in different situations and contexts.** One key principle to the development of these skills is the STA approach, in which learners are encouraged/supported in their desire to understand and take ownership of the world they live in (simply performing a task or following instructions might undermine the effectiveness of STA).

With the support of their teachers/educators in learning about STA, learners will develop skills and knowledge that will allow them to:

- Conduct research and experiments and use technological or scientific design in problem-solving; this involves discovering their environment using the five senses, and knowing how to observe and describe it, to look for things, and compare and contrast
- Experience curiosity and a sense of wonder, which are at the heart of scientific knowledge and technological skills; this involves asking questions, making observations, and describing one's experience
- Become creative, inventive, and entrepreneurial, as well as confident about their ability to learn about science and technology; although creativity and imagination are most frequently associated with culture and the arts, they can also be found in STA, with new ideas being generated while examining community issues, problems, and concerns/challenges
- Continuously develop their interest, motivation, and understanding of the surrounding world
- Know how to work together to solve problems (often in the context of project-based learning), which includes emerging skills in communication, conflict management, planning and organisation, sharing ideas and listening to others' ideas
- Approach problem solving creatively; this involves reasoning, adaptation, and flexibility skills, continuous learning (i.e. growth mindset), resilience and risk taking

Different players along the curriculum chain (at various levels of the curriculum that is being prescribed, interpreted, implemented, and evaluated) must therefore reach an agreement concerning the exit profile and desired skills. Each of them will try their best, drawing on their expertise, to identify the most relevant ways of achieving this. Thus, teachers and educators will make sure to specify the main theme of their pedagogical intent, i.e. the plan for what they need to set up (strategies, resources, methods) to facilitate learning. Similarly, teacher and educator trainers will need to transcribe elements from the exit profile and skills so that they are appropriated and implemented in training (both initial and in-service) for teachers/educators.

Moreover, it is important to note that these guidelines are part of a curriculum transformation process that strives to make the learning process more learner-centred, with active learners who are taught based on their interests, motivations and needs, as well as previously acquired knowledge (in their families/communities for ECCE). The learning objectives - introduced here as target skills - cannot take the form of a requirement or be strict and highly structured, forcing learners to move from "learning" one concept to the next. Rather, there should be tendency to use these in a spontaneous and justified manner. Teaching strategies will need to be adapted so that the active learners' curiosity and creativity can be expressed in an environment in which relationships are built on trust, caring and respect.

b) Themes, content, and activities

In the critical analysis of the status of Science and Technology Awareness in 18 ECCE curricula in West and Central Africa, which was completed before this guide, it was noted that reliance upon the various fields of science and technology is often not desirable. For example, technology is usually limited to topics related to Information and Communications Technology (ICTs), including introducing young learners to recognizing and directly using digital tools (not without accounting for the risks[4] that overexposure to screens carries for brain development and therefore learning as well). To offer a broad spectrum of themes that can be the subject of contextualised reflection, we are reusing the (non-exhaustive) list of themes and subthemes presented in the critical analysis report (UNESCO-IBE, 2023). It includes 12 themes and about 50 related subthemes, broken down into science awareness on the one hand and technology awareness on the other:

Science Awareness

Living things

Theme	*Sub-themes*
Learning about my body	Health and hygiene
	Parts of the human body
	The five senses
	The body map
	The needs of the human body
The animal world	Characteristics of living things
	Insects
	Livestock and fish farming practices
	Pets and how to care for them
	Wild animals and their habitats
The plant world	The decomposition of matter
	Fruits and vegetables (harvest and consumption)
	Plants and their flowers
	How gardening works (where my food comes
	Fruit and non-fruit trees
	From seed to plant

Non-living things

Theme	*Sub-themes*
The materials	The qualities of surfaces
	Building materials
	The resistance of materials
	Natural/artificial materials
	Magnetic materials
Water	Buoyancy
	The states of matter
Air	Becoming aware of air
	Hot air and cold air
	Air and birds
	Air and music
Light and shadow	Light
	Colours
	Shadows
Celestial bodies	The sky and the stars
	Planet Earth
	The moon phases
	Time and how it's represented
The environment and climate change	Time and seasons
	The weather
	Recycling and composting
Natural resources	Renewable energy
	The water cycle
	Minerals and rocks

