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Spiral Progression of Biology Content in the Philippine K to 12 Science Curriculum

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***Abstract*— *This study assessed the organization of the Philippine K to 12 science curriculum in terms of Biology content and science process skills from primary to secondary level. The intended curriculum was analyzed based on the framework of spiral progression of learning known as the integrated model of progression in science. Using document analysis as an approach, science curriculum guide from grade 3 to grade 10 was examined. The current science curriculum was found to be spirally sequenced in terms of content in the Biology learning areas following the principles of sequencing in the spiral progression approach. However, science process skills were found to be not spirally sequenced with no principle of sequencing being followed in most cases. Therefore, curriculum development efforts should emphasize on aligning science process skills with the principle of spiral sequencing of gradual sophistication and increasing complexity as grade level increases*

***Keywords*— *Organization of content; science content; science process skills; spiral progression*.

I. Introduction

Science education in the Philippines has gone through a significant change upon the implementation of the K to 12 curriculum in 2012. This major revision in Science curriculum is the offshoot of external pressures such as issues of the Philippines lagging behind other countries in international assessment results in Trends in International Mathematics and Science Study (TIMSS) in 1995, 1999 and 2003 among others. It is in this light that the need to explore the current Science curriculum and examine its nature arise to point out its implications in the current situation of Science education in the country.

Several researches identified factors behind the low performance of Filipino students in science [1]-[2]. According to Science Education Institute, Department of Science and Technology (SEI-DOST) these factors include: teacher quality, the process of teaching and learning, the school curriculum, instructional resources and administrative support [3]. Efforts to address these concerns are made by various science education stakeholders. The University of the Philippines National Institute for Science and Mathematics Education Development (UP NISMED) consider it wise to focus our efforts on science curriculum to improve education quality in the elementary and secondary levels [3].

Looking at the new curriculum, it currently adopts the Spiral Progression of learning science as developed by Jerome Bruner [4]. Bruner pointed that the success of educational programs can be linked to content selection in alignment to levels of students and its presentation in suitable structure. Content selection requires examining if information is relevant and whether content enable the individual become a better adult [4].

Research studies regarding effect of the new Science curriculum in the Philippines on student science concept formation, scientific skills acquisition and values/attitude development are perceived by students to be highly relevant [5].

Spiral Progression Approach highly influenced Science curriculum in Philippine schools with regards to content and transitions of four science areas namely, Earth Science, Biology and Physics based on a study conducted by Resurreccion and Adanza [6].

Further, spiral content organization is widely used approach in organization of content and how topics are revisited and increased in complexity as grade level also increases becomes the subject of several researches. Sequencing and integrating science content in the intended junior secondary curriculum in Bangladesh has been examined and found to be partially implemented [7].

A similar study on content organization and gradual sophistication of topics in increasing grade levels in a Spiral curriculum in Turkey also revealed to be partially implemented [8]-[9]. This implies that science content in the spiral curriculum is less organized in other countries which pose an issue in the learning process. A logical and meaningful sequenced content facilitates better comprehension and retention of concepts [10]-[11].

While there exist an established literature on how content in science curriculum is arranged and implemented with regards to spiral progression approach in international counterparts, there are few empirical studies in the organization of content in Science in the Philippine context. To address this gap, there is a need to examine existing basic science education curriculum materials to find out how sequencing of content is organized according to spiral progression to assess whether topics covered in basic education classroom were dealt with in a richer concept by avoiding repetition and concept gaps within the frame of spirality.

According to SEI-DOST and UP NISMED, the new Philippine science curriculum framework adopted the Grade 1 to 10 approach which provides a structure of understanding big ideas of science over the years and enables students to progress through the grade levels smoothly providing continuity and consistency. Science subject is formally introduced in the third grade while during the first and second grade, science is incorporated in subjects such as Health, Languages and Math Subjects. As a whole, the three content areas such as life science, physical science and earth and space science are incorporated in each grade level following spiral progression [3].

