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Knowledge and skills proficiency progress in spiral approach in Science instruction of Grade 10 students

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Abstract. This study delves into the analysis of knowledge and skill proficiency progression among respondents, unveiling significant trends that offer insights into the efficacy of science education strategies. The research reveals fluctuating patterns in knowledge proficiency, with notable increases observed until Grade 9, succeeded by a sudden decline in Grade 10. These variations are attributed to diverse factors impacting student performance, encompassing gender disparities and curriculum variables. Likewise, skill proficiency displays a consistent upward trajectory until Grade 10, followed by a decline, potentially influenced by similar contextual factors affecting students' abilities. Scholars emphasize the role of active learning and curiosity cultivation in enhancing skill competency, underscoring the link between science process skills and creativity. The significance of adopting a spiral approach to skill acquisition underscores the need for competent teaching to ensure effective skill instruction. However, the observed gap between knowledge and skill proficiencies highlights the necessity for a more holistic educational approach, emphasizing not only theoretical comprehension but also practical application. The concept of spiral progression accentuates the gradual development and reinforcement of concepts, vertically and horizontally, emphasizing the importance of building upon prior knowledge and skills for sustained mastery. In essence, the findings underscore the intricacies of educational dynamics and emphasize the need for multifaceted strategies to foster comprehensive student development.

Keywords: Spiral Progression, Science Knowledge, Science Proficiency, Science Education

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INTRODUCTION

Originally, the Philippine public school system was organized to facilitate the pacification of our nation during the American colonial period. The Americans used education as a tool to conquer our free spirit just like religion was used by the Spaniards to maintain our ignorance. Education and religion were the means that allowed our foremost colonial masters to rule over us (Flores, 2014).

It has been a long held view that public schools should be means of social control through the teaching of Christian based morals. Public schools have the power to break down the barriers between the rich and poor, create a common community and unite the diverse cultures (Flores, 2014).

Education is supposed to lead to economic liberation but apparently not so in the Philippine context. It is a fundamentally held belief among Filipinos that education is a ticket out of poverty and a means of empowerment. In our culture, the lack of education is seen as a sure way to failure. This is the reason why responsible parents want to see their children complete their education and every diligent student feels the pressure to succeed in school. But the household budget needed for quality education is out of reach for the majority (Flores, 2014).

Compared with other countries, the literacy rate in the Philippines is quite high. A study conducted by the graduate students of Nagoya University (2000) found that compared with other countries, the literacy rate in the Philippines is quite high. Moreover enrolment rate is 99.9% in primary level and 77.8% in secondary level, which is higher than Singapore and the highest in ASEAN countries. While statistics on educational attainment may be high but the economic situation in the Philippines is still not so good. The Philippines has succeeded in expanding its education in quantitative terms, but now they have to think about "Quality of education". The researchers eventually pointed out that there are four factors affecting the poor quality in the Philippine education system.

First, there are not enough teaching materials in the Philippines. Two or three students have to share a textbook and some of them cannot bring it home. Second, in the Philippines, the medium of instruction is English (for subjects like math, science and English) and Filipino (for the other subjects). However there are more than 100 local languages (including dialects) used in the Philippines and the language used in classroom is sometimes different from their local language. Third, there are too many students per class in the Philippines. Although the reasons are varied, people's lack of awareness about over population is also one of the reasons. Finally, after finishing their secondary education, many people go directly to work in the society.

To remedy this defect and to keep pace with neighboring countries where basic education spans 12 years, K-12 was introduced as a reform to the education system. The K to 12 Program covers Kindergarten and 12 years of basic education (six years of primary education, four years of Junior High School, and two years of Senior High School [SHS]) to provide sufficient time for mastery of concepts and skills, develop lifelong learners, and prepare graduates for tertiary education, middle-level skills development, employment, and entrepreneurship.

THEORETICAL FRAMEWORK

One of K-12's salient features is ensuring integrated and seamless learning or spiral progression, which is the topic of this study. In spiral progression, subjects are taught from the simplest concepts to more complicated concepts through grade levels in spiral progression (Gov.ph, . As early as elementary, students gain knowledge in areas such as Biology, Geometry, Earth Science, Chemistry, and Algebra. This ensures a mastery of knowledge and skills after each level.For example, currently in High School, Biology is taught in 2nd Year, Chemistry in 3rd Year, and Physics in 4th Year. In K to 12, these subjects are connected and integrated from Grades 7 to 10. This same method is used in other Learning Areas like Math.