[4] *Numerous studies demonstrate the harmful effects of overexposure to screens among young children, such as language delays, trouble sleeping, problems with concentration, addictive behaviour.* Among others: JAMA Pediatrics (2019), "Association Between Screen Time and Children's Performance on a Developmental Screening Test"

Technology Awareness	
Objects	ITC (+)

Theme	*Sub-themes*
Objects	Construction objects
	Mechanical objects
	Rolling objects
	Magnetic objects
	Balanced objects
	Electrical objects

Theme	*Sub-themes*
Digital learning workshop	Device
	Software

<u>In order to avoid curriculum overload, themes should be selected based on four key points:</u>

- *Interdisciplinary themes and subthemes*: These themes and subthemes must be considered in a non-siloed manner, while ensuring a progression towards the exit profile and expected skills. For example, the theme of water can be addressed by exploring changing states of matter (solid, liquid, gas) from a "chemical sciences" perspective. This can then segue into an exploration of the water cycle and water filtration, while raising awareness of the importance of having healthy water for consumption, the impact on the environment and water management (from a "life and earth sciences" perspective) ***(see box 1)***.

- *Impact on the interconnected aspect of overall child development*: The themes and subthemes provide guidance to better direct potential activities that cover the expanded scope of science and technology. It is key to remember that one single activity can cover different areas of overall child development (language, cognitive, social/emotional, and psychomotor). This involves planning and preparing a thematic activity in order to achieve the various items in the expected exit profile (which can also be based on areas of development, as seen in the diagram below).

- *The relevance and adaptation of themes to local realities*: The development of an endogenous curriculum is anchored in national realities, capacities, needs, and resources. An endogenous curriculum has roots in a country's local history, culture, traditions, value systems, and challenges. If local plants are used for medicinal purposes or to manufacture soap or other cosmetic

<u>Box 1:</u> Example of a "Gardening and plant care" ECCE activity

<u>Objectives:</u> Developing an understanding of the life cycle of plants, observation skills, basic mathematics skills and use of technology.

1. Set up a small garden either inside or outside the classroom. Ask children to participate in planting seeds or young plants. Tell them how they can care for the plants by watering them, exposing them to sunlight, etc.
2. Invite children to regularly observe the plants (with a microscope if possible) and to record their observations in a journal. Encourage them to ask questions about plant growth and to see out answers by conducting research or by asking an expert for help (for example, a gardener or a teacher).
3. Use technology (online resources or camera, etc.) to document plant growth. Children can take photos at different stages of the life cycle of plants and make a slideshow or a digital album to follow their evolution.
4. Incorporate mathematical elements and ask children to measure the height of plants, count the number of leaves or flowers, or observe changes in growth over time.

This activity allows children to develop their understanding of life sciences, their observation skills, as well as their basic mathematical skills (e.g. recognizing numbers from 1-10, counting, enumerating, developing a number sense, recognizing quantities, recognizing attributes of size/length, recognizing series, categorising, recognizing some geometric shapes, understanding the concept of space). They are also introduced to using technology to document and track the plants' progress.

<u>Source:</u> UNESCO-IBE, A Critical Analysis of the Role of Science and Technology Awareness in ECCE Curricula in West and Central Africa, 2023

products, it is important to draw on this local wealth to help children explore the chemical sciences. Similarly, addressing the subtheme of the changing states of matter of palm oil can be relevant (depending on the region), while also looking into the negative consequences of using palm oil for other species (environmental science). Teachers/educators are invited to explore various subjects of possible interest in their local environments to help implement certain STA themes in a concrete and contextualised manner (e.g. learning about fish farming and visiting fish ponds), to keep track of the news in their country/region (e.g. if there is a cyclone), and to work with the educational community at school (e.g. with experts on the traditional pharmacopeia).