Problems of disjunction in the learning of pupils at transfer from primary to secondary education have been recognized for over half century in the U.K. [12]. There is inconsistent teaching provision on either side of transfer in a spirally arranged curriculum that assumes learning in continuity and progression but does not take into account the content of primary school curriculum or the former experiences and achievement of the pupils. Pupils from the primary schools look forward in undertaking science in their secondary education but often their eagerness become dulled by unnecessary repetition of work without an added encounter, an atmosphere that does not celebrate their work and learning context that seem unconnected to their daily lives [12]. Further, Seefeldt contends that continuity must be existing through early childhood years of children. This implies that curriculum practices should be organized and continuous from one school situation to another [13].

A model of spiral progression was developed by Qualter, Strang, Swatton and Taylor [14] known as an integrated model of progression in science (Figure 1). This model shows a relationship between procedural knowledge known as 'Exploration of Science' and conceptual knowledge known as 'Knowledge and Understanding of Science'.

It can be assumed that in examining spiral progression science learning, it is essential to look at two aspects, the procedural and conceptual understanding. Figure 1 shows the integrated model of progressions in science [14]. From the integrated model of progression in science known as double spiral model it can be noted that 'experiential blobs' represented by letters blobs' represented by letters 'p' and 'c' referring to the fact that concept level behind each investigation and the procedures to carry it out progress in accordance with demand and complexity related to the content of the study program in each key stage [14]. This model shows solid and dotted lines representing two areas of science learning as four turns of a double spiral. This model implies that procedures and concepts are revisited in each key stage (Figure 1).

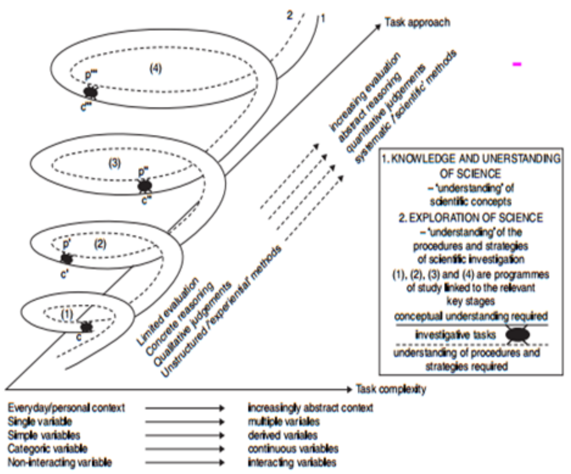

Fig. 1. An integrated model of progression in science (Qualter et. al, 1990)

Conceptual understanding allows learners to generate known facts, theories and models designed to explain those two phenomena to progressively reach more levels of sophistication to understand how the world works. Procedural understanding on the other hand is associated with skills in practical science or what is known as process skills fundamental in the development of understanding of a certain phenomenon or concept and also in testing out theories. Science is considered to be both content as well as process. Content and process in science are intertwined. The significance of science processes is to improve content or to progress the body of knowledge. Devoid of content, students will have trouble applying the science process skills [14].

Science processes cannot occur in a vacuum. They are being learned in a context. A condition for discerning about how and why students able or not able to move forward in their learning at transitions is the understanding of progression and continuity in science learning. In the early grades, students should experience science as a "hands-on, minds-on" process and allowed to discover and ask questions about the world that surrounds them. As they go up the grades, they should cultivate skills to design and conduct investigations pertaining self-, as well as teacher-made questions, and recognizing and controlling variables. Through the grades, students should improve their abilities to methodically collect and consolidate data and communicate investigations, gaining abilities to create explanations or models based on results of investigations.

Therefore, the need to regard how science is structured in the primary education and how continuity of content is organized to smoothen transfer to secondary education in the K to 12 science would be highly relevant in this present study to determine the gap that may exist in the spiral arrangement of concepts and processes without sacrificing coordination and connection and targeting needless repetition of learning experiences. By looking into the science curriculum starting from the 3rd grade to 10th grade emphasizing on biology content allow the researchers to establish the nature of spiral progression of science learning in the Philippine basic education.