The new Science curriculum strongly links science and technology, including indigenous technologies to preserve the country's distinct culture.In the old curriculum, Science was taught using the discipline-based approach in the most part of high school (Biology in 2nd Year, Chemistry in 3rd Year, Physics in 4th Year). In the new curriculum, spiral approach is applied in teaching science concepts and applications in all subjects.

This study is anchored on the theory of constructivism posited by Jerome Bruner (1960). Constructivism is the theory that learners construct their own knowledge based on the things they currently know and have known in the past. He argues that the curriculum should revisit basic ideas and repeatedly build upon these ideas until the learner understands fully. He suggests that the early teaching of a subject should put emphasis on grasping the basic ideas intuitively. He advises that the curriculum should revisit these principal ideas repeatedly, building cumulatively upon them, gradually making connections between fundamental ideas and new ones until the students understand them fully. Bruner recommends that the curriculum be built upon the natural thinking processes of the learner. He argues that the child should be presented with ideas that are not too distant from his or her natural way of thinking.

STATEMENT OF THE PROBLEM

The researcher wants to find out if spiral progression approach affects students' and proficiency in their science subjects. Specifically, the researcher wants to provide answers to the following the questions:

Statement of the Problem

1. What is the progression in the level of knowledge proficiency of Grade 10 students for four years?
2. What is progression in the level of skills proficiency of Grade 10 students for four years?
3. Is there a significant relationship between knowledge and skills proficiency for four years?

LITERATURE REVIEW

Knowledge and Skills Proficiency in Science

Science Academic Performance

Science education aims to cultivate scientific literacy among all students, encompassing a deep understanding of core science concepts, the nature of science, and the relevance of science and technology in daily life, with the aim of fostering continued engagement in scientific pursuits beyond formal education. A pivotal aspect of modern educational systems is student-centered active learning, where teachers act as guides within the learning process. Active learning empowers learners to take charge of their education, making decisions and regulating their own learning processes. This approach personalizes learning, emphasizing the development of process skills, as advocated by Akinoglu & Tandogan (2007).

Science encompasses three critical dimensions: content, process, and attitudes. Central to the development of scientific literacy are science process skills, which are naturally acquired as individuals interact with the world scientifically, shaping their understanding of concepts. The interplay between concepts and process skills underscores the need for science teachers to nurture these skills, enabling students to investigate real-world issues effectively (Deng, 2007).

Defined as broadly transferable abilities reflective of scientists' behavior, science process skills encompass cognitive and psychomotor skills essential for problem-solving, data interpretation, and communication (Akinbobola & Afolabi, 2010). Ozgelen (2012) emphasizes their role in constructing knowledge and solving problems in scientific inquiry, highlighting their integration into science learning.

Effective science teaching hinges on teachers' understanding of science processes, content, and inquiry. However, studies indicate deficiencies in elementary teachers' science content knowledge and inquiry pedagogical skills (Arzi& White, 2007). The integration of science content and process skills yields significant increases in subject matter understanding, underlining their complementary nature (Arzi& White, 2007).

Early exposure to science process skills is crucial, with basic skills emerging even before kindergarten, fostering scientific curiosity and laying the groundwork for future learning (Kirch, 2007). Middle school marks a critical period for further skill development, enhancing students' active learning and sense-making abilities (Settlage and Southerland, 2007).

Science process skills instruction not only benefits students academically but also cultivates scientific creativity and higher-order thinking, with potential transferability to other subjects (Meador, 2003). The National Science Teachers Association (NSTA, 2002) advocates for hands-on exploratory investigations centered on inquiry and process skills, enhancing student learning and achievement in science, mathematics, and language arts.

Moreover, understanding the nature of science is integral to comprehending how science operates as a discipline, aiding in the learning of science concepts (Chiappetta and Koballa, 2010). Science process skills play a pivotal role in facilitating the learning of the nature of science (Rezba, et al., 2007).

Additionally, prior knowledge and beliefs significantly influence students' learning experiences, underscoring the importance of addressing misconceptions and building on existing knowledge to foster effective learning outcomes (Vodopivec, et al., 2002).

The cultivation of science process skills is paramount in promoting scientific literacy and fostering students' engagement in scientific inquiry, necessitating competent teaching and integration into science education curricula to ensure holistic and effective learning experiences.

