**Republic of Zambia**

**Ministry of General Education**

# Guidelines for Assessing STEM Education in Zambia

*Directorate of National Science Centre*

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## List of Acronyms

| | |
|---|---|
| CA | Continuous Assessment |
| CDC | Curriculum Development Centre |
| DESO | District Education Standard Officer |
| ECZ | Examinations Council of Zambia |
| HOD | Head of Department |
| MoGE | Ministry of General Education |
| NSC | National Science Centre |
| SBCA | School Based Continuing Professional Development |
| SESO | Subject Education Standards Officer |
| STEM | Science Technology Engineering and Mathematics |

## Preface

The booklet was produced as a result of the STEM Curriculum development carried out by the Ministry of General Education under the auspices of Curriculum Development Centre and the Directorate of National Science Centre. The development of the STEM Curriculum started in December of 2019 when the Ministry of General Education was given cabinet approval to commence the implementation of the STEM curriculum in 52 pilot secondary schools. This booklet guides stakeholders in how STEM Education in Zambia should be assessed. The booklet provides assessment strategies that serve teaching and learning in STEM Education. Most of the assessment will be school based to assist and empower learners to learn and nurture them in the process. This booklet is intended to provide STEM assessment information to various stakeholders who include Learners, Teachers, Guardians, School Managers, Standard Officers and Educational Administrators.

The learners have the right to access this document so that they are aware of what is required of them in terms of assessment. The teachers too should access this document on grounds that they will be in charge of formative assessments and therefore need to understand their roles on how they need to conduct assessment. Teachers will also be assessed on how well they understand and implement curriculum intentions therefore; they equally need to know what is expected of them. Moreover, this document is important for school managers due to the dual roles they serve. It is essential for them to understand that they too will be assessed regarding the STEM school learning environment and strategies put in place as regards to effective STEM Education implementation. Additionally, to ensure effective implementation of STEM Education, Standards Officers and Education Administrators need to understand what and how to assess in STEM education. Further, guardians can also access the guidelines for assessing STEM Education booklet in order for them to have insights and help guide their children on assessment expectations.

It is imperative that all stakeholders that will be involved in the assessment of STEM education ensure salience, validity, reliability, fidelity and robustness in assessment. It is sincerely hoped that these guidelines for assessing STEM Education will greatly contribute positively in assessing learners and ultimately bring out the quality of learners expected in STEM Education.

## Acknowledgement

The Ministry of General Education wishes to express gratitude to all those who participated in the development of the STEM Curriculum and subsequently Guidelines for Assessing STEM Education in Zambia.

Sincere thanks to Curriculum Development Centre staff, Directorate of National Science Centre staff and Examinations Council of Zambia staff for their valuable contributions and guidance.

# 1. Introduction

The success of any intervention, STEM Education inclusive requires a robust multi-sectoral system in order to attain its intentions. The way such a system is tracked from process to product will speak to its success or failure. In the context of STEM Education, assessment is a critical aspect of the teaching and learning process that will help determine the extent of achievement of the courses' learning objectives. The objective of STEM Education is to produce a learner who is a Critical, Creative and Analytical Thinker (CCAT).

This document therefore, stipulates guidelines for assessing STEM Education in Zambia. This guideline will be used by learners, teachers, teacher educators, education officers, the community and other stakeholders. Through this guideline a clarity of purpose on STEM Education as regards to the what, why, how and who issues surrounding this aspect is provided. To this effect the operational definition of assessment in STEM Education encompasses institutional management, curriculum intentions, teacher and teaching as well as learner and learning. Therefore, in the context of STEM Education in Zambia, assessment is viewed holistically to include learners learning, teachers teaching as well as the curriculum and context.

## 1.1. Types of Assessments in STEM Education

There are different types of assessment in education due to varying purposes they serve. However, all assessments provide an idea of learners' understanding at a particular time in the learning process. In Zambia's STEM Education the types of assessment will involve formative and summative. In both of these two types of assessment the process and product will be given attention with emphasis on skills acquisition.

### 1.1.1. Formative Assessment

Formative assessment is the type of assessment that will be used to monitor, track and provide feedback on learners' learning progress. It will also help to refocus learning by adjusting teaching and learning strategies. In the context of STEM Education in Zambia, formative assessment will include; institutional management, tests, assignments, practicals, research, and workbook management. Formative assessment is 65% of the total aggregate marks.

### 1.1.2. Summative Assessment

Summative assessment will be aimed at assessing the extent to which learning outcomes have been understood at the end of the learning period. In this context, summative assessment will be at the end of the two and three years for junior and senior secondary school learning respectively. Summative assessment is 35% of the total aggregate marks.

### 1.2. Contextual Framework of Assessing STEM Education

During assessment, data and feedback on all aspects of the learning process will be involved. Learning cannot happen effectively unless the curriculum, teaching and the institutional management are effective. Therefore, assessment of STEM Education will involve institutional management, teachers teaching and learners learning as shown in Figure1.

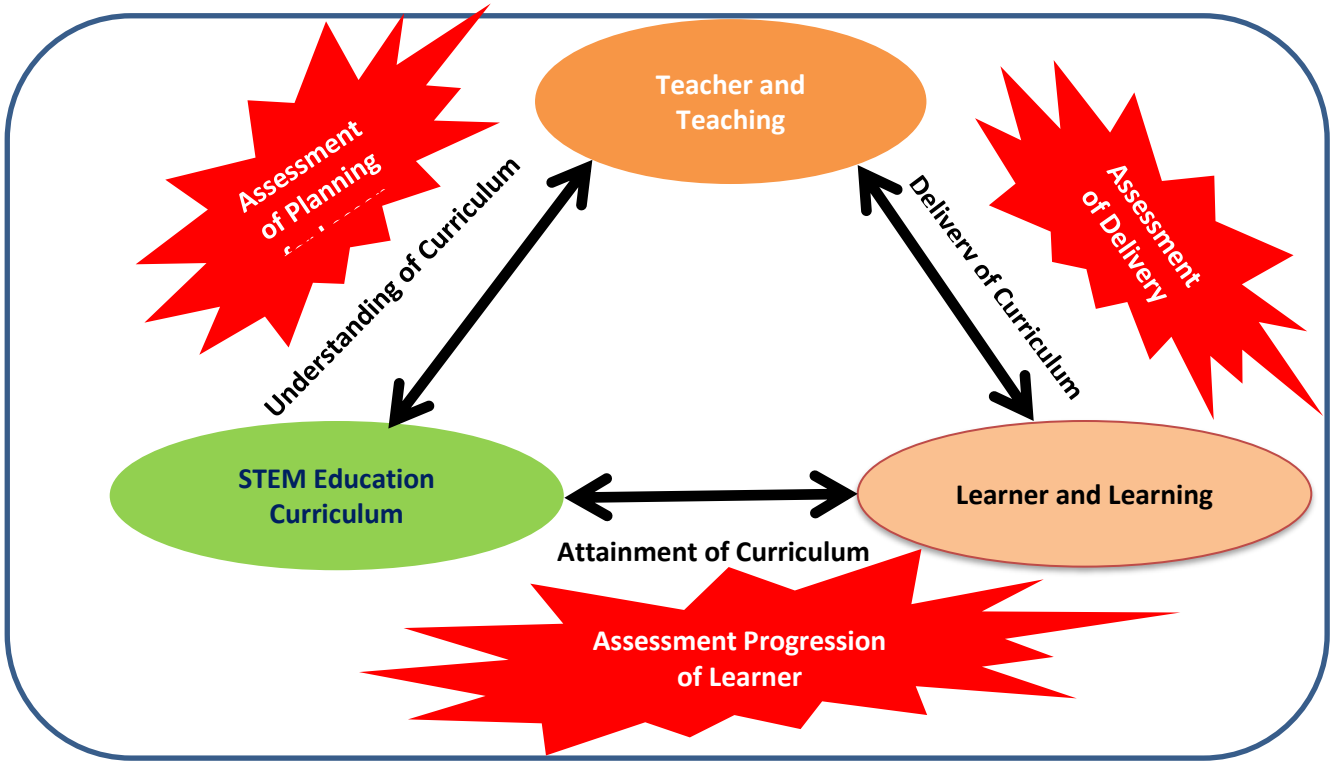


*Figure 1: Contextual Framework of STEM Education assessment*

#### 1.2.1. Institutional Management Assessment in STEM Education

Assessment does not pertain solely on the classroom and learners' achievement; however, it should be visualized holistically within a specific context occurring before, during and after the learning process. In this regard assessment in STEM Education also encompasses institutional management. Learner achievement in the learning process is dependent on institutional management in terms of conducive learning environments created in order to attain the intents of the curriculum. Using aspects such as specialized rooms, furniture, competent human resource, Continuing Professional Development (CPD) strategies as well as provision of teaching and learning materials the institutions can be assessed on the extent of managing STEM Education.

### 1.2.2. Curriculum in STEM Education

The assessment of STEM Education curriculum includes; assessment of the intended curriculum and teachers understanding of STEM curriculum through planning for lessons. STEM Education advocates the use of constructivist learning approaches that demands learners to take center stage in the learning process. STEM Curriculum seeks to develop learners who are:

i. Critical, Creative and Analytical thinkers (CCAT) \
ii. Able to relate thinking with real world situations
iii. Problem solvers
iv. Responsible citizens

Therefore, in assessing STEM Education curriculum understanding stakeholders' validation of lessons to be taught should hinge on how curriculum aspects such as Topic, Subtopic, Outcomes, Knowledge and Skills are understood. This is going to be assessed using planned lessons, suitability of teaching and learning aids alongside resource materials consulted during lesson preparation.