This study investigates the spiral progression of content and science process skills with focus on life science or "biology" learning area covered in the third grade to tenth grade K to 12 Basic Education science curriculum in the Philippines. How biology content is organized and structured will be examined by looking at existing curriculum documents of the Department of Education (DepEd).

II. Objectives of the Study

This study aims to analyze the scope and sequence of content and science process skills in the Biology learning area in the intended Philippine K to 12 science curriculum. Specifically, it seeks to determine the scope and sequence of Biology content and process skills for Grade 3 to Grade 10 Basic Education Science Curriculum in relation to some features of Spiral Progression in terms of:

a) iterative revisiting of topics as grade level increases; and

b) gradual sophistication of topics from simple to complex as grade level increases.

III. MATERIALS AND METHODS

Document analysis was used to determine the sequencing of Biology content in the spiral progression approach of the K to 12 basic science education. Curriculum documents that were studied include curriculum guides of Grade 3 to Grade 10 science giving focus on how Biology content is organized based on topics and learning competencies provided in the science curriculum guide. According to the words of Patton, when information rich cases are selected for in-depth study, purposeful sampling can be considered powerful and logical [15].

Documents to be studied as a source of data include the given details provided by the Department of Education (DepEd) K to 12 Science Curriculum Guide [16]. Document analysis is useful for gathering qualitative data from written documents [17]. Thus, document analysis will be the method used to gather and analyze data from the current science curriculum using the K to 12 science curriculum guide of the DepEd.

Triangulation in this study is achieved by looking at other sources of data that would provide substantial information that supports the initial findings from the other curriculum document previously analyzed. Textbooks or Learning Materials (LM's) and Teacher's Guide (TG) were the other sources of data used in this study for document analysis.

Analysis of Data

According to Fraenkel and Wallen, data analysis basically involves synthesizing the information from various sources that the researcher obtained (e.g. observations and document analysis) into a logical description of what has been observed or otherwise discovered by the researcher [18].

For the document analysis on the sequencing of Biology content and science process skills based on the spiral progression approach, a checklist will be used for examining the sequence of Biology content as well as process skills in the curriculum guide. Following the four principles of sequencing content by Print [19], the components of the checklist includes simple to complex, prerequisite learning, whole to part and chronology [7].

Further, four key questions (KQ) based on Bruner [4] and Johnston [20] that has been developed by Bain and Siddique (2017) will be used to examine how Biology content and process skills are sequence in the K to 12 science curriculum based on the spiral progression approach [7]. The KQs based on Bain and Siddique with minor modifications are the following:

1. Does the concept appear in multiple grades (within the 3rd to 10th grade)?
2. Has the learning from previous grade(s) on the same concept been referred in the curriculum guide?
3. Has the learning from previous grade(s) on the same concept been used as the base of future learning?
4. Have the breadth and complexity of the concept been increased from the previous grade?

Table 1 below shows the decision on spiral sequence based on response against the KQs based on Bain and Siddique [7]. The decision whether Biology content in the K to 12 science curriculum is spirally sequenced or not will be based on the responses against the KQs. It will also be used to assess how the science process skills are sequenced based on spiral approach.

TABLE 1. Decision on spiral sequence based on response against the KQs

Type of Response	Decision
Yes against all 4 KQs	Truly spirally sequenced
Yes against most of the KQs	Spirally sequenced
Yes against 2 KQs and No against 2 KQs	Partially spirally sequenced
No against most of the KQs	Not spirally sequenced
No against all 4 KQs	Not spirally sequenced at all

KQ: Key Questions

IV. RESULTS AND DISCUSSIONS

Organization and Scope of Content in the K to 12 Science Curriculum

Curriculum can be considered to have three main forms or levels namely: intended, implemented and attained curriculum. The most common form is the formal intended curriculum comprising the prescribed statements of rationale, goals, list of intended content or to be known concepts or skills and competencies found in study programs and validated in assessment. The specified or intended curriculum focus on the aims and concepts to be taught, planned and expressed through the framework of the curriculum and added formal papers [21].