Spiral Approach

Modern theories of learning and teaching encompass various dimensions such as cognitive styles, multi-intelligence, critical and creative thinking, motivation, cooperative and interactive learning, and ambient learning, all contributing to a more student-centered, self-aware, creative, and autonomous learning experience (Veselinovska, et al., 2011). These theories emphasize the importance of utilizing the senses to facilitate learning channels effectively, guiding learners towards positive learning outcomes and achieving instructional goals (Veselinovska, et al., 2011).

Jerome Bruner's spiral progression theory has significantly influenced curriculum development, emphasizing the importance of structure, the teachability of any subject at any age, and the implementation of a spiral curriculum. Spiral curricula, such as the Everyday Mathematics program, spread learning over time and revisit concepts repeatedly, contrasting with massed approaches (University of Chicago School of Mathematics, 2015). The spacing effect, highlighted by the U.S. Department of Education, emphasizes the benefits of distributed learning over massed learning, promoting long-term retention and application of knowledge (Pashler, et al., 2007).

However, despite the proven efficacy of spaced learning, curricula often neglect to incorporate this approach due to misconceptions about massed learning's short-term performance benefits (Bjork, 2000). Teachers' and students' preferences for massed learning further deter the widespread adoption of spaced learning, despite its long-term benefits (Tulio, 2008). Spiral progression, while essential for fostering deep understanding and mastery of concepts, faces challenges in implementation due to complex curriculum design and insufficient awareness among educators (Taba, 2003).

Spiral progression entails the gradual development and revisiting of concepts over time, deepening understanding and broadening learning experiences (Corpus, 2015). However, the Philippine DepEd's K+12 curriculum exemplifies a misunderstanding of spiral progression, as it fails to implement the approach effectively, focusing on dividing subjects into segments rather than facilitating progressive learning (Zhang, 2000). Bruner emphasizes the importance of revisiting different subjects each year, aligning with an apprenticeship approach to expose students to diverse concepts progressively (Bruner, 2007).

Early exposure and repetition play crucial roles in fostering appreciation and understanding of subjects, as demonstrated in approaches integrating music into learning experiences (Campbell, 2008). Case study approaches, such as those used in introductory chemistry, have shown promise in engaging students and enhancing comprehension of complex topics (Brink, et al., 1995).

Furthermore, the organization of learning experiences is vital for effective teaching and learning, with progressive and recursive methods facilitating student engagement and understanding (Ngozimba, 2001). Performance-based approaches, such as Zhang's proposal for Chinese L2 reading instruction, emphasize contextual learning and task performance to enhance comprehension and retention (Zhang, 2010).

The K-12 Curriculum

The K to 12 Program, encompassing Kindergarten and 12 years of basic education, aims to provide ample time for mastering concepts and skills, fostering lifelong learners, and preparing graduates for various pathways including tertiary education, employment, and entrepreneurship (Department of Education, 2015). Research indicates that children who attend Kindergarten have higher completion rates and are better prepared for primary education, as the early years lay the foundation for lifelong learning and holistic development (Presidential Communications Group, 2013).

One significant aspect of the K-12 curriculum is the emphasis on language proficiency through mother tongue-based multilingual education, recognizing that students learn best in their first language. Mother Tongue instruction begins in Kindergarten, facilitating easier transition to learning English and Filipino in later grades (Department of Education, 2015). Additionally, subjects are taught through spiral progression, ensuring a seamless and integrated learning experience where concepts evolve from simple to complex across grade levels.

Senior High School (SHS) is a highlight of the K-12 program, offering two years of specialized upper secondary education with various tracks catering to students' aptitude and interests. Students can choose among Academic, Technical-Vocational-Livelihood, and Sports and Arts tracks, with each track offering different strands such as Business, Humanities, and Science (Department of Education, 2015). Immersion programs provide students with practical experience in their chosen track, enhancing their employability through certifications from the Technical Education and Skills Development Authority (TESDA) (Department of Education, 2015).

RESEARCH METHODOLOGY

Research Design

The descriptive research was used in this study. David (2005) explains that this particular research design describes the present existing conditions. It involves the collection of data in order to test hypotheses or to answer questions concerning the current status of the respondents under study.

The independent variable in this study is the Students Knowledge in Grade 7 to 9 Science of the given population while the dependent variable is the Knowledge and Skills Proficiency in Science of Grace 10 Students

Data gathered were computer-processed using the Statistical package for Social Science (SPSS) software. The study utilized the descriptive statistical tools such as mean, standard deviation, T-test and Pearson r. All inferential statistics were set at .05 level of significance.

