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Joymie R. Orbe
Amadeo National High School, orbejoymie@gmail.com

Allen A. Espinosa
Philippine Normal University, espinosa.aa@pnu.edu.ph

Janir T. Datukan
Philippine Normal University, datukan.jt@pnu.edu.ph

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Teaching Chemistry in a Spiral Progression Approach: Lessons from Science Teachers in the Philippines

Joymie R Orbe
Amadeo National High School, Philippines
Allen A Espinosa
Janir T Datukan
Philippine Normal University, Philippines

Abstract: As the Philippines moves towards implementing the K-12 curriculum, there has been a mismatch in teacher preparation in science. The present teacher education curriculum prepares science teachers to specialise in a specific field (e.g. integrated science, biology, chemistry, and physics). However, in the K-12 curriculum, they are required to teach all the sciences in a spiral progression approach. Hence, this study analysed the experiences of science teachers in teaching chemistry in the K-12 curriculum in order to identify their challenges and how they are overcoming them. Findings suggest that the teacher's content, pedagogy, and assessment in chemistry are problematic; specifically, challenges such as instruction-related factors, teacher competence, in-service training sufficiency, job satisfaction, support from upper management, laboratory adequacy, school resources, assessment tools, and others influence teacher success in teaching chemistry. These identified challenges greatly affect the ultimate beneficiaries of education, which is the learner.

Keywords: chemistry teacher education, science teacher education, spiral progression, Philippine K-12 curriculum

Introduction

Before the implementation of K-12, the Philippines is the only country in Southeast Asia and one of the only three countries in the world with a ten-year program prior to entry to the university (SEAMEO INNOTECH, 2012). The continuous deterioration of the quality of education in the Philippines has prompted the Department of Education (DepEd) to push for the implementation of the K-12 curriculum, which entails the institutionalisation of kindergarten and the addition of two more years of high school in the basic education cycle. Republic Act No. 1033 or the Enhanced Basic Education Act of 2013 has made the said innovation in Philippine basic education legal. K-12 aims to give every learner an opportunity to receive quality education based on an enhanced and decongested curriculum that is internationally recognised and comparable (Ferido, 2013; Laureano, Espinosa, & Avilla, 2015).

Among the different subjects, science is one of the subjects that underwent major revisions (Montebon, 2014). In the old curriculum, science subjects, except in the first year, were offered one in each year level (biology in second year, chemistry in third year, and physics in fourth year) and were taught using discipline-based approaches. In the new curriculum, however, science concepts and applications in all subjects are introduced in a spiral progression approach (SEAMEO INNOTECH, 2012). In terms of instruction, the science program shifted from traditional methods of teaching to a more innovative exploration that emphasises the enhancement of the students' critical thinking and scientific skills.

The K-12 curriculum utilises learner-centered approaches such as the inquiry-based learning pedagogy–concepts and skills are taught by providing pedagogy which will enable them to enhance their cognitive, affective, and psychomotor domains (Montebon, 2014). As a whole, the K-12 science curriculum is learner-centered and inquiry-based, emphasising the use of evidence in constructing explanations. Concepts and skills in Life Sciences, Physics, Chemistry, and Earth Science are presented with increasing levels of complexity from one grade level to another through spiral progression, thus paving the way for deeper understanding of key concepts (SEAMEO INNOTECH, 2012). With this high demand from teachers, the DepEd gave due consideration and appropriate support to ensure that teachers will be able to fulfill their significant role in the K-12 curriculum (SEAMEO INNOTECH, 2012).

However, other factors have been found to affect students' performance aside from the teacher factor. Student and environment-related factors were also found to be greatly contributing to performances of students in science subjects like chemistry. The chemistry teacher, students, parents, high school administrators, curriculum planners, and the government are therefore faced with the daunting challenge of re-awakening interest and providing enabling environment for the effective teaching of chemistry in particular and the sciences in general (Edomwonyi-Otu & Avaa, 2011). Since one of the biggest innovations in the new science curriculum is the spiraling of the competencies in science (Montebon, 2014), this conversion greatly affected chemistry education in the high school level. For chemistry teaching to be effective, pre-service as well as in-service chemistry teachers will need to be educated about how knowledge is structured in the discipline that they are teaching (Erduran et al., 2006).

Chemistry in the K-12 curriculum is arranged spirally into four years from grade 7 to grade 10. One quarter per grade level is devoted to teaching chemistry instead of compressing all the chemistry lessons in one school year, which was a characteristic of the old curriculum– the 2002 Basic Education Curriculum (BEC). Chemistry is learned during the first quarter of grade 7, third quarter of grade 8, second quarter of grade 9, and fourth quarter of grade 10. Science teachers who graduated with specialised training in teaching General Science, Biology, Chemistry, and Physics are now tasked to teach all the sciences in one year level. Teachers who are Biology majors are tasked to teach Chemistry, Physics, and Earth Science, and teachers who are Physics majors are tasked to teach Biology, Chemistry, and Earth Science.