Spiral content organization is one of the most widely used approaches in content organization also known as spiral curriculum firstly defined by Bruner [4]. The important hypothesis according to Bruner underlying the spiral curriculum is that learning subjects crucial in the early stages of the child form a good basis for future learning [8]. Subjects in a spiral curriculum are structured from concrete to abstract and progress from simple to complex and from basic ideas to sound comprehension [22].

Table 2 shows the organization of content in the K to 12 science curriculum focusing on Biology from grade 3 to grade 6. Based on the table, biology topics were organized based on the concept of spiral sequencing of content from simple to complex, prerequisite learning, whole to part and chronology as described by Print [19].

The biology topics in the K to 12 science curriculum guide from grade 7 to grade 10 were also plotted as shown in table 3. When plotted against the 4 KQs, the decision in terms of spirality of content is spirally sequenced (Table 3). Fom the data on sequencing of Biology content in the four learning areas in the K to 12 science curriculum, aside from the iterative revisiting of concepts as the grade level progresses, an integration among the Biology learning areas were also found to be evident. There exist a connection between concepts across learning areas as being underscored in table 2 on Biology content from grades 3 to grade 6 and from grade 7 to grade 10 in table 3.

TABLE 2. Biology content learning areas from grade 3 to grade 6 science

	Grade 3	Grade 4	Grade 5	Grade 6
Parts and Function of Animals and Plants	-**Sense Organs** of Humans -External Parts of Animals and Plants -Characteristics of Living and Non-living Things	- **Major organs** of the Human Body -Some parts of plants and animals for survival	- **Organs of reproductive systems** of humans, animals and plants.	-**Major organs of the Human Body** and interactions among parts. -Vertebrates and invertebrates differences -reproduction by non-flowering plants
Heredity: Inheritance and Variation	- Living things **reproduce** - Certain **traits** are passed-on to offspring	-Life cycles of humans, animals and plants -**Inherited traits** affected by the environment in certain stages of life cycle	-**Reproduction** in flowering & non-flowering plants -Asexual and sexual modes of reproduction	-**Reproduction** in non-flowering plants (spore-bearing & cone-bearing plants, ferns & mosses)
Biodiversity and Evolution	- Living things found in **different places**	-Animals & plants found in **specific habitats**	-Reproductive structures as bases for **classifying** living things	- **Plants & animals** share common characteristics as bases for **classification**
Ecosystems	-**Living things** depend on the **environment** for food, water, and air to survive	-**Interactions** between **living things** & the **environment** both beneficial & harmful to obtain basic needs	-**Interactions** among components of larger habitats such as estuaries & intertidal zones -Conditions for certain organisms to live	-**Interactions** among components of other habitats such as tropical rainforests, coral reefs and mangrove swamps