Locale and Respondents of the Study
This study was conducted in in a public school in the municipality of Tapaz, Capiz. The respondents of the study were 147 Grade 10 students who are enrolled for SY 2020-21. The researcher has the entire student population as respondents of the study.

Data Gathering Instrument and Procedure
A researcher made instrument was used to gather information for this study. A permit to condut the study was sought by the researcher from the Schools Division Superintendent of the Department of Education Capiz Division Office before the start of her research. Upon the approval of the permission, the researcher made a letter to the principal of the school where the study will take place asking permission to look at the previous and current academic records in science of the grade 10 students of the current school year. After which, the researcher asked permission from the teacher advisers and subject teachers from the previous school years to look at the Grade 10 academic records of the respondents in Science so as to acquire the necessary data for the reference of the researcher. Data obtained were tabulated and interpreted using the appropriate statistical tools.

Statistical Data Analysis and Procedure
The gathered data was analyzed with the use of the following statistical tools: frequency count, mean and regression. t-Test was used to compare the actual difference between two means in relation to the variation in the data. Linear regression was used to compare the relationship between two variables by fitting a linear equation to observed data. One variable is considered to be an explanatory variable, and the other is considered to be a dependent variable. One-Way ANOVA test set at 0.05 alpha level was used to determine the significance of the differences among two groups compared. Pearson's r., set at .05 alpha level of significance, was used to determine the relationship of the knowledge and skills proficiency progress in spiral approach in science instruction of Grade 10 students

RESULTS AND DISCUSSION

Knowledge proficiency progression from Grade 7 to Grade 10 of Grade 10 High school Students

Table 2. Progression in knowledge proficiency of Grade 10 Students

Progression in knowledge proficiency.	Knowledge Proficiency	
(N=147)	Mean	SD
Grade 7 (2012-2013)	82.01	4.41
Grade 8 (2013-2014)	83.42	4.27
Grade 9 (2014-2015)	83.11	6.02
Grade 10 (2015-2016)	80.82	5.49

In this study, to determine the knowledge proficiency progression of the respondents the data were gathered from the previous and current academic records in Science of the respondents. Since the knowledge is comprised of 60% of the total grade in Science subject which includes written quizzes and quarterly exams, Knowledge was measured by adding the equivalent grade in written works which is 40% added with the equivalent grade in the quarterly exam which was 20% thus resulting to the 60% of the general average in Science subject from Grade 7 to the first grading of Grade 10 of the individual respondent.

The results of the investigation in knowledge proficiency is shown on table 2. The mean and standard deviation of the knowledge proficiency from grade 7 up until the first grading of grade 10, as seen on table, during their Grade 7 SY: 2012-2013 (M=82.01, SD= 4.41, and Grade 8 SY: 2013-2014 (M=83.42, SD=4.27) there was an increase in terms of knowledge proficiency but during their Grade 9 SY: 2014-2015 (M=83.11, SD=6.02) the respondents showed a slight decrease which continued on the first grading of Grade 10 SY: 2015-2016 (M= 80.82, SD=5.49)when there was an abrupt decrease in the knowledge proficiency in the Science subject of the Grade 10 students, which can beattributed due to various factors.

Findings of this study is supported by the claim of Akinoglu and Tandogan (2007), who said that the goal of science education is to enhance all students' scientific literacy; that is to help students grasp essential science concepts, to understand the nature of science, to realize the relevance of science and technology in their lives and to willingly continue their science study in school or beyond school.

Furthermore, it is perceived that attaining high knowledge proficiency is manifested by activities that trigger active learning process giving the the opportunity to make decisions about various dimensions of the leaning process and to perform self-regulation. In an active learning process, learning is no longer a standard process, but transforms into a personalized process where process skills are developed.

Furthermore, Gardner (1975) posited that several studies have identified a number of factors affecting students' performance to science in general. These can be largely categorized as gender, personality, structural variables, and curriculum variables.