This study explored the experiences encountered by these science teachers who are teaching chemistry in the K-12 curriculum with regard to the spiraling content, pedagogy, and assessment. This study also identifed the prevailing problems in chemistry instruction and their implications to education. Specifically, this study sought to answer the research question: What are the problems encountered by science teachers in the implementation of the K-12 curriculum in terms of the spiral progression of content, pedagogy, and assessment?

The new K-12 Curriculum in the Philippines

The DepEd in the Philippines implemented the new K-12 Curriculum, which started school year 2012-2013 by virtue of Republic Act No. 10533 or the Enhanced Basic

Education Law of 2013. Ultimately, the government's ability to secure resources to implement the K-12 program and at the same time address the unresolved shortages in educational inputs will determine the country's quality of education in the future (SEPO Policy Brief, 2011).

The new science program has many innovations in terms of the arrangement of competencies, integration of each branch of science in every grade level, mode of instruction, and learning pedagogies (Montebon, 2014). It aimed to develop scientific literacy among students towards application of scientific knowledge that will have social, health, and environmental impact. The curriculum strongly links science and technology, including indigenous technologies to preserve the country's distinct culture (SEAMEO INNOTECH, 2012). Students' motivation to learn chemistry and science in general is a complex construct that it can be conceptualised and assessed in at least five different dimensions. Salta and Koulougliotis (2012) showed that motivation interacts closely with cognition and subsequently influenced science learning and the level of scientific literacy.

Science Education before K-12

Prior to the K-12 education reform, elementary and secondary schools implemented the Basic Education Curriculum (BEC) in 2002 and then the Secondary Education Curriculum (SEC) in 2010, introduced in 2010-2011. Both the BEC and SEC aimed for functional literacy. The science program at the secondary level was designed to promote students' awareness of the relevance of science in life and develop critical and creative thinking as well as skills in problem solving through the teaching of science in an outdoor environment and cooperative learning. More than the understanding of science concepts, emphasis was given to the application of these concepts to improve the environment and quality of life. In the first year, integrated science built on elementary science, and wove together concepts of earth science, biology, chemistry, and physics which flowed sequentially in a more unified and meaningful pattern of study. In the second year, the learners focused on biology, which dealt with the living world of human and non-human species, human interactions and relationships with the environment, and the problems we face relative to health, reproduction, and heredity, food production, resource management, and conservation. In the third year, the learners focused on chemistry, which dealt with the properties and chemical behavior of matter, atomic structure, chemical changes, and technology affecting the environment and society. In the fourth year, the learners focused on physics, which dealt with nature of Physics, mechanics, thermal and mechanical properties of matter, waves and oscillations, magnetism and electricity, and modern physics (DepEd-Bureau of Secondary Education, 2002). The 2010 Secondary Education Curriculum (SEC 2010) also made use of the same concepts but it followed the Understanding by Design (UbD) framework.

On Spiral Progression

The new science program has many innovations, one of which is the decongestion of the competencies and arrangement where science concepts and applications in all subjects are given in a spiral progression approach (SEAMEO INNOTECH, 2012). Spiral progression approach is when the scope and sequence of the content are developed such that concepts and skills are revisited at each grade level with increasing depth (Ferido, 2013). New concepts are built on pupils' prior knowledge and skills to allow gradual mastery from one grade level to the next. In this approach, 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 (Ferido, 2013).

On Science Teacher's Self-efficacy

Science teachers' self-efficacy may be one area of importance, which has been overlooked in implementing change to improve science teaching (Ramey-Gassert et al., 1996). Teacher efficacy has proven to be powerfully related to many meaningful educational outcomes such as teachers' persistence, enthusiasm, commitment, and instructional behavior, as well as student outcomes such as achievement, motivation, and self-efficacy beliefs (Tschannen-Moran & Hoy, 2001). After years of increased efforts into science teaching, when the teacher perceives little success in students' achievement, the teacher may conclude that science is not worth the effort and is too difficult for students (Ramey-Gassert et al., 1996). In other words, when a teacher expends extra effort to teach hands-on science and has "success" with 197 students and "fails" with 22, the memory of the failures and the extra effort required overshadow the successes. This results in low efficacy belief in students' abilities to succeed in science. Thus, for most teachers, the belief that one personally can accomplish a goal (i.e. I can effectively teach science) does not necessarily translate to the belief that one can effect change in others enabling them to accomplish a different goal (students can learn science) (Ramey-Gassert et al., 1996).

Teacher efficacy research has been in place for almost 25 years now. Early work suggested powerful effects from the simple idea that a teacher's beliefs in his or her ability to positively impact student learning are critical in actual success for failure in a teacher's behavior (Henson, 2001). If teachers do not know the content or do not know how to teach it, most students will not learn it (Jolly et al., 2004). Ramey-Gassert et al. (1996) showed that personal science teaching efficacy correlates positively with attitude toward science and with choosing to teach science.