TABLE 3. Biology content learning areas from grade 7 to grade 10 science

	Grade 7	Grade 8	Grade 9	Grade 10
Parts and Function of Animals and Plants	L**evels of organizations of the human body** & other organisms -Organisms consist of cells grouped into organ systems with specialized function	- **Human body** breaks down food and absorb nutrients via digestive system and transported to cells -**Respiratory system** functions for gas exchange and provide **oxygen** for cells to release stored energy -Urinary system removes dissolves wastes while excretory system eliminates solid wastes in the body.	-Digestive, respiratory & circulatory systems coordinated functions -**Respiratory system** take in **oxygen** and combine with nutrients in the bloodstream and transported to cells	-Feedback mechanisms coordinated by nervous & endocrine systems for organisms to maintain homeostasis to reproduce & survive
Heredity: Inheritance and Variation	Asexual **reproduction** results in genetically identical offspring and sexual **reproduction** gives rise to variation	-Cell division through mitosis and meiosis - Meiosis as a form of sexual reproduction resulting to variation of traits	- **Gene and chromosome structure** and their function in transmission of **trait**s from parents to offspring	-**DNA molecule structure** & function -Changes in sex cells are inherited while changes in body cells are not passed on
Biodiversity and Evolution	- Cells in similar tissues and organs in other **animals** are similar to humans but differ in **plants**	- **Species** are group of organisms that can mate to produce fertile offspring -Biodiversity as collective variety of **species** in an ecosystem.	- Some **species** that once existed have gone extinct -Extinction is due to some species not adopting to **changes in the environment**	-Mechanisms involved in inheritance of traits results to certain changes -Natural selection results to succession of diverse **species** -Variation increase the chance of survival in a **changing environment**
Ecosystems	**Interactions** among different levels of organization in **ecosystems** -Populations are formed from organisms of the	-**Energy** are transformed and materials are cycled in **ecosystems**	-Plants capture **energy** from the sun and stored it in sugar molecules through photosynthesis -Stored **energy** is used by cells in cellular respiration	-Human activities and other organisms impact the environment -Biodiversity influences stability in **ecosystems**

Biology learning areas in the K to 12 science curriculum can be considered as spirally sequenced in terms of content. Based on the KQs, the response was yes against most of the KQs which entails the decision on spirally sequenced content. Key concepts were revisited several times in one grade level to another for the concepts to be further developed as grade level increases. Based on Bruner’s theory of learning, spiral sequencing of content in Biology learning areas were evident in the K to 12 science curriculum.

Organization of content is an important part of the curriculum that has two important aspects composing of the following: sequence of curriculum content and scope of curriculum content [19]-[23]. In the spiral curriculum, sequencing of content involves repeating key concepts several times for added progress of the concepts based on Bruner’s theory of learning [20].

Spiral sequencing has been described by Johnston based on the work of Bruner following three key features [20]. The first feature involves student revisiting a topic, subject or theme a number of times during the course of their schooling career. The second feature comprises the increasing complexity of the concepts with each topic revisit. While the third feature describes new learning being related to the old learning and put in context with the old knowledge [20].

While the sequence of curriculum can be regarded as a vertical organization of content [24], the scope of curriculum can be referred to as horizontal organization of content known as integration [20], which serves as one of the guiding principle in determining the scope. Alberta Education defined integration as an approach in curriculum that draws knowledge, skills, attitudes and values together from within or across the subject or areas of discipline for the purpose of developing more potent understanding of main ideas [24].

From Fraser, the New Zealand Ministry of Education describes integration as a broad education of making links within and across areas of learning [25]. Furthermore, according to Demirel content must also be consistent to scientific, artistic as well as philosophical perspectives. Content is a program dimension which addresses what has to be taught to achieve defined goals [22].

Linking one concept to another among the Biology learning areas enriches the scope of the content. A richer breadth and depth of topics can be achieved through a logical sequencing of content as well as a horizontal organization known as integration among concepts across the learning areas [7].

Organization of Science Process Skills in terms of Spiral Progression Approach

After examining how content is organized based on spiral progression, the learning competencies in the K to 12 science curriculum guide were examined to determine how process skills are arranged from simple to complex, prerequisite learning, whole to part and chronology as described by Print [19].

Science process skills were plotted in a table according to the four learning areas in Biology in the K to 12 science curriculum guide. Learning competencies from grade 3 to grade 10 were also assessed using the 4 KQs developed by Print and the responses against the KQs were used as the bases for the decision on spiral sequencing of science process skills across the grade levels [19].

Table 4 shows the science process skills in Biology under Parts and Function of Animals and Plants learning area from grade 3 to grade 10. It was found out that the K to 12 curriculum followed no principle of sequencing of science process skills (Table 4).