- *Coherent transition to themes treated in higher levels*: as stated above, Science and Technology Awareness in ECCE must be able to contribute to learning about science and technology in higher grades: motivation and interest in the ambient environment, demystifying this area, active pedagogy that promotes experimentation and research. A careful analysis of themes related to the experimental sciences (biology, chemistry, physics, earth science) throughout the children's school career must be carried out, while optimising the resources available outside of school ***(see box 2).*** Also, in view of research data on the hierarchical nature of emerging skills, experts on science and technology will need to contribute to help children identify and discover basic concepts such as force, friction, and weight, before they can acquire more complex concepts such as gravity, attraction and mass. In line with progressive learning in science and technology as per the Curriculum Orientation Framework (COF), this idea of increasing complexity can be defined based on the number of years of ECCE (ages 3-6) or the progression from ECCE (1 mandatory year in preschool) and primary education.

Box 2: Example of coherence and linkage between science practices

A primary school successfully planned high-quality progressive science curricula by collaborating and participating in effecitive cluster learning cycles. Teachers from three levels of primary school observed science classes in three levels of middle school, and vise versa. The goals of this partnership were to:

- Explore the manner in which the scope, depth, and challenges of learning were addressed
- Apply the learners' skills in new contexts
- Ensure that planning accounted for pupils' previous learning to avoid content duplication

The staff used the results from the learning sessions together with the relevant scientific literature to create well-planned learning programs that outline a clear progression and other important aspects of learning.

Source: Education Scotland (Scottish Government executive agency)

Activity planning

Within themes and subthemes, activities may be selected on the subject of salient, recognizable and relevant phenomena related to everyday life, which are suitable for exploration and practical discovery in the design of play- and discovery-based learning activities.

Experts in development and education can then define and design activities, allowing young learners to initiate the discovery of these basic notions. The same concept may be treated in a variety of activities, with a variety of materials to the extent possible, to ensure better ownership during the learning process. The activities (non-exhaustive list) can be organised as follows (See ***box 3):***

- In physical systems: phenomena such as atmospheric pressure, the mirror effect, light and shade, floating have demonstrated their usefulness
- In living systems: the process of growth and decomposition, growing plants, the categorisation of seeds, plants and animals based on different properties

- Within technical/engineering systems: drive systems (with gears), levers, pulleys/lifting. Chemistry was not included (it is harder to observe/experiment with chemical processes). Astronomy was also not included (but geospatial systems and the Earth were).

Box 3: Other examples of activities appropriate for children aged 3-6

- *Building structures:* Children can use building blocks, recycled materials, or construction kits to create simple structures. This promotes the understanding of basic concepts in engineering, physics, and geometry, while also developing fine motor skills and creativity.
- *Observing nature:* Outings and nature walks offer numerous opportunities for using the STEAM approach to learning. The children can observe plants, animals, insects and learn more about their habitat, growth, and life cycle by using tools such as magnifying glasses and binoculars.
- *Experimenting with water:* Activities involving water are perfect for exploring basic concepts in science and mathematics. The children can have fun measuring and comparing volumes of water, observing floating and flowing objects, and creating water circuits to study movement and forces.
- *Building simple electrical circuits:* Using safe and age-appropriate materials, the children can explore simple electrical circuits by using batteries, wires and light bulbs. This helps them learn about basic concepts in electricity and engineering.

c) Education strategies and pedagogical methods in STA

An education program can include examples of strategies or methods to guide the design of teaching tools or the work of the teacher/educator in the classroom. A learning strategy is the process of activities followed by the young learner (who learns through imitation, observation, experimenting, and questioning) to obtain knowledge and/or develop skills with the support of the teacher. The following possible strategies and methods may be considered:

- *Play-based learning*: there are many studies that mention play as the preferred way of teaching and supporting young learners in realising their full potential in ECCE. A rich environment where play - with a wide variety of games, including free play and symbolic play - is initiated by children and supported by adults allows children to explore, create, improvise, role play, manipulate, etc. Through play, children can improve their sensorimotor and affective memories, acquire knowledge and concepts, organise their thoughts, and forge their vision of the world to take ownership of reality. Through play, children also learn to develop their independence and their relationships with others. They make choices, take decisions, discover, produce ideas, imagine situations, and learn to focus on something without becoming distracted. They need to communicate with each other and sometimes perform the role of conciliator or mediator and find solutions. For children, the pleasure and satisfaction of play become important motivating factors, allowing them to remain engaged and persevere. Finally, in play, there is greater tolerance of errors; this allows learners to experiment with a trial-and-error strategy, which is so useful in Science and Technology Awareness: “errors” are extremely important as a learning experience. Accessibility, the amount of time allotted, the variety of games, and professional attitude are all factors impacting the correlation between play and the quality of learning. **While play is a key and recognized approach in ECCE, it can also be extrapolated to a broader context: active methods and a learning-centred approach, necessary in Science and Technology Awareness and relevant to other levels of education (especially primary school)**.