### 1.2.3. Teacher and Teaching in STEM Education

In STEM Education, since implementation takes place through the interaction of the learner and the planned learning opportunities, the teacher's expertise shall be assessed in line with learning expectations. To this effect, the focus of assessing the teacher and teaching will not only be on the pedagogies used in lesson introduction, development and conclusion but also on the ability of the teacher to foster critical, creative and analytical attributes in the learners.

### 1.2.4. Learner and Learning in STEM Education

Assessment practices that focus on the learner and learning is of paramount importance in STEM Education. This shall involve a continuous flow of practices that will take place before, during and after the teaching and learning process. The assessment of the learner and learning shall encompass STEM skills attainment by learners who come out of the STEM schools. The continuous assessment process will include Tests, Assignments, Practicals, Research and Workbook Management.

## 2. Scientific Skills Assessment in STEM Education

In STEM Education, Scientific skills acquisition are major aspects that will help establish whether the curriculum intentions have been attained or not. In the context of STEM Education in Zambia, Scientific Skills shall refer to proficiencies needed to; study and apply Science, design and utilise Technology effectively, design and develop Engineering innovations, and solve Mathematics and apply Mathematical literacy. As learners go through the learning process, it is expected that they shall acquire certain educational attributes known as scientific skills, which take place as

progressive attainment of learning outcome(s). It is from skills that we can attain a learner who is: critical, creative, analytical, innovative and an inventor. For STEM Education skill acquisition will be assessed in both formative and summative assessments. To this effect, at every level in the teaching and learning process as shown in the scientific skills conceptual framework STEM skills need to be well grounded.

### 2.1. Scientific Skills Conceptual Framework

Figure 2 shows the STEM Education conceptualization of scientific skills. In order to produce desired STEM attributes in learners, all the three levels of; the understanding of curriculum intentions, teaching and learning process, delivery and attainment of curriculum will have scientific skills typified. This is because ideally scientific skills are an integral part in the lives of learners as they help in eliciting thinking, problem solving, creativity and innovativeness.

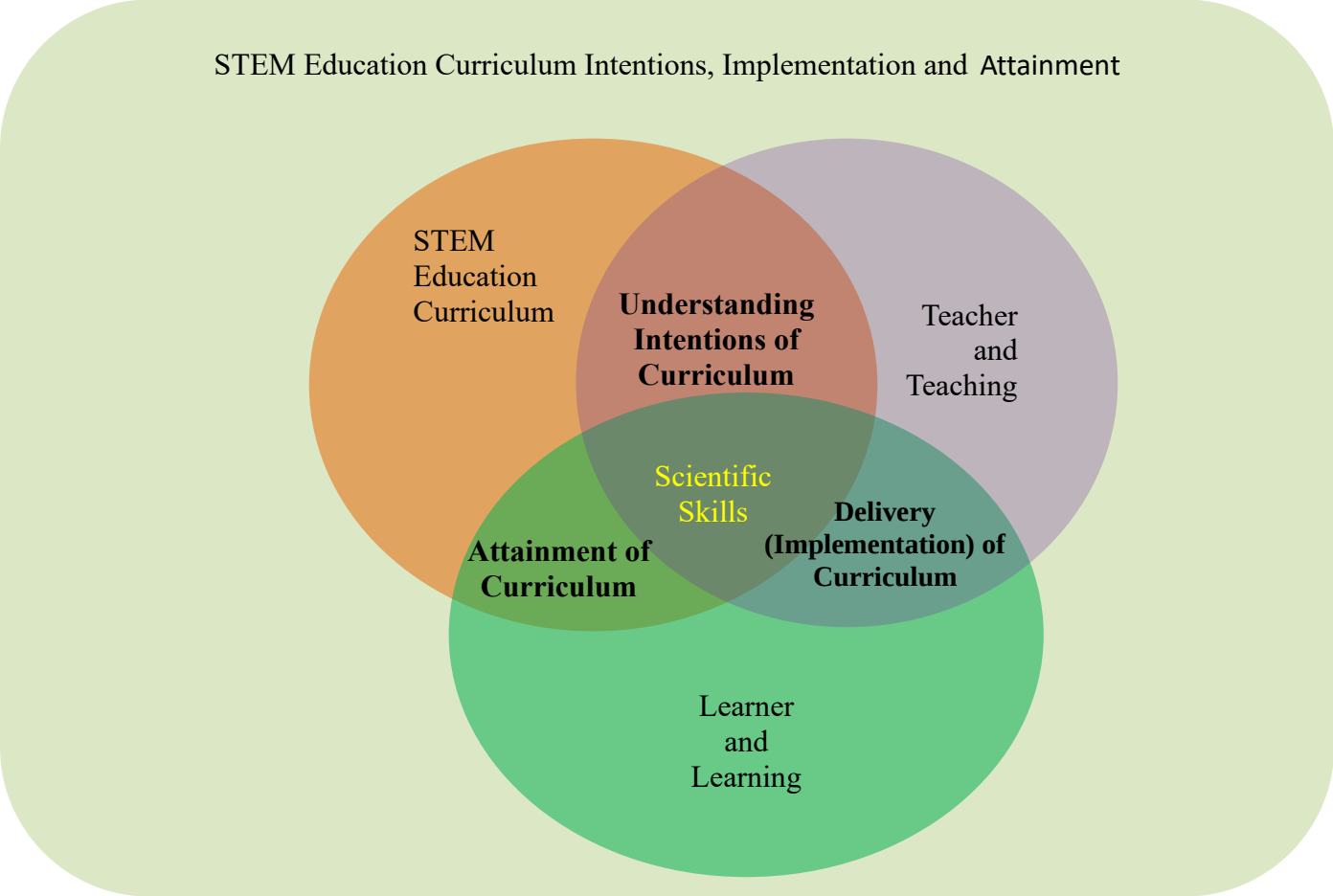


*Figure 2:Scientific Skills Conceptual Framework*

### 2.1.1. STEM Education Curriculum Scientific Skills Assessment

STEM Education curriculum emphasizes on the acquisition of scientific skills. To ensure these skills are acquired, STEM advocates the use of constructivist learning approaches that demands learners to take center stage in the learning process. Zambia's STEM Education curriculum is a three-way model of theories, practices and product development. To this effect, STEM Education curriculum intentions aim at eliciting desirable STEM skills.

### 2.1.2. Teacher and Teaching Scientific Skills Assessment

The teacher, being the bridge between the curriculum and the learner, should be a facilitator in the process of attainment of the skills and competences. To meet the demands of the curriculum intent, the teacher needs to have adequate pedagogical content knowledge to help them plan for lessons which will bring out expected learning outcomes. Therefore, desirable scientific skills are expected to be elicited by the teachers during lesson delivery.

### 2.1.3. Learner and Learning Scientific Skills Assessment

The focus of STEM Education is to produce a holistic learner who is creative, critical, analytical and innovative. The constructivist learning approaches used in STEM Education makes learners to be active participants as seen in the following teaching and learning techniques:

a) Problem posing / situation [teacher]
b) Hypothesizing [learner]
c) Designing solutions [learner]
d) Presenting solutions [learner]
e) Confirmation of solution [learner and teacher]
f) Further problem posing [ learner and teacher]

This learner driven approach to teaching and learning ensures that learners spend adequate time on various learning activities so that they develop the necessary skills and competences needed in life. The learners will be able to exhibit expected scientific skills if there is an effective reflux relationship between the teacher & teaching and the learner & learning processes.

## 2.2. Scientific Skills Attainment in STEM Education

In STEM Education learners are expected to develop certain STEM Skills during and after the teaching and learning process. To attain desired STEM Skills there should be blend amongst Curriculum intentions, teacher's understanding of the curriculum intentions and delivery of the curriculum. The Scientific skills expected to be enhanced and developed in the learners include broader categories of Acquisitive, Organizational, Manipulative, Creative and Communicative skills.

### 2.2.1. Acquisitive Skills

Acquisitive Skills are the ability to possess and accumulate intrinsic potential for eagerness to input information through sensory channels and proprioception in both passive and active ways in order to process it for making decisions about a situation or concept.

*Characteristics of Acquisitive Skills*

The 9 sub-acquisitive skills that should be elicited are described in Table 1.

*Table 1 :Description of Acquisitive skills*

| Category | Skills | Description of skill |
|---|---|---|
| Acquisitive | (i) Listening | - Ability to accurately receive and interpret messages in the communication process |
| | (ii) Observing | - Ability to use five senses to derive characteristics of objects, events, attitudes and phenomena |
| | (iii) Searching | - Ability to know where to find information - the key texts in your area, the journals, primary sources, etc., and how to get hold of them.<br>- Ability to know what information is needed – understanding topic and knowing the key concepts you should research. Knowing how to search the sources - using keywords etc.<br>- Ability to record your searches, so that you have an 'audit trail' |
| | (iv) Inquiring | - Ability to ask questions, and then research, interpret, share, and reflect on answers<br>- Ability to apply and use higher order thinking skills like analysis and synthesis<br>- Ability to develop curiosity, critical thinking, and independent thinking |
| | (v) Investigating | - Ability to develop active listening, questioning. interviewing, funnelling, summarising and note-taking |
| | (vi) Gathering data | - Ability to effectively collect and curate data for research purposes |
| | (vii) Researching | - Ability to search for, locate, extract, organise, evaluate and use or present information that is relevant to a particular topic |
| | (viii) Defining operationally | - Ability to state how to measure a variable in an experiment |
| | (ix) Formulating hypotheses | - Ability to state the expected outcomes of an experiment |

### 2.2.2. Organizational Skills

Organizational Skills are the capacity to manage and stay focused on different tasks by using time, energy, mental strength and physical space effectively through forming structures within which order of doing tasks is clear and coordinated to achieve the desired outcomes.