As the grade level increases the principle of sequencing from simple to complex based on spiral approach was not evident. The breadth and depth of complexity as the grade level increases was not being organized in a spiral manner. Instead of adding more and more information while at the same time working on the basic concepts to help build on new ideas from the previous knowledge, the process skills appear to become lesser and simpler as the grade level increases.

The decision based on the responses against the KQs in terms of science process skills in Biology in the case of Parts and Function of Animals and Plants learning area was not spirally sequenced. From table 4, the science process skills were being repeated and emphasizing only on simple process skills becoming less complex as the grade level progresses.

TABLE 4. Science process skills in Biology under Parts and Function of Animals and Plants learning area from grade 3 to grade 10 K to 12 curriculum

Grade 3	Grade 4	Grade 5	Grade 6
1. **describe** the parts and functions of the sense organs of the human body; 2. **enumerate** healthful habits to protect the sense organs; 3. **identify** the parts and functions of animals; 4. **classify** animals according to body parts and use; 5. **state** the importance of animals to humans; 6. **describe** ways of proper handling of animals; 7. **describe** the parts of different kinds of plants; 8. **state** the importance of plants to humans; 9. **describe** ways of caring and proper handling of plants; 10. **compare** living with nonliving things;	1. **describe** the main function of the major organs; 2. **communicate** that the major organs work together to make the body function properly; 3. **identify** the causes and treatment of diseases of the major organs; 4. **practice** habits to maintain a healthy body;	1. **describe** the parts of the reproductive system and their functions; 2. **describe** the changes that occur during puberty; 3. **explain** the menstrual cycle; 4. **give ways** of taking care of the reproductive organs; 5. **describ**e the different modes of reproduction in animals such as butterflies, mosquitoes, frogs, cats and dogs; 6. **describe** the reproductive parts in plants and their functions;	1. **explain** how the organs of each organ system work together; 2. **explain** how the different organ systems work together; 3. **determine** the distinguishing characteristics of vertebrates and invertebrates;
Grade 7	**Grade 8**	**Grade 9**	**Grade 10**
1. **Identify** parts of the microscope and their functions; 2. f**ocus** specimens using the compound microscope; 3. **describe** the different levels of biological organization from cell to biosphere; 4. **differentiate** plant and animal cells according to presence or absence of certain organelles; 5. **explain** why the cell is considered the basic structural and functional unit of all organisms; 6. **identify** beneficial and harmful microorganisms;	1. **explain** ingestion, absorption, assimilation, and excretion; 2. **explain** how diseases of the digestive system are prevented, detected, and treated; 3. i**dentify** healthful practices that affect the digestive system;	1. **explain** how the respiratory and circulatory systems work together to transport nutrients, gases, and other molecules to and from the different parts of the body; 2. **infer** how one's lifestyle can affect the functioning of respiratory and circulatory systems;	1. **describe** the parts of the reproductive system and their functions; 2. **explain** the role of hormones involved in the female and male reproductive systems; 3. **describe** the feedback mechanisms involved in regulating processes in the female reproductive system (e.g., menstrual cycle); 4. **describe** how the nervous system coordinates and regulates these feedback mechanisms to maintain homeostasis;

TABLE 5. Science process skills in Biology under Heredity: Inheritance and Variation learning area from grade 3 to grade 10 K to 12 curriculum

Grade 3	Grade 4	Grade 5	Grade 6
1. **describe** animals in their immediate surroundings;	1. **infer** that body structures help animals adapt and survive in their particular habitat; 2. **compare** body movements of animals in their habitat; 3. **make** a survey of animals found in the community and their specific habitats; 4. **choose** which animals to raise in a particular habitat; 5. **identify** the specialized structures of terrestrial and aquatic plants; 6. **condu**ct investigation on the specialized structures of plants given varying environmental conditions: light, water, temperature, and soil type; 7. **make** a survey of plants found in the community and their specific habitats; 8. **choose** which plants to grow in a particular habitat;		
Grade 7	**Grade 8**	**Grade 9**	**Grade 10**
1. **differentiate** asexual from sexual reproduction in terms of: number of individuals involved; and similarities of offspring to parents; 2. **describe** the process of fertilization;	1. **compare** mitosis and meiosis, and their role in the cell-division cycle; 2. **explain** the significance of meiosis in maintaining the chromosome number; 3. **predict** phenotypic expressions of traits following simple patterns of inheritance;	1. **describe** the location of genes in chromosomes; 2. **explain** the different patterns of non-Mendelian inheritance ;	1. **explain** how protein is made using information from DNA; 2. **explain** how mutations may cause changes in the structure and function of a protein;