On Pedagogy

A diverse and wide body of research suggest that inquiry-based approaches to learning positively impact students' ability to understand core concepts and procedures (Friesen & Scott, 2013). Inquiry also creates a more engaging learning environment (Friesen & Scott, 2013).

In chemistry education, laboratory activities increase the students' interest in the subject matters covered in the class and help their learning (Tuysuz, 2010). Due to a lack of laboratories at schools or insufficient instruments in laboratories, hands on experiments are rarely performed and ICT activities such as virtual labs are explored instead. It has been found that virtual laboratory applications made positive effects on students' achievements and attitudes when compared to traditional teaching methods (Tuysuz, 2010). However, some students felt they would have performed better if exposed to practical lessons (Edomwonyi-Otu & Avaa, 2011).

Chemistry is a subject that requires demonstrations and can only be effectively taught in the laboratory for easy access to instructional materials; however, most schools lack essential facilities (Edomwonyi-Otu & Avaa, 2011). This is unfortunate since Ojediran et al. (2014) said that science teachers should be encouraged to adopt laboratory based instructional intervention method as an effective learning strategy to enhance the performance of low performing students in and influence their attitude towards science.

Studies showed that the quality of output was best in schools having laboratories in three science subjects: physics, chemistry, and biology (Adeyemi, 2008). Science laboratory is a critical variable in determining the quality of output from secondary schools. It has a significant relationship with quality of output from secondary schools. Schools having laboratories in the three science subjects performed best in the examinations (Adeyemi, 2008). As wisely stated in the Philippine EFA plan, "good education is expensive but lack of education costs many times more" (SEPO Policy Brief, 2011, p. 10).

On Assessment of Student Learning

Part of the K-12 educational reform is the improvement in the process of assessing student learning. The skills that needed to be assessed in the classrooms are presented in a nomenclature on Knowledge, Process, Understanding, and Performance or Product (KPUP). This nomenclature was made for the students to reach the content and performance standards of the curriculum (Magno & Lizada, 2014). The assessment process is holistic, with emphasis on the formative or developmental purpose of quality assurance of student learning. Assessment should be used primarily as a quality assurance tool to track student progress in the attainment of standards, to promote self-reflection and personal accountability for one's learning, and to provide a basis for the profiling of student performance (DepEd Order No. 73, 2012).

Assessment in the K-12 curriculum is also standards-based as it seeks to ensure that teachers will teach to the standards. The students' attainment of standards in terms of content and performance is, therefore, a critical evidence of learning (DepEd Order No. 31, 2012). Tordecillas (2014) reported that K-12 teachers understand the standards-based assessment and all other terminologies connected to it. Further, they have a positive view of it. However, understanding the concept and having a positive perception of it do not guarantee teachers' ease where construction of the assessment is concerned.

Methodology

A permit to conduct the study addressed to the administrators of state-funded high schools in a certain district in the Province of Cavite, Philippines was accomplished before collecting data. This study involved all the science teachers (Table 1) teaching in the K-12 curriculum in a certain district in the Province of Cavite, Philippines.

Overall, twelve science teachers met the inclusion criteria and agreed to participate in the study. The inclusion criteria required that participation be willing and voluntary, and that the participant is currently teaching in the K-12 curriculum as a chemistry teacher. As indicated in Table 1, 83.33% of the respondents were female teachers, 58.33% had been teaching for 10 to 20 years and only 25% has a university chemistry background. Most of the respondents have two to three years of experience in the K- 12 curriculum.

Profile	Number of Respondents	Percent (%)
Gender		
Male	2	16.67
Female	10	83.33
Age		
25-30	2	16.67
31-40	4	33.33
41-50	2	16.67
50 and above	4	33.33
Educational Background		
Chemistry related courses	3	25.00
Non-chemistry science courses	5	41.67
Non-science related courses	4	33.33
Number of years in teaching		
Less than 10 years	2	16.67
10-20 years	7	58.33
21-30 years	3	25.00
Number of years teaching in the K-12		
1 year	2	16.67
2 years	5	41.67
3 years	5	41.67

Table 1: Demographic profile of the participants

This study employed qualitative interviewing as the data collection approach. The interview guide undergone development, validation, pilot testing, and revision before the interview was conducted.

Interview transcripts were analysed through inductive thematic analysis by the first author and by an independent interrater. This was followed by a discussion to identify common themes. Three themes emerged from the discussion and data analyses of the experiences of science teachers in teaching chemistry in a spiral progression approach: (1) Spiral progression of the content is learner-centered, advanced and sophisticated, but is not concentrated, extensive and it also challenges instruction, (2) Chemistry instruction in the K-12 is dynamic, realistic and productive, but it requires competent and highly qualified teachers and sufficient facilities, and (3) KPUP is a favorable assessment, at the same time a complicated and problematic one.

Findings and Discussion

On the Spiral Progression of the Content

This study uncovered two major characteristics of chemistry content spiral progression as experienced by science teachers in the K-12 framework. While it is viewed as learner-centered, advanced, and sophisticated, the claim that it is unconcentrated