- *Competency-Based Approach (CBA)*: mainly used in Curriculum Orientation Frameworks in many African countries. Some countries use Teaching by Objectives (TO), a Pedagogy of Integration (PI), and/or

Scenario-Based Learning (SBL). As part of a socio-constructivist theoretical framework[5] that serves as the basis for SBA, this pedagogical approach is most suited for connecting the aforementioned foundations and concepts with high-quality Science and Technology Awareness. The two founding notions of SBA - skills development and integration - are at the very heart of STA: mobilising a set of knowledge, skills, and attitudes to know what to do and how to solve various everyday problems, facilitating a transfer and active recall of knowledge. Nonetheless, as stated above in the curriculum diagnostic study, it may involve theoretical frameworks contained in official texts, but it is important to conduct a careful analysis of the interpreted curriculum (teacher/educator trainers) and the implemented curriculum (teachers and educators): **obtaining an exhaustive understanding of how SBA or any other pedagogical approach (SBA/TO/PI) is implemented and using this field data to better support the implementation of STA.** Moreover, for the purpose of curriculum and program alignment (especially in science and technology), it is important to **ensure that the same pedagogical approach is applied to all levels of education, from ECCE through secondary education.** This must be included in both the Curriculum Orientation Framework and in the implementation of curricula across all areas, including science and technology.

- *Project-based learning* means that learners conduct a detailed and potentially interdisciplinary analysis of a subject of their choosing. The added educational value of this approach is that it places the interest of the learner front and centre in the sense that it is the pupils themselves, **individually or in small groups**, who can be encouraged to propose the subjects that interest them and that will become the focus of the project. This approach aims to enhance the pupils' creativity in solving difficult or poorly structured problems. The assumption is that if pupils select a subject that is interesting to them, this increases the likelihood that they will be involved in the research, thereby reinforcing their learning, and increasing their chances of success. Children learn best when they are proactive and actively involved in their own learning (Ledrapier, 2007). However, this approach requires upstream work from teachers because the schedule and the deliverables expected from the pupils must be ready by the start of the project.

- *The integrated STEAM approach* (Science, Technology, Engineering, Arts and Mathematics) incorporates science, technology, engineering, arts, and mathematics into the learning process. It encourages a holistic approach to these areas by combining knowledge and skills from them to foster creativity, problem solving and innovation. STEAM aims to develop transferable skills in children, such as critical thinking, collaboration, communication, and creativity. This integrated approach helps further de-silo themes, subthemes, and related activities in Science and Technology Awareness and explore a more interdisciplinary approach by connecting it with other areas of the ECCE curriculum.

d) Learning assessment

To observe children's progress in their activities, one must have a willingness to listen and be attentive to what is happening and what can be deduced from their words and body language. Professional observation helps identify the children's knowledge, learning, interests, and needs, as well as the questioning, attitudes, behaviours, processes, and strategies they have established. Activities are another opportunity to identify whether children need additional support, and to provide them with tools to promote their development;

[5] *The main principle is as follows: knowledge is obtained through experience. Learners must be active and obtain knowledge in a variety of situations, in contact with their environment (social, family, etc.). Learning takes place among peers and with the support of teachers/educators.*

observations are made during activities that bring children into their Zone of Proximal Development[6] (ZPD). **This professional observation of learning is important and offers opportunities for identifying new education strategies and/or pedagogical methods, helping to better target future educational interventions/activities, keeping in mind the desired exit profile and target skills.**

The interpretation of professional observations must be based on learners' knowledge and their overall development, on the ECCE curriculum, its educational aims, its components, and objective professional opinion. These observations can be cross-referenced with those made by other players in education (e.g. ECCE teachers and colleagues and/or other levels, school administrators, etc.). Moreover, the learning assessment resulting from this professional observation can raise the children's awareness of their learning and skills and help them to make progress. **This is a formative assessment, the kind recommended for ECCE.** Sharing this formative assessment with parents allows them to better understand the process/progression of learning (the way their child is learning) and the content of the available activities.