The science process skills in Biology under Heredity: Inheritance and Variation learning area from grade 3 to grade 10 K to 12 were plotted in table 5. From the table, the learning competencies appear to be more concentrated in grade 4 while there were no process skills under the case of Heredity: Inheritance and Variation in grades 5 and 6. This is not consistent with the learning progression in science based on the integrated model of Qualter, Strang, Swatton and Taylor wherein spiral approach should be both content and process skills [14]. A glaring gap in the sequencing of science process skills is evident in this case.

Table 6 shows the science process skills in Biology under Biodiversity and Evolution learning area from grade 3 to grade 10 K to 12. It appears that no principle of sequencing is followed from the lower grade level to the higher grades (Table 6).

From the table, instead of building on the skills from simple to complex as grade level increases, the process skills are not properly arranged in a spiral way from grade 3 to grade 6 and grade 7 level has no learning competency under the case of Biodiversity and Evolution. This could result to learning disjunction as the learner moves from grade 6 to grade 7 which is consistent with Braund that recognizes the problem that exist in the learning of pupils as they transfer from primary to secondary level [12]. Higher order skills of comparing and distinguishing are found in grade 4 and grade 6 but not in higher grade levels. Instead, lower order skills of explaining and classifying are present in grade 8 to grade 10 (Table 6).

In table 7, the science process skills in Biology under Ecology learning area were plotted from grade 3 to grade 10 in the K to 12 curriculum. The process skills from grade 3 to grade 10 are mostly understanding concepts of identifying, explaining, recognizing, discussing, predicting and describing which according to Bloom's Taxonomy belongs to lower order thinking skills [26].

TABLE 6. Science process skills in Biology under Biodiversity and Evolution learning area from grade 3 to grade 10 K to 12 curriculum

Grade 3	Grade 4	Grade 5	Grade 6
1. **infer** that living things reproduce; 2. **identify** observable characteristics that are passed on from parents to offspring (e.g., humans, animals, plants);	1. **compare** the stages in the life cycle of organisms; 2. **describe** the effect of the environment on the life cycle of organisms;	1. **describe** the different modes of reproduction in flowering and non-flowering plants such as moss, fern, mongo and others;	1**. distinguish** how spore-bearing and cone-bearing plants reproduce;
Grade 7	**Grade 8**	**Grade 9**	**Grade 10**
	1. **explain** the concept of a species; 2. **classify** organisms using the hierarchical taxonomic system; 3. **explain** the advantage of high biodiversity in maintaining the stability of an ecosystem;	1. **relate** species extinction to the failure of populations of organisms to adapt to abrupt changes in the environment; and	1. **explain** how fossil records, comparative anatomy, and genetic information provide evidence for evolution; 2. **explain** the occurrence of evolution;

TABLE 7. Science process skills in Biology under Ecology learning area from grade 3 to grade 10 K to 12 curriculum