*Characteristics of Organizational Skills*

The variety of organizational skills include; recording, comparing, contrasting, classifying, organizing, outlining, reviewing, evaluating, analyzing, predicting, inferring and interpreting data. These skills are described in table 2 below.

*Table 2 : Description of Organizational Skills*

| Category | Skill | Description of Skill |
|---|---|---|
| Organisational Skills | (i) Recording | - Ability to select and keep useful information, usually focused for a specific purpose |
| | (ii) Comparing | - Ability to find similarities between or among objects, ideas, entities, concepts, events, or other subjects in order to organize both new and known information |
| | (iii) Contrasting | - Ability to find differences between or among objects, ideas, entities, concepts, events, or other subjects in order to organize both new and known information |
| | (iv) Classifying | - Ability to sort, group and arrange events, ideas, concepts and entities based on similarities and differences |
| | (v) Organising | - Ability to create structure and order as well as to efficiently manage time, workload and resources in order to improve productivity and lower stress level |
| | (vi) Outlining | - Ability to list the general features of a research/experiment/event/story in order to shape research/experiment/event/story as intended |
| | (vii) Reviewing | - Ability to learn from experience in order to get more from the work, allowing for flexibility and paying attention to detail |
| | (viii) Evaluating | - Ability to assess the credibility of the claims, and to assess the quality of the reasoning of the arguments or explanations |
| | (ix) Analysing | - Ability to collect and analyse information, problem-solve, and make decisions<br>- Ability to develop a logical and rational approach to tackling new ideas, sorting information, and discovering creative solutions |
| | (x) Predicting | - Ability to state the outcome of a future event based on a pattern of evidence |
| | (x) Inferring | - Ability to explain observations and data |
| | (xi) Interpreting data | - Ability to organise, conclude from data and make sense of data |

### 2.2.3. Manipulative Skills

Manipulative Skills are the ability to physically interact with the materials or procedures to help in understanding of the underlying principles which might also involve some alterations in order to enhance the performance of equipment and functionality of processes

*Characteristics of Manipulative Skills*

Table 3 shows STEM Education Manipulative skills. From the descriptions of manipulative skills, it is evident that these are the key drivers in STEM Education.

*Table 3 : Descriptions of Manipulative Skills*

| Category | Skill | Description of Skill |
|---|---|---|
| Manipulative Skills | (i) Using, handling and maintaining instruments | - Ability to use, handle and maintain instruments and apparatus appropriately and carefully |
| | (ii) Demonstrating | - Ability to give a practical exhibition and explanation of (how a machine, skill, or craft works or is performed).<br>- Ability to clearly show the existence or truth of (something) by giving proof or evidence |
| | (iii) Experimenting | - Ability to test by following procedures to produce verifiable results |
| | (iv) Constructing | - Ability to build or make something or form an idea (scientific) or theory by bringing together various conceptual elements |
| | (v) Calibrating | - Ability to correlate readings of (an instrument) with those of a standard in order to check the instrument's accuracy and to adjust (experimental results) to take external factors into account or to allow comparison with other data |
| | (vi) Measuring and using numbers | - Ability to use standard and non-standard measures to describe dimensions |
| | (vii) Controlling variables | - Ability to identify variables, keep variables constant and manipulate variables |
| | (viii) Handling specimen correctly and carefully | - Ability to organise, manipulate and manage specimen correctly in order to gather information about them |

### 2.2.4. Creative Skills

Creative Skills are the ability to perceive and think in an imaginative approach about physical occurrences to enable one to find hidden patterns and make connections among apparently discrete concepts in order to generate novel or unorthodox solutions and come up with something new to address the present and future challenges.

*Characteristics of Creative Skills*

Creative skills are the main drivers of STEM education as they have intrinsic characteristics that if used effectively can help propel sustainable development. The inherent problem solving qualities of creative skills are described in Table 4 .

*Table 4 : Description of Creative Skills*

| Category | Skill | Description of Skill |
|---|---|---|
| Creative Skills | (i) Planning ahead | - Ability to develop strategies to accomplish goals<br>- Ability to anticipate what is needed to know, to have, and to do, in order to achieve set goals |
| | (ii) Designing | - Ability to think creatively and visualise new ideas, relationships, applications, systems and products in order to develop solutions |
| | (iii) Inventing | - Ability to get new materials or processes by disassembling items in order to manufacture discoverable devices<br>- Ability or process of creating or making up something or figuring out a way to do something |
| | (iv) Synthesizing | - Ability to combine parts of a whole in new and different ways by thinking flexibly, determining alternatives, and finding new ways to accomplish a given task |
| | (v) Formulating models | - Ability to create a mental or physical model of a process or event |
| | (vi) Sketching specimen and science apparatus | - Ability to develop visual recall, rendering, and novel visualization of specimen and science apparatus |

### 2.2.5. Communicative Skills

Communicative Skills are the ability to effectively inquire and engage others, to obtain or disseminate vital information, coherently and clearly through the use of mutually understood symbols, signs and semiotic rules in order to make sense of what is intended. Table 5 below shows descriptions of communicative skills

*Table 5 : Description of Communicative Skills*

| Category | Skill | Description of Skill |
|---|---|---|
| Communicative | (i) Questioning | - Ability to ask appropriate and relevant questions in order to obtain information, clarify a point, test knowledge or encourage further thought |
| | (ii) Discussing | - Ability to state an opinion confidently and ask for others' opinions<br>- Ability to argue constructively, offer suggestions and express uncertainty |
| | (iii) Explaining | - Ability to present the subject matter in a simplified form and making it acquirable<br>- Ability to use verbal and non-verbal cues at appropriate times in a discussion to show understanding by describing logically' how', 'why' and 'when' concept etc. ... |
| | (iv) Reporting | - Ability to provide status information, detailed descriptions of the tasks or communication to show presence |
| | (v) Writing | - Ability to put feelings and ideas on paper, to organize knowledge and beliefs into convincing arguments, and to convey meaning through well-constructed text |
| | (vi) Criticising | - Ability to judge the merits and faults of something<br>- Ability to provide constructive arguments for improvement, and being able to withstand the pressure of unfair or dispiriting criticisms while motivating oneself to work harder and better instead of giving up |
| | (vii) Graphing | - Ability to read, construct, analyse and interpret graphs and graphical information in order to visually communicate information |
| | (viii) Teaching | - Ability to use appropriate pedagogy and didactics in order to facilitate learning and communication |
| | (ix) Communicating | - Ability to use words or symbols to describe an action, object or event |

## 3. Continuous Assessment in STEM Education

In the context of STEM Education, Continuous Assessment is the frequent evaluation of learners' learning performance and progress through out a prescribed course of study as distinct from

examination. Continuous Assessment (CA) is an integral part of the STEM Education teaching and learning process. It helps to determine whether teaching and learning has taken place and outcomes have been achieved. Learners interact with their learning environment in which teachers operate as curriculum implementers. This interaction between the teachers and learners offers great opportunities for teachers to assess learning of their learners. To this effect, upon entry into a STEM school, learners need to be continuously assessed by their teachers under the supervision of the head of department, deputy Head-teacher and the school Head-teacher. The essence of school-based assessment is to encourage both learners and the teachers to take responsibility of the learning and teaching and own them respectively. Formative assessment will be used in the continuous assessment of learners.

### 3.1. Continuous Assessment Conceptual Framework

Continuous assessment in STEM Education will involve assessing learners using practical work, tests, assignments and workbook. STEM Education Continuous Assessment will comprise 65% of the School-Based Continuous Assessment (CA). The 65% will be distributed as follows: Assignments 30%, Practical's' 20%, Tests 10% and Workbook Management 5%. Figure 3 shows the Conceptual Framework of Continuous Assessment.