Skills proficiency progression of Grade 10 High school students

Table 3. Progression in skills proficiency of Grade 10 Students

Progression in skills proficiency	Skill Proficiency	
(N=147)	Mean	SD
Grade 7 (2012-2013)	81.74	3.59
Grade 8 (2013-2014)	82.95	3.49
Grade 9 (2014-2015)	83.79	4.34
Grade 10 (2015-2016)	81.78	3.89

The results of the investigation in skill proficiency is shown on table 3. As seen on the given data during Grade 7 SY: 2012-2013 (M=81.74, SD=3.59), Grade 8 SY: 2013-2014 (M= 82.95, SD= 3.49) and Grade 9 SY: 2014-2015 (M= 83.79, SD= 4.34) there was an observable increase in the skill proficiency progress in the last three years whereas during the first grading of Grade 10 SY:2015-2016 (M=81.78, SD=3.89) there was a sudden decrease in terms of the skills proficiency progress of the respondents. This may also be due to some factors that also affects the students in terms of their skills proficiency. In view of this, Settlage and Southerland (2007) justify the purpose for teaching skills competency. Students should be provided with active learning, sense-making tools, language development, a community of learners, and foster a natural sense of curiosity. Furthermore, the science process skills are essential to scientific creativity and creative thinking. The results of this study is further enriched by Meador's claim (2003) that science process skills are essential for fostering creativity. Creative thinking and science process skills are intertwined and those who use science process skills are better atscientific creativity. Creativity and higher mental processes also have a high likelihood ofbeing transferred to other subject areas.

The benefits of acquiring skills through the spiral approach are eminent. The National Science Teachers Association (NSTA, 2002) explicitly states that this enhances student learning. Knowledgable teachers, therefore, provide appropriate and effective skill instruction. Likewise, students who are exposed to science skills demonstrate a higher level of science achievement and enhancetheir math and language arts abilities. Students provided with the process skill instructiontend to have and be able to use higher mental process and creativity. Therefore, scienceeducators must develop teachers who are competent in the knowledge and teaching of the science process skills, to consequently ensure that students get effective and valuableskill instruction (Karsli, Sahin and Ayas, 2009).

Relationship between knowledge and skills proficiency

Table 3 Pearson r Between Knowledge and Skill Proficiencies of grade 10 students

N-588		Skill Proficiency
Knowledge proficiency	r	.859*
	Sig	.000

*p<0.05 significant @ 5% level of significance

Table 3 shows the relationship between knowledge and skills proficiencies of Grade 10 students, as presented in the table, there is a significant difference between the knowledge and skills proficiencies of Grade 10 students from Grade 7 to present, this proves that knowledge proficiency is not related to the skill proficiency of the respondents. Thus it may be inferred that the students may know the knowledge and competencies but can be weak in terms of practical applications of the competencies being taught.

In spiral progression, developing the same concepts from one grade level to the next in increasing complexity and sophistication of the knowledge and competency of students (Elcin, 2014). Scope, sequence and knowledge are developed gradually. Furthermore, progression is not only vertical (e.g. increasing complexity), but also horizontal (e.g. broader range of applications). Learning is extended, reinforced and broadened each time a concept is revisited. Mastery from one grade level to the next is ensured by building on pupils' prior knowledge and skills.

CONCLUSIONS

In this study, an analysis of knowledge and skill proficiency progression among respondents reveals significant trends that shed light on the effectiveness of science education strategies. The findings indicate fluctuations in knowledge proficiency, with notable increases observed up to Grade 9, followed by a sudden decrease in Grade 10.

These variations may be attributed to multifaceted factors impacting student performance, as elucidated by Akinoglu and Tandogan (2007) and Gardner (1975), ranging from gender differences to curriculum variables. Similarly, skill proficiency exhibited a consistent upward trajectory until Grade 10, where a decline was evident, possibly influenced by similar contextual factors affecting students' abilities. Settlage and Southerland (2007) underscore the importance of active learning and fostering curiosity to enhance skill competency, while Meador (2003) highlights the interconnectedness between science process skills and creativity. The significance of acquiring skills through the spiral approach, as advocated by the National Science Teachers Association (NSTA, 2002), underscores the necessity of competent teaching to ensure effective skill instruction. However, the observed disparity between knowledge and skill proficiencies suggests a need for a more comprehensive approach to education, emphasizing not only theoretical understanding but also practical application.

The concept of spiral progression, as proposed by Elcin (2014), emphasizes the gradual development and reinforcement of concepts, both vertically and horizontally, underscoring the importance of building on prior knowledge and skills for sustained mastery. In essence, the findings highlight the complexity of educational dynamics and underscore the imperative for multifaceted approaches to fostering holistic student development.

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