Grade 3	Grade 4	Grade 5	Grade 6
1. **identify** the basic needs of humans, plants and animals such as air, food, water, and shelter; 2. **explain** how living things depend on the environment to meet their basic needs; and 3. **recognize** that there is a need to protect and conserve the environment.	1. **describe** some types of beneficial interactions among living things; 2. **describe** certain types of harmful interactions among living things; and 3. **conduct** investigations to determine environmental conditions needed by living things to survive. 4. **describe** the effects of interactions among organism in their environment	1. **discuss** the interactions among living things and non-living things in estuaries and intertidal zones; and 2. **explain** the need to protect and conserve estuaries and intertidal zones.	1. **discuss** the interactions among living things and non-living things in tropical rainforests, coral reefs and mangrove swamps; and 2. **explain** the need to protect and conserve tropical rainforests, coral reefs and mangrove swamps.
Grade 7	**Grade 8**	**Grade 9**	**Grade 10**
1. **differentiate** biotic from abiotic components of an ecosystem; 2. **describe** the different ecological relationships found in an ecosystem; 3. **predict** the effect of changes in one population on other populations in the ecosystem; and 4. **predict** the effect of changes in abiotic factors on the ecosystem.	1. **describe** the transfer of energy through the trophic levels; 2. **analyze** the roles of organisms in the cycling of materials; 3. **explain** how materials cycle in an ecosystem; and 4 .**suggest** ways to minimize human impact on the environment.	1. **differentiate** basic features and importance of photosynthesis and respiration.	1. **explain** how species diversity increases the probability of adaptation and survival of organisms in changing environments; 2. **explain** the relationship between population growth and carrying capacity; and 3**. suggest** ways to minimize human impact on the environment

From table 7, although higher order skills such as analyzing and differentiating are found in grades 7, 8 and 9, they are not being used in grade 10. Thus, it can be viewed that there is no principle of sequencing evident in the Ecology learning area based on spiral progression approach in terms of science process skills.

The decision on spiral sequencing of science process skills in Biology in the K to 12 curriculum based on the responses against the KQs is not spirally sequenced. As emphasized on the framework of learning progression in science by Qualter, Strang, Swatton and Taylor conceptual understanding and procedural understanding otherwise known as concepts and process skills should be both spirally sequenced [14].

However, based on the findings, only conceptual knowledge is spirally sequenced while procedural knowledge is not sequenced based on spiral progression approach. The overall decision therefore for Biology in the K to 12 science is partially spirally sequenced. This findings have implications for both curriculum development as well as teacher practice. Since the content of the K to 12 science curriculum is spirally sequenced based on spiral progression approach, teachers in the field can confidently adopt the curriculum guide. The science content in Biology learning areas is organized based on spiral sequence thus, students would learn science in an orderly fashion and in a more holistic way [7].

However, in terms of science process skills, the current curriculum lacks order in terms of sequencing from simple to complex and are not in lined with spiral progression approach of learning. One cannot expect learners to have the necessary higher order thinking skills as they finished grade 10 since most learning competencies are lower order thinking skills. Therefore, teachers should make necessary planning and considering a way of making efforts in preparing learning competencies that target proper sequencing of science process skills aligned with the spiral approach that involve gradual sophistication of concepts and skills of learning science.

V. Conclusion and Recommendation

The K to 12 science curriculum in terms of Biology learning areas follows a spirally sequenced content based on the principle of sequencing content by Print [19]. From the findings, it can be concluded that iterative revisiting of concepts and gradual sophistication of topics as grade level increases are evident in the current science curriculum in terms of Biology content. Also, there exist a rich breadth and depth of content since integration among the learning areas of Biology has been observed based on the alignment of concepts across learning areas.

When science process skills are examined based on spiral sequencing of learning competencies in the different grade levels of the K to 12 science curriculum, there exist no proper sequencing of process skills. The current curriculum in the Biology learning areas is found to be not spirally sequenced. Since learning progressions in science involves both content and process skills following the double spiral model known as integrated model of learning science, Biology learning areas are thus considered to be partially spirally sequenced with the content being spirally sequenced while the science process skills being not spirally sequenced.

Curriculum development efforts should be focused on revising the science curriculum so that learning competencies will be organized following the principle of spiral sequencing. Curriculum developers should formulate process skills appropriate for the particular level of students giving attention to higher order thinking skills that are aligned also to the assessment methods to be used and the teaching learning process.

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