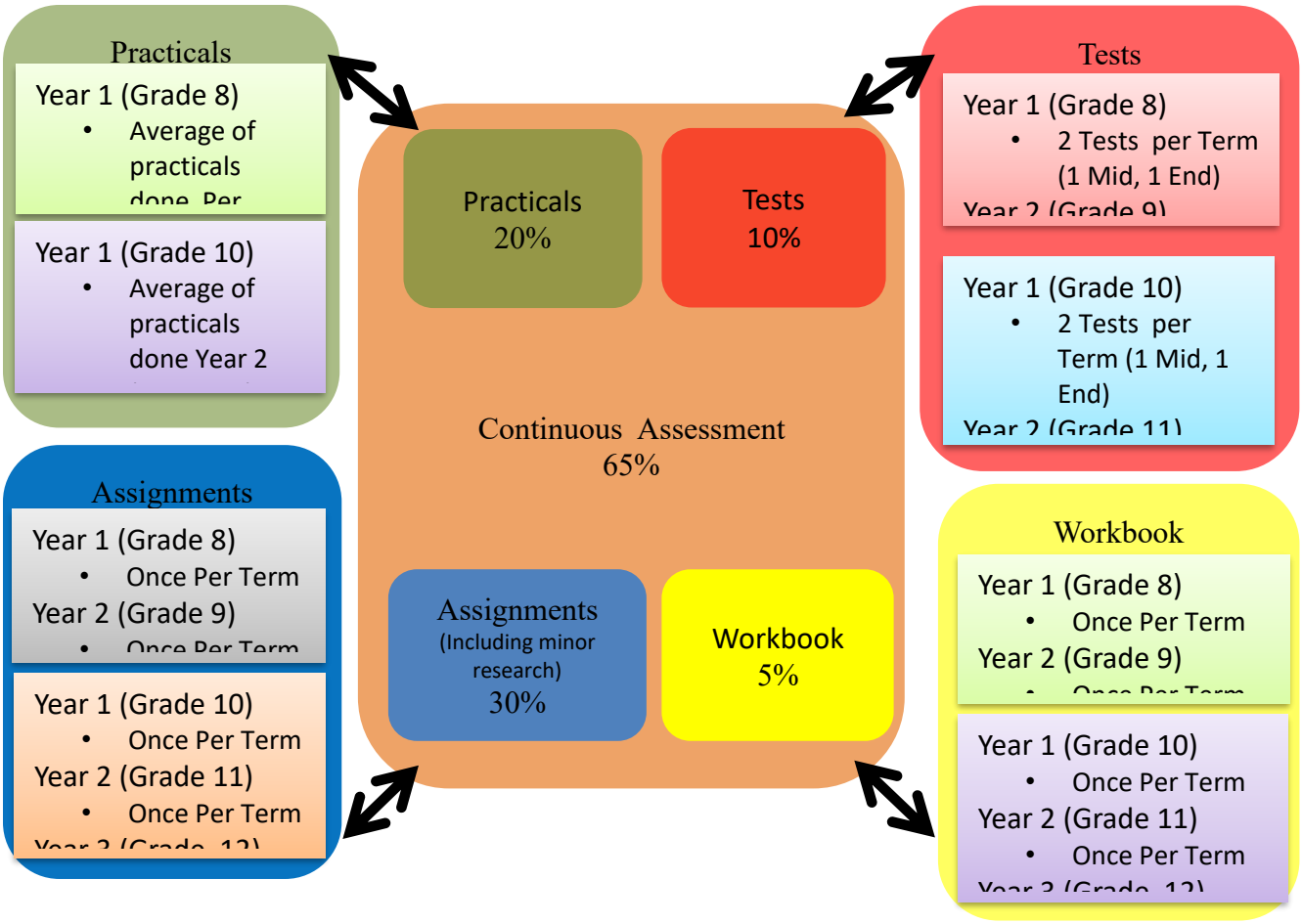


*Figure 3 :Continuous Assessment Conceptual Framework*

Components that would need to combine such as junior Biology, Chemistry and Physics into Integrated Science, shall administer CA within the distinct component and then the total aggregate percentage shall be the average percentage of the assessments of all the sub subjects.

### 3.1.1. Tests in Continuous Assignment

In STEM Education tests are written tasks with a specified time allocation intended to measure a learner's knowledge and skills. Learners are required to write these tests on hardcopy or softcopy. Additionally, some electronic tests will require to be answered and submitted in real time. The tests will carry 10 % of the 65 % marks allocated for continuous assessment. Figure 4 shows details of tests to be considered for assessment at both Junior and Senior Secondary levels.

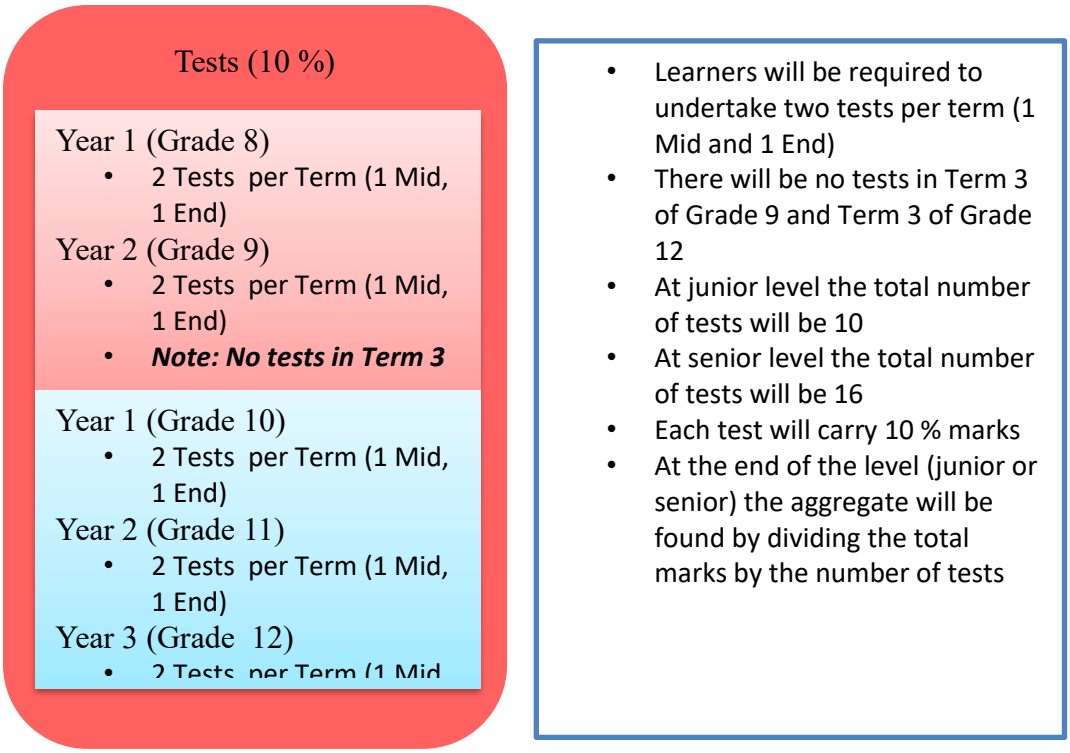


*Figure 4 : Detailed Illustration of Tests in continuous Assessment*

### 3.1.2. Practicals in Continuous Assessment

Practicals are assessment tasks which involve learners working in groups or individually as they observe and manipulate objects to build up understanding of concepts through collection, processing and interpreting data. In STEM Education practical work shall include a range of activities and is also used for a range of purposes, such as:

a) Illustrating concepts or ideas to help students generate arguments from evidence in the process of knowledge construction

b) Developing skills and learning how to use Scientific, Technological and Mathematical equipment

c) Developing experience and understanding of 'the nature of a learning area.

Practical Work will carry 20 % of the 65 % marks allocated for CA. Figure 5 is a detailed illustration of the assessment criterion of practicals in continuous assessment. the 20 % marks.

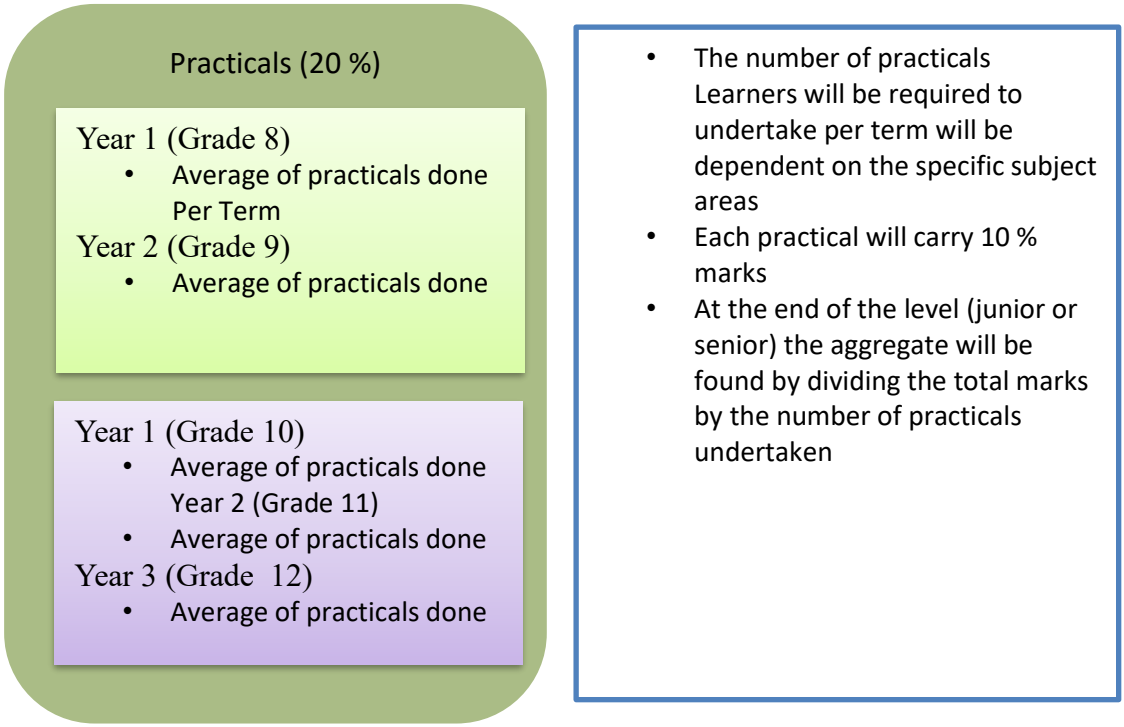


*Figure 5 : Detailed Illustration of Practical's in Continuous Assessment*

In STEM Education, the number of practicals learners will be required to undertake in a term will be dependent on the specific subject area. The aggregate will be found by dividing the total marks obtained by the number of practicals undertaken at the end of Junior or Senior course.

### 3.1.3. Assignments in Continuous Assessment

Assignment are tasks assigned by teachers to STEM learners for completion outside regular class time on content already done or yet to be done. They are intended to enhance learners' learning capabilities. Assignments should be allocated to learners as part of the course of study at Junior and Senior levels. Each assignment will carry 10% marks except for the major assignment which will carry 20% of the 65 % marks allocated for CA. Learners will be required to do one assignment per Term at both junior and senior levels. There will be no assignment in Term 3 of Grade 9 and Term 3 of Grade 12. The total number of assignments will be 5 and 8 at junior and senior levels respectively. Each assignment will carry 10% marks except for the research-based major assignment which will carry 20%. At the end of the level (junior or senior) the aggregate will be found by dividing the total marks obtained by the number of assignments given. Details are indicated in Figure 6.