In early prevention and inclusive education, these observations and formative assessments, based on knowledge of children's overall development, can help detect developmental delays (e.g. in language, physical and motor development, etc.) and take remedial action, with potential support from health professionals.

Observation forms with an assessment scale (for one activity, or one step of a science activity, for example) and assessment grid must be developed in a consistent and relevant manner to ensure a quality teaching/learning process, in general and specifically in Science and Technology Awareness (STA). The conclusions of the curriculum diagnosis will help identify gaps in the learning evaluation system while making the most of the system's strengths.

The assessed items, the indicators, and the assessment scales must identify key benchmarks in the learning process, in relation to the expected exit profile and skills development. The two examples below illustrate the possible extent of the assessment.

<u>Example 1:</u> Assessment grid for assessing whether children have entered the zone of proximal development (assessment of the process, scientific approach, problem solving)

Items	Child's performance indicators		
	Works without the educator's assistance	Works with occasional assistance	Works with frequent assistance

<u>Example 2</u>: Template for an assessment grid for achievements or learning outcomes

Assessed skills/abilities	Indicators on an assessment scale		
	Acquired	In the acquisition process	Not acquired
Able to distinguish between objects based on their colour and properties (hard, soft, light, heavy)			

6 In neuroscience, the Zone of Proximal Development is a concept that refers to the (neuro)plasticity of the human (neuro)cognitive system. In practical terms, it refers to a range of capacities and skills that children can acquire with a little help, but which they cannot yet use on their own, i.e. the distance between the actual development level and the level of potential development. Development can be stimulated in this ZPD through various situations, tasks, and specific tools, including those related to STA. It is vital to consider the ZPD while professionally observing children's activities to promote the development of precursor, emerging, and more complex skills.

Able to classify objects based on their material and shape			
Able to distinguish between the stages of human development (baby, child, adult, old person)			
Able to connect animals with the food they eat			

e) Pedagogical and teaching resources

The pedagogical resources must offer a variety of learning situations. The materials and tools can be provided to learners depending on the student setup (individually, in small groups, or large groups depending on the context). Resources must be identified and selected in conjunction with the identified activities, which are themselves established to develop learners' specific skills in the various areas of the ECCE curriculum. **This means that the pedagogical intent of the teacher regarding the use of different materials must be clearly identified and explicit.**

Here are a few examples:

SEEING UP CLOSE	MEASURING TEMPERATURE	MEASURING DISTANCE AND LENGTH	MEASURING TIME	TRANSFORMING
Magnifying glass	Thermometer	Tape measure	Clock	Peeler and small gloves
Binoculars		String	Hourglass	Scraper
			Timer	Brushes

Resources may be organised in the form of experiment kits, the use of visual aids (can be interactive) for display in the classroom, tools for building and manipulating that allow for experimenting with scientific and technological concepts in a practical manner.

To place learners at the heart of the learning process, setting up a classroom space (providing materials and making sure they are accessible) is also an important element that must be considered in conjunction with the objectives, the selected themes, and available resources. The classroom may be organised to promote each child's participation and exploration of different games (e.g. motors, symbolic, manipulation, building, board games).

There may be both permanent (stay the same year-round) and modular areas (which would require a schedule) based on the objectives of the ECCE curriculum and of the various areas. Within these areas, the STA area can be set up as either a permanent and/or modular space to foster an atmosphere that would be conducive to the acquisition of skills in young children.

The external environment has a wealth of STA resources so that learners may observe, explore, manipulate, try out, reflect, imagine, use their memory, design projects, use their abilities and develop their motor, affective, social, language, and cognitive skills.

The use of simple "everyday" materials that are accessible to children is highly recommended; this requires creativity and basic knowledge of pedagogical content in science and technology on the part of teachers when planning activities. Partnerships with the education community (parents, civil society in science mediation, professionals in some areas of STA, etc.) make it possible to avoid the prohibitive cost of some materials and to incorporate STA into everyday life in the medium and long term.