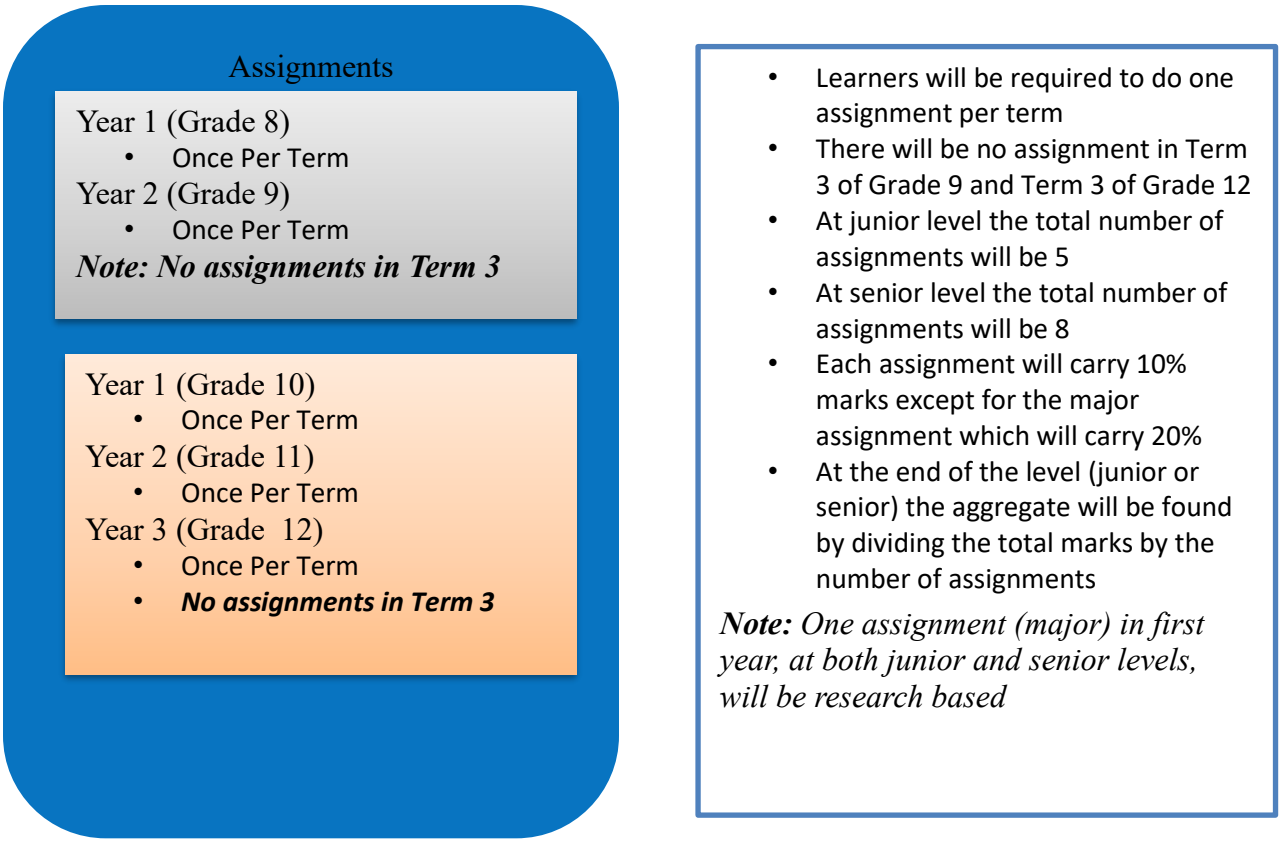


*Figure 6 : Detailed Illustration of Assignments in Continuous Assessment*

The major assignment will be research-based. Like all other assignments the subject teacher will assess the major assignments with a focus on eliciting research skills in learners. It can be in form of laboratory work or not but should incorporate elements of research such as Title, Table of Contents, Abstract, Introduction/Background, Objectives/Research Questions, Problem Statement, Literature Review, Methodology, Results/Findings, Conclusion, Recommendations, References. The detailed description and assessment criteria of the major assignment are given in Table 6.

*Table 6 : Detailed Description and Assessment Criteria of Major Assignment*

| S/N | Detailed Description | Weight Allocation | |
|---|---|---|---|
| A. | **Sequential logical flow** | | |
| | Title and Table of Content | 0.9 | |
| | Abstract *(purpose of study, research gap, methodology, major findings, implications, recommendations, key terms – 3 to 5, 250 words)* | 1.6 | |
| | 1. Introduction/Background | 1.6 | |
| | i. Objectives/Research Questions | 1.6 | |
| | ii. Problem Statement | 1.6 | |
| | 2. Literature Review | 1.6 | |
| | 3. Methodology | 1.6 | |
| | 4. Results/Findings | 1.6 | |
| | 5. Discussions | 1.6 | |
| | 6. Conclusion | 0.9 | |
| | 7. Recommendations | 0.9 | |
| | 8. References – quality of reference (APA) | 0.9 | |
| | **Subtotal** | | **16.4** |
| B. | **Formatting** | | |
| | Font type – Times new Roman | 0.9 | |
| | Font size – 12 points | 0.9 | |
| | Line spacing – 1.5 | 0.9 | |
| | Page numberings | 0.9 | |
| | **Subtotal** | | **3.6** |
| | **Total** | | **20** |

## 4. Workbook in STEM Education

In the context of STEM Education in Zambia, a **Workbook** shall be referred to as a learner repository platform in either soft or hard copy format in which learners document their learning activities and experiences validated by the teacher in the process of teaching and learning with the view of attaining CCAT learner status. Therefore, learners need to document tasks in line with the concepts they will be learning in the workbook or activity book. For each lesson the layout of the learner's book can vary depending on what is being taught and learnt. In the workbook, the learner should put down the most important pieces of information on the new knowledge while the teacher will get the evidence of the thought organization of the learner in the learning process. As such the learner's workbook becomes a major resource for a learner to organize the thoughts and the learning progress in a coherent way for present and future references. The bias of this workbook should be in line with the constructivist STEM ideals.

### 4.1. Conceptual Framework of a STEM Workbook

In order to attain desired learner out comes the workbook will interpret curriculum intentions and practices as shown in Figure 7

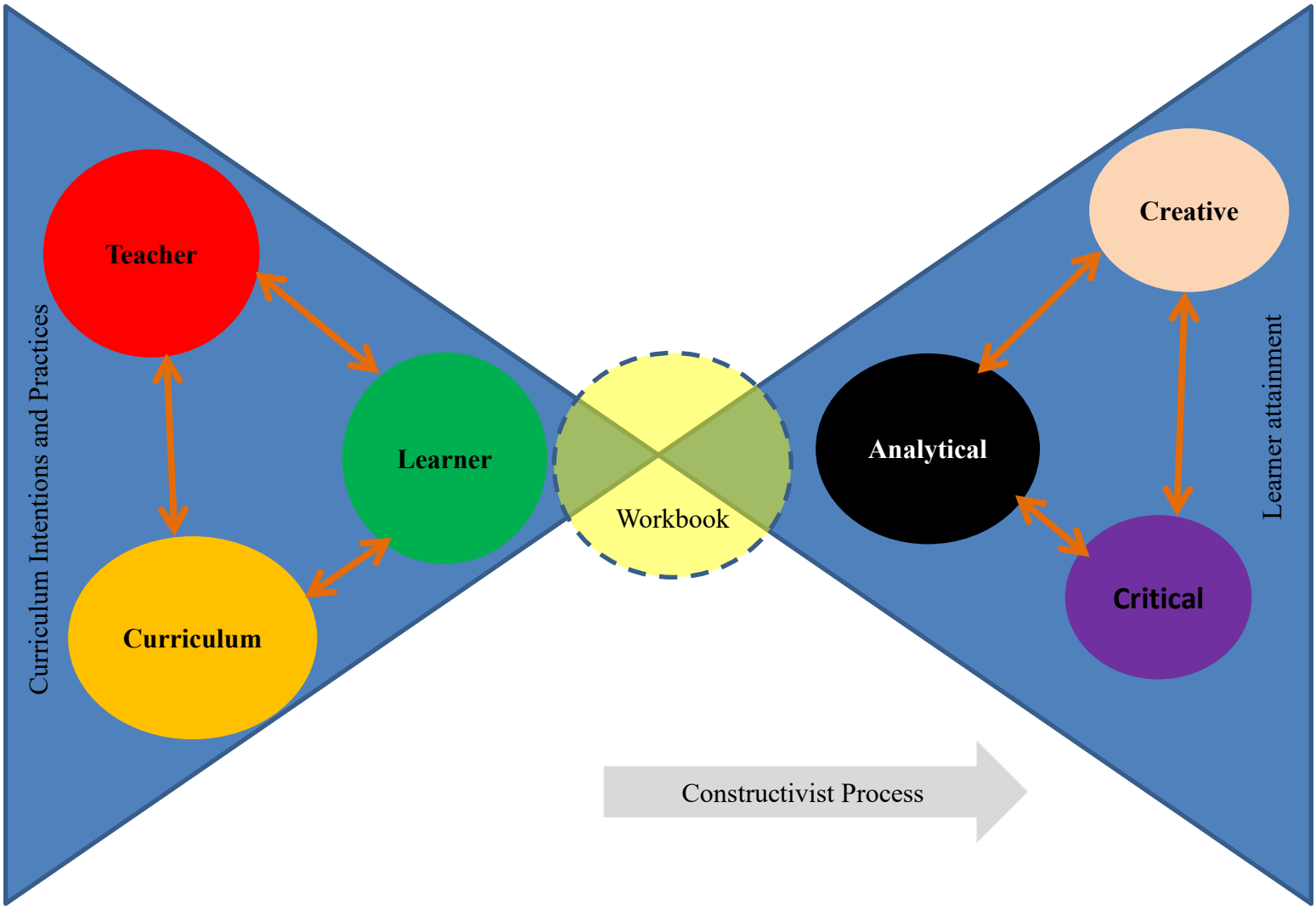


*Figure 7 : Conceptual Framework of STEM Workbook*

#### 4.1.1. Curriculum Intentions and Practices

The STEM curriculum intentions and practices should aim at contributing to pupils' general

education by not only providing applications of concepts and principles but also provide learners with sufficient knowledge and understanding to make them become useful and confident citizens. Therefore, the intentions of the STEM Curriculum of producing CCAT thinkers who are problem solvers and able relate thinking to real world situations shall be evident through the scientific skills the learners will be exhibiting. To produce such leaners there should be effective interaction between the curriculum, teacher and leaners. Workbook use is therefore, amongst the avenues that shall help elicit the STEM skills, document and track the learners progress as well as nurture learners in the learning process. To this effect, the assessment of the workbook management cannot be overemphasized.

### 4.1.2. Learner attainment

Learner attainment in this context entails the achievement of STEM Curriculum intentions. The expected outcomes of the STEM Education Curriculum are that the learning process should produce learners who are:

i. Critical, Creative and Analytical thinkers (CCAT)
ii. Able to relate thinking with real world situations
iii. Problem solvers
iv. Responsible citizens

In every assessment therefore, these aspects should be taken into consideration as facets that learners need to display.

## 4.2. Workbook

Workbooks will be used to track the progress of learners in STEM education. Therefore, learners are expected to have a record of practicals, assignments, tests, daily reflections and research activities. This means that the Workbook activity processes will be triggered by the teacher, driven by learner and validated by teacher. The Workbook will be provided and owned by the learner or the institution. As such the learner's workbook becomes a major resource for a learner to organize the thoughts and the learning progress in a coherent way for present and future references. Workbooks can vary in structure and approach. This means that the layout may vary according to the lesson concept. Therefore, learners have opportunities to provide diverse multiple viewpoints. The notes in the workbook should be co-developed by learner and teacher. Despite being cumbersome the workbook is an inevitable process as it helps to develop desired learner competencies. There are differences between the notebook and workbook. The workbook and note book dynamics are shown in Table 7.

*Table 7 : Workbook versus Notebook Dynamics*

| S/n | Notebook | Workbook |
|---|---|---|
| 1. | Provided & owned by the learner | Provided & owned by the learner or institution |
| 2 | Notes provided by the teacher | Notes are co-developed by learner and teacher |
| 3 | Comes as a blank slate | Comes with variety in structure and approaches |
| 4 | Notes are as prescribed by the teacher and owned by learner | Process triggered by teacher , driven by learner , validated by teacher and owned by learner |
| 5 | Learners rarely question the content, the source, the authenticity but faithfully memorize | Learners are continuously Critical, Creative and Analytical Thinkers |
| 6 | Positivist in nature | Constructivist in nature |
| 7 | Little learner input | Major learner input and ownership |
| 8 | Notebook | Workbook |
| 9 | Teacher dependent (dependence syndrome) | Learners dependent (independent syndrome) |
| 10 | Standardization , uniformity, limited view point | Variety, diverse, multiple view points on one concept |
| 11 | Assessment made in line with notes | Assessment made in line with learner progression |
| 12 | Little creativity | Research-based learning |
| 13 | Tailored toward syllabus completion | Learner progression determine the learning pace |
| 14 | Easy to use | Cumbersome but inevitable process |
| 15 | May not require any skill or competency | Requires skills and competencies |

The Workbooks should be Learner dependent, comprise of variety and diverse multiple view points on one concept, and have records of research-based learning activities such as assignments, tests as well as practical work as shown in Figure 8.

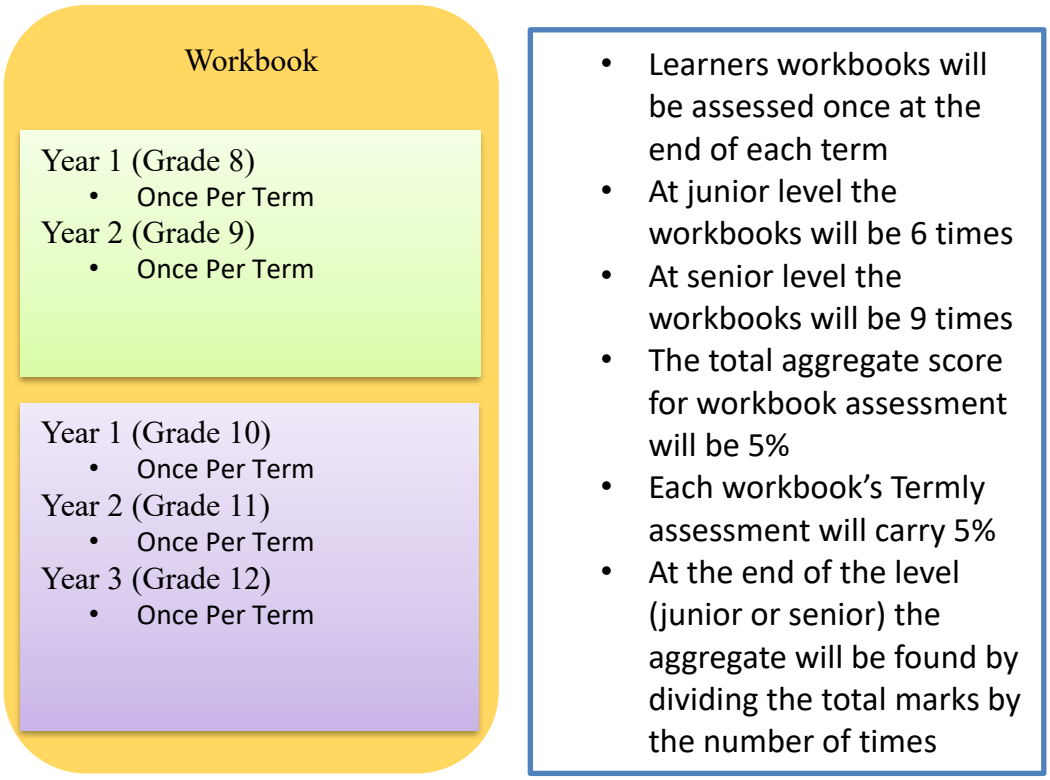


*Figure 8 :Workbook in Continuous Assessment*

Learners' workbooks will be assessed once at the end of each Term. At junior level the workbooks will be assessed 6 times while at senior level the workbooks will be assessed 9 times. The total aggregate score for workbook assessment will be 5% and each workbook's Termly assessment will carry 5%. The 5% will be allocated from the following aspects; General management, Practicals, Assignments, Tests, Daily reflections and Research activities. The detailed assessment of the workbook aspects and the weight allocations are shown in Table 8.

*Table 8 : Detailed description of Workbook Assessment in STEM Education*

| Aspect | Detailed Description | Weight Allocation |
|---|---|---|
| General management of the workbook | Presence of table of content, clear partitions | 0.5 |
| Practicals | Record of all practicals done | 1 |
| Assignments | Record of all Assignments done | 1 |
| Tests | Record of all tests done | 1 |
| Daily reflections | Record of all Daily reflections done | 0.5 |
| Research activities | Record of all Research activities done | 1 |

In order to be effective in tracking and assessing learning progress the teachers and learners need to perform specific roles in workbook management.

### 4.2.1. Role of a Teacher in Workbook Management

The roles of teachers in workbook management under each workbook aspect will include the following:

a) *Provided and Owned by the Learner or Institution*
   i. Ensure that all learners have their workbooks
   ii. Orient the learner on the importance and content of workbook
   iii. Where appropriate provide relevant workbook for learners
   iv. Develop own workbook for cross referencing

b) *Notes are Co-developed by Learner and Teacher*
   i. Develop the notes for the teacher for cross referencing
   ii. Ensure that learners construct their notes either in soft or hard copy

c) *Comes with Variety in Structure and Approaches*
   i. Develop varieties of workbook structures
   ii. Use variety of approaches

d) *Process Triggered by Teacher, Driven by Learner, Validated by Teacher and Owned by Learner*
   i. Trigger what is to be written in the workbooks
   *ii. Support and validate the learner workbook progress*

e) *Learners are Continuously Critical, Creative and Analytical Thinkers*

   i. Create an enabling environment for CCAT to thrive in learners

f) *Constructivist in Nature*

   i. Create appropriate tasks that conform with constructivist approaches

   ii. Facilitate and support learning

g) *Major Learner Input and Ownership*

   i. Develop competencies and skills in learners to manage the workbook

   ii. Learner Dependent

   iii. Facilitate ownership in workbook management by learner

   iv. Check what learners are depositing in their workbooks

h) *Variety, Diverse, Multiple Viewpoints on a Concept*

   i. Expose learners to variety of viewpoints on a concept

   ii. Encourage collaboration and team work among learners

   iii. Create tasks that result in multiple viewpoints

i) *Assessment Made in Line with Learner Progression*

   i. Design assessment tasks to be given to leaners

   ii. Check the progress and provide support during the execution of the learners' tasks

   iii. Document the assessment of the learners

j) *Research-based Learning*

   i. Introduce the layout of research stages and major components of research paper

   ii. Facilitate the choice of research topics

   iii. Provide support during the research process

   iv. Assess and document research activities at various stages

k) *Learner Progression Determine the Learning Pace*

i. Appreciate the fact that all learners are able and understand their individual levels of capability

ii. Encourage learners to be assertive

iii. Provide individualized support during the learning process

iv. Assess the learner progression at different stages

*l) Cumbersome but inevitable process*

i. Deepen the pedagogical understanding on effective constructivist approaches

ii. Make learners appreciate the bulky tasks and activities to be undertaken and documented

iii. Develop organizational skills in learners

*m) Requires Skills and Competencies*

i. Develop Scientific Skills in oneself and learners

ii. Assess Scientific Skills in learners using the workbook

### 4.2.2. Role of a Learner in Workbook Management

The roles of learners in workbook management under each workbook aspect will include the following