Moreover, teachers and educators may draw inspiration from developmentally appropriate online STA educational resources: science podcasts for children (existing ones or to be created), science fairs (e.g. Science and Technology Week, launched 10 years ago in the Democratic Republic of Congo), TV series (e.g. Ubongo Kids in Tanzania with characters that learner can identify with).

f) The professionalisation of ECCE teachers and educators and curriculum alignment

The practical implementation of the ECCE curriculum, including the area of Science and Technology Awareness, requires quality support for teachers and educators (current and future) to achieve quality learning, particularly in STA. This support aims to help ECCE teachers and educators become thoughtful, committed professionals in their work as a whole and in Science and Technology Awareness (STA) specifically.

The curriculum providing curriculum guidance for teaching science and technology (including STA) must be created in conjunction with the curriculum in this specific area. This requires defining and developing the profile and required skills for ECCE teachers/educators, as well as expected professional attitudes in line with defined pedagogical approaches, the level and extent of necessary and relevant STA pedagogical content knowledge, and the STA teaching tools and materials that can be provided to them for activities.

Through scaffolding, teachers can ask learners to make predictions and to explain, using specific vocabulary as appropriate to summarise or rephrase explanations. Teachers themselves must be familiar with the basic concepts of STA, and guides and other specific and relevant materials are available to educators, explaining basic concepts and providing them with technical language and examples of design. **Pedagogical content knowledge in STA consists of aligning the way in which children explore and learn, reason and interact with the world (both living and non-living), as well as the factors that motivate them (natural curiosity) with the basic concepts of Science and Technology Awareness (STA):** Then they can be better supported in transitioning to more complex STA concepts. ECCE learning requires support from teachers and educators, whose role and extent of involvement can be made to vary based on specific situations, so that learners can learn the selected concept.

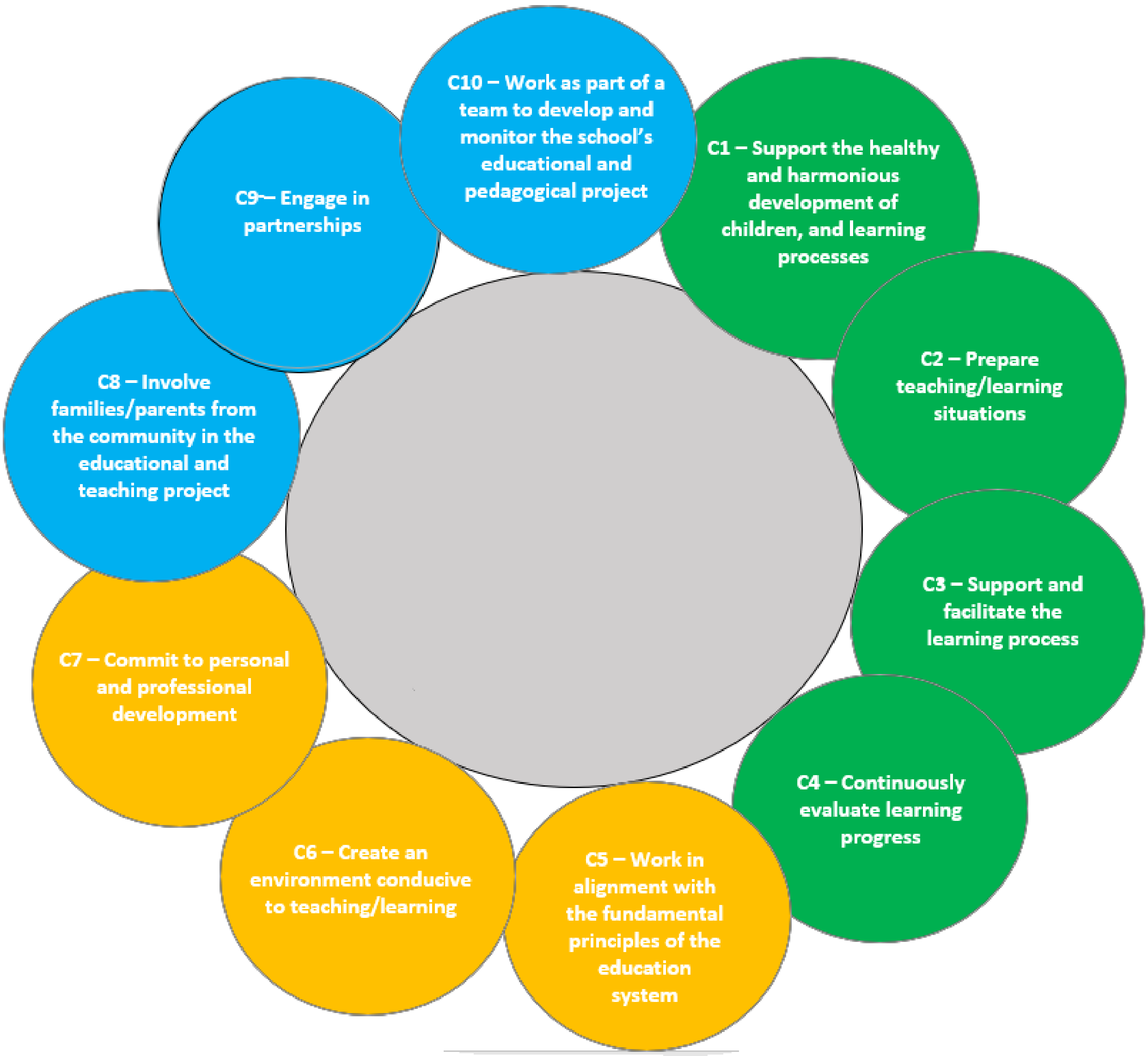
The adoption of relevant professional practices and attitudes is highly encouraged and needs to be supported (in initial and in-service training):

- Using a practical approach to encourage the children to engage in practical, concrete activities (e.g. simple scientific experiments, manipulations, building models, the use of appropriate technological tools)
- Creatively adapt learning content to local realities (agricultural techniques, natural resource management such as water, technological innovations)
- Encourage the children's creativity (asking questions, formulating problems and hypotheses for solving them, making an argument, etc.)
- Using adapted pedagogical resources for interactive learning
- Promoting cooperation among children, working together, or group projects
- Continuously using fun activities with a continuum from the activity initiated and led by the child (without learning objectives) to play-based learning initiated by the teacher (with learning objectives).
- Establish partnerships with the community to allow children to better understand how science and technology can be applied to everyday life and realise the usefulness of applying science (which can help motivate and interest children in science and technology).

- Adopting a holistic approach to the child: addressing multiple developmental and learning areas (and their relationships with one another) in an integrated manner in preschool education.

For teachers and educators to be able to adopt these professional practices and attitudes, they must be trained based on a skills framework that must be included in initial and in-service training, support on the ground, mentorship, etc. A general ECCE skills framework could lay a solid foundation for outlining the specific skills to be prioritised for STA teaching.

Diagram: Example of ten key skills for ECCE teachers and educators



This can be applied to Science and Technology Awareness (STA) in the following manner:

- Discipline-specific skills: understanding the scientific and technological concepts in the preschool curriculum to better adapt and use them with the children.
- Pedagogical and teaching skills: mastering methods for conducting learning activities appropriate to science and technology: discovery, interactive activities, using simple and contextualised materials, generating questions, helping to formulate a problem and simplified hypotheses to solve it, guiding practical activities, evaluating children's progress, using "errors" to help children make progress in science and technology activities, etc.
- Creativity and innovation skills: offer activities that encourage the curiosity and imagination of children in specific and technological phenomena, while relying on local (or endogenous) knowledge and practices.
- Interpersonal and communication skills: ability to listen, using age-appropriate language with children, encouraging discussion and exchanges among children, supporting, and facilitating fun STA activities, knows how to establish partnerships with the education community.
- Basic technology skills: knows how to use the relevant technological tools for STA (computer, cell phones, tablets, educational software, tutorials, etc.); able to use tools for measuring and setting up experiments.
- Reflection and support skills: develop self-assessment practices, support children in discovering, observing, modelling, problem-solving, rational argumentation, and communication.
- Intercultural skills: sensitivity to sociocultural differences, ability to contextualise or adapt scientific and technological knowledge to the situation and children's needs.
- Behavioural skills in ethics and professional conduct: ability to maintain a kind, warm approach with learners, building an atmosphere of trust that is conducive to learning.

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