*a) Provided and Owned by the Learner or Institution*

i. Acquire workbooks in each subject and one for research

ii. Appreciate the importance of workbook

*b) Notes are Co-developed by Learner and Teacher*

i. Develop own notes either in soft or hard copy

*c) Comes with Variety in Structure and Approaches*

i. Develop varieties of workbook structures

ii. Use variety of approaches

*d) Process Triggered by Teacher, Driven by Learner, Validated by Teacher and Owned by Learner*

i. Account for all the tasks to be written in the workbooks

ii. Ensure work is validated and advice adhered to, if any

*e) Learners are Continuously Critical, Creative and Analytical Thinkers*

i. Develop and display CCAT competencies and skills

*f) Constructivist in Nature*

i. Work on tasks and activities diligently in conformity with constructivist approaches

*g) Major Learner Input and Ownership*

i. Own the workbook

ii. Manage the workbook effectively by documenting all necessary activities

*h) Learner Dependent*

i. Be the main driver of what goes in the repository

ii. Regularly submit the workbook for checking

*i) Variety, Diverse, Multiple Viewpoints on a Concept*

i. Use a variety of viewpoints on a concept

ii. Collaborate with other learners for unity of purpose

*j) Assessment Made in Line with Learner Progression*

i. Work on assessment tasks given

ii. Document worked solutions and activities

iii. Submit worked solutions and activities for assessment

iv. Record assessment scores

*k) Research-based Learning*

i. Understand and implement research

ii. Regularly submit research activities (including write-ups) for checking at various stages

*l) Learner Progression Determine the Learning Pace*

i. Work independently and in collaboration with others

ii. Be assertive

*m) Cumbersome but inevitable process*

i. Appreciate the bulky tasks and activities to be undertaken and documented

ii. Develop organizational skills

*n) Requires Skills and Competencies*

i. Develop Scientific Skills in oneself

## 5. Research in STEM Education

In the context of STEM Education in Zambia, research is a sandwich intermediate process in which the theories in STEM Education are transited into evidence-based products closer to prototype status as the learners go through the learning process. All the learners in STEM Education are expected to do a research project within the career pathway they are taking.The nomenclature of the researches are career pathway inclined as shown in Table 9.

*Table 9 : Research Nomenclature*

| | Pathways | Research |
|---|---|---|
| 1. | Agricultural Science STEM | Agricultural Science STEM Research |
| 2. | General STEM | General STEM - Mathematics Research |
| | | General STEM - Biology Research |
| | | General STEM - Chemistry Research |
| | | General STEM - Physics Research |
| | | General STEM - Computer Science Research |
| 3. | Technological STEM | Technological STEM - Graphic Communication Research |
| | | Technological STEM - System Technology Research |
| | | Technological STEM - Manufacturing Materials Research |
| 4. | Hospitality and Tourism STEM | Hospitality and Tourism STEM - Hospitality Research |
| | | Hospitality and Tourism STEM - Tourism Research |

### 5.1. Research Conceptual Framework

In STEM research learners will be required to write a research report, defend the research and make a product. The research conceptual framework is as shown in Figure 9

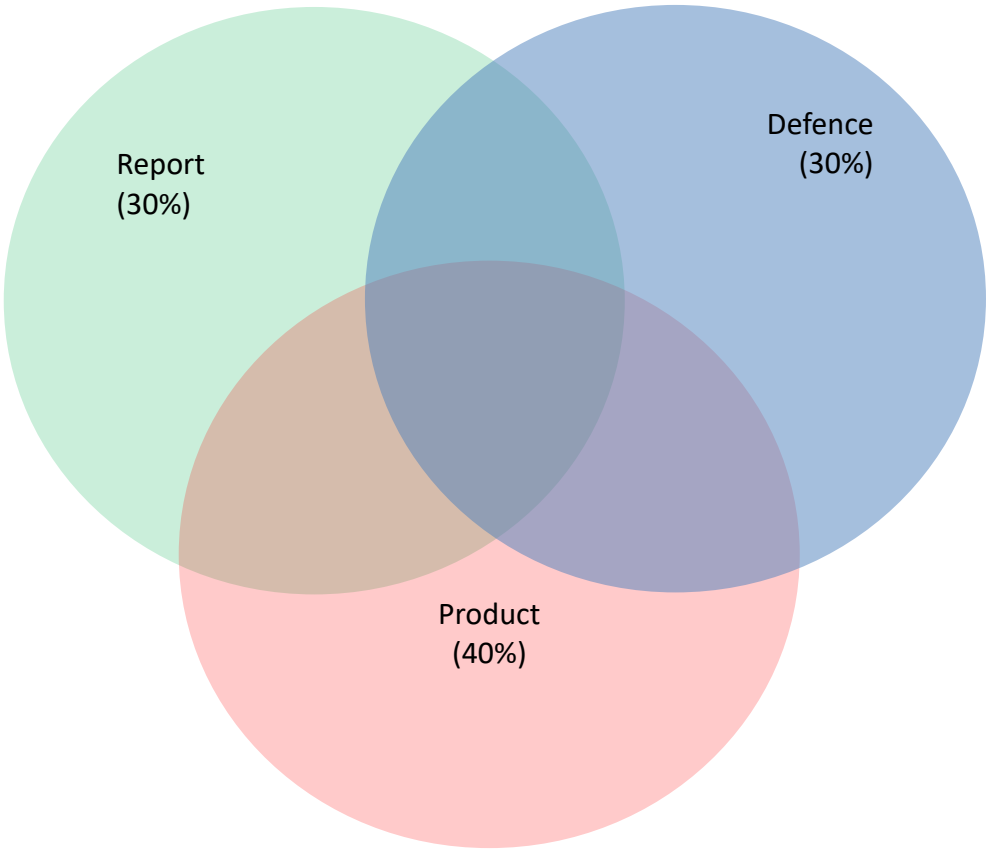


*Figure 9 : Research Conceptual Framework in STEM Education*

#### 5.1.1. Report in STEM Education Research

A research report in STEM is a document that contains basic aspects of the research project which include recorded data prepared after analyzing gathered information. It can also be considered as a condensed form or brief description of research work presented as a report. In assessing a research report the layout and format of the research must be taken into consideration to include; logical sequencing of the Title, Abstract, Introduction/Background, Objectives/Research Questions, Problem Statement, Literature Review, Methodology, Results/Findings, Conclusion, Recommendations, References. Other than that, this report needs to be typed in times new roman font, with 12 font size and line spacing of 1.5 and pages need to be numbered. The assessment of

the research report will carry 30% of the 100% allocated for research. The detailed weight allocations of the research report are as shown in Table 10.

*Table 10 : Detailed Description and Assessment Criteria of Research Report*

| S/N | Detailed Description | Weight Allocation | |
|---|---|---|---|
| A. | **Sequential logical flow** | | |
| | Title | 1.2 | |
| | Abstract *(purpose of study, research gap, methodology, major findings, implications, recommendations, key terms – 3 to 5, 250 words)* | 2.4 | |
| | 1. Introduction/Background | 2.4 | |
| | i. Objectives/Research Questions | 2.4 | |
| | ii. Problem Statement | 2.4 | |
| | 2. Literature Review | 2.4 | |
| | 3. Methodology | 2.4 | |
| | 4. Results/Findings | 2.4 | |
| | 5. Discussions | 3.6 | |
| | 6. Conclusion | 1.2 | |
| | 7. Recommendations | 1.2 | |
| | 8. References – quality of reference | 1.2 | |
| | **Subtotal** | | **25.2** |
| B. | **Formatting** | | |
| | Font type – Times new Roman | 1.2 | |
| | Font size – 12 points | 1.2 | |
| | Line spacing – 1.5 | 1.2 | |
| | Page numberings | 1.2 | |
| | **Subtotal** | | **4.8** |
| | **Total** | | **30** |

### 5.1.2. Defense in STEM Education Research

In STEM Education, apart from a report and product, a learner will be required to carry out an oral presentation of the research in form of a defense. A research defense is a viva voce presentation of evidence of a research report. Learners are supposed to defend their research before a chosen committee or audience. The committee should comprise of a community representative, STEM HODs, DESO/SESO, Deputy Headteacher, Subject specialist but not learner supervisor, NSC process observers. The main purpose is not only for defender to present the research work so that the committee validates but also to receive input for further consideration and improvement if any.

During the research defense presentations assertiveness, understanding of subject matter, quality of power point presentation and time management are aspects to be assessed. The assessment of the research defense will carry 30% of the 100% allocated for research. Table 11 shows the detailed descriptions and weight allocations that would be applicable when assessing defense in STEM Education research.

*Table 11 : Detailed Description and Assessment Criteria of Research Defense*

| | Aspect | Detailed description | Weight allocation |
|---|---|---|---|
| 1. | Assertiveness | Confidence, Self Esteem, Gestures, (Rapport with audience) | 6 |
| 2. | Understanding of subject matter | Communicating most important points of research work, ability to respond to questions raised | 15 |
| 3. | Quality of power point presentation | Coherent Power point form, Logical Flow | 6 |
| 4. | Time management | Coherent Power point form, Logical Flow | 3 |
| | **Total Marks** | | **30** |

### 5.1.3. Product in STEM Education Research

A product in STEM Education is a research invention, innovation, artefact or manufactured good that emanates from a research process. The assessment of the research product will carry 40% of the 100% allocated for research. The aspects that will be assessed on the product are:

(i) Research work involved that will include originality, innovativeness, use of appropriate materials (preferably largely local), value addition principle,

(ii) Practical use to ascertain the operational, application in reality, environmentally friendly, quality, and cost effective of the product,

(iii) Operational principle will assess how well Scientific, Technological, Engineering and Mathematical principle (s) are applied and illustrated, how user friendly the product is, and whether it can easily be replicable and scalable, and

(iv) Suitability for commercialization of the product will assess the potential of the product for market entry, patentability and whether it could be able to solve the societal problems.

The detailed assessment of the aspects and weight allocations for consideration are shown in Table 12 below.

*Table 12 : Detailed Description and Assessment Criteria of Research Product*

| | Aspect | Detailed Description | Weight Allocation |
|---|---|---|---|
| 1. | Research work involved | Originality, innovativeness, use of appropriate materials (preferably largely local), value addition principle | 12 |
| 2. | Practical use | Operational, application in reality, environmentally friendly, quality, cost effective | 16 |
| 3. | Operational principle (s) | How well Scientific, Technological, Engineering and Mathematical principles are applied and illustrated, user friendly, replicable, scalable | 8 |
| 4. | Suitability for commercialization | High potential for market entry, patentable, problem-solving | 4 |
| | | **Total Marks** | **40** |

## 6. Summative Assessment

The summative ECZ assessment in STEM Education will comprise 35%. This entails that the 65% of the continuous assessment in every subject will be added to this 35% to make an aggregate score of 100%.

## 7. Conclusion

Assessment of STEM Education in Zambia will not only include the assessment of the teacher & teaching but also the learner & learning as well as institutional management, curriculum intentions and implementation. Assessment in STEM Education will be highly formative (65%) and summative (35%). Additionally, in order to elicit the development of necessary proficiencies in learners' research will be assessed at (100%). The assessments provided will enable learners to access and receive accurate performance measurements of their abilities.

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# Appendices

## Appendix 1: Assessment Instrument for Scientific Skills

### a) Acquisitive Skills

| *Scientific Skills* | School | Subject | Grade | Acquisitive Skills | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Listening | Observing | Searching | Inquiring | Investigating | Gathering Data | Researching | Defining operationally | Formulating hypotheses |
| | | | | | | | | | | | | |
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### b) Organizational Skills

| *Scientific Skills* | School | Subject | Grade | Organizational Skills | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Recording | Comparing | Contrasting | Organising | Outlining | Reviewing | Evaluating | Analysing | Predicting | Inferring | Interpreting Data |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
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### a) Manipulative Skills

| *Scientific Skills* | School | Subject | Grade | Manipulative Skills | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Using, handling & maintaining instruments | Demonstrating | Experimenting | Constructing | Calibrating | Measuring & using numbers | Controlling variables | Handling specimen correctly & carefully |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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c) Creative Skills

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **Creative Skills** | | | | | |
| ***Scientific Skills*** | School | Subject | Grade | Planning ahead | Designing | Inventing | Synthesizing | Formulating Models | Sketching specimen & apparatus |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

d) Communicative Skills

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Communicative Skills** | | | | | | | | |
| ***Scientific Skills*** | School | Subject | Grade | Questioning | Discussing | Explaining | Reporting | Writing | Critiquing | Graphing | Teaching | Communicating |
| | | | | | | | | | | | | |
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Appendix 2: Assessment Instruments for Planning for Lessons

a) Lesson in Relation to Curriculum Intentions

| **STEM Curriculum Intentions and Implementation** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Lesson in Relation to Curriculum Intentions** | | | | | | | | | | |
| | School | Subject | Grade | Topic | | Sub-Topic | | Outcome | | Knowledge | |
| | | | | In line with | Not in line | In line with | Not in line | In line with | Not in line | In line with | Not in line |
| Planning for lessons | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

a) Lesson Plan Format

| **STEM Curriculum Intentions and Implementation** | | | | | | |
|---|---|---|---|---|---|---|
| | **Lesson Plan Format** | | | | | |
| | Individual | Collaborative | Plan to clear misconceptions | Assessment Criteria | Lesson Template | |
| | | | | | Open | Pre-Designed |
| Planning for lessons | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

b) Planning for Rationale

| **STEM Curriculum Intentions and Implementation** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Planning for lessons | **Rationale** | | | | | | | | | |
| | Content | | Importance | | Methodology | | | Position | | Comment |
| | Indicated | Not Indicated | Indicated | Not Indicated | Not Indicated | Indicated | Type | Indicated | Not Indicated | |
| | | | | | | | | | | |
| | | | | | | | | | | |
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| | | | | | | | | | | |

a) Planning for Lesson Introduction

| **STEM Curriculum Intentions and Implementation** | | | | | | |
|---|---|---|---|---|---|---|
| | **Plan for Introduction** | | | | | |
| | Scenario | | Problem Statement | | Key Question | |
| | Appropriate | Not Appropriate | Appropriate | Not Appropriate | Appropriate | Not Appropriate |
| | | | | | | |
| | | | | | | |
| Planning for lessons | | | | | | |
| | | | | | | |
| | | | | | | |

a) Planning for Lesson Development and Conclusion

| **STEM Curriculum Intentions and Implementation** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Plan for Development | | | | Plan for Conclusion | | |
| | Activities | | Consolidation | Comments | Summary | Evaluation | Comment |
| | Constructivism | Positivism | | | | | |
| Planning for lessons | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

b) Resource Materials

| **STEM Curriculum Intentions and Implementation** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | School | Subject | Grade | Name of Resource Material | Indicated | | Not Indicated |
| | | | | | Appropriate | Not Appropriate | |
| Resource Materials | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

c) Teaching and Learning Aids Preparation

| **STEM Curriculum Intentions and Implementation** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | School | Subject | Grade | Not Indicated | Indicated | Type | Usage | | Comment |
| | | | | | | | Teacher | Learner | |
| Teaching and Learning Aids Preparation | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
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## Appendix 3: Assessment Instruments for delivery of Lessons

| **STEM Curriculum Delivery** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | School | Subject | Grade | **Introduction** | | | | |
| | | | | Appropriate | Not Appropriate | Key Task | | Comments |
| | | | | | | Not Presented | Presented (Verbally or written) | |
| Lesson Delivery | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| **STEM Curriculum Delivery** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Development** | | | | | | | |
| | Strategies | | Flow of Activities | | | Consolidation | | |
| | Group Work | Individual | Constructivist | Positivist | Comment | Done | Not Done | Comment |
| Lesson Delivery | | | | | | | | |
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| **STEM Curriculum Delivery** | | | | | |
|---|---|---|---|---|---|
| | **Conclusion** | | | | |
| | Summary | | Evaluation | | Comment |
| | Done | Not Done | Done | Not Done | |
| Lesson Delivery | | | | | |
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| **STEM Curriculum Delivery** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | School | Subject | Grade | **Teaching Learning Aids** | | | | |
| | | | | Indicated on the Lesson Plan | Utilized in the Lesson | Prescribed by Teacher | Prescribed by Learners | Comment |
| Teaching and Learning Aids Utilization | | | | | | | | |
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Appendix 4 : Assessment Instrument for STEM School Learning Environment

**Section A: School Information**

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|---|---|---|---|---|---|
| **A1** | Name of School: | **A2** | District | **A3** | Province |
| **A4** | Provincial/District STEM School | **A5** | Boys/Girls/Co | | |
| **A6** | Name of Head teacher | **A7** | TS No. | **A8** | Phone No. |
| **A9** | Total No. of Teaching Staff | **A10** | No. of Maths Teachers | **A11** | No. of Comp Science Teachers |
| **A12** | No. of NS Teachers | **A13** | No. of D & T Teachers | **A14** | No. of HE Teachers |
| **A15** | No. of G8 Learners | **A16** | No. of G9 Learners | | |
| **A17** | No. of G10 Learners | **A18** | No. of G11 Learners | **A19** | No. of G12 Learners |
| **A20** | No. of Classrooms | **A21** | No. of Desks | **A22** | No. of Chairs |
| **A23** | Availability of Biology Laboratory | **A24** | Availability of Physics Laboratory | **A25** | Availability of Chemistry Laboratory |
| **A26** | Availability of Agric Science Laboratory | **A27** | Availability of Mathematics Laboratory | **A28** | Availability of Metal Workshop |
| **A29** | Availability of Wood Workshop | **A30** | Availability of TD/GMD Room | **A31** | Availability of food & nutrition Room |

| | |
|---|---|
| **A32** | Availability of fashion & fabrics room |
| **A33** | Availability of computer laboratory |
| **A34** | Availability of internet connectivity |
| **A35** | Availability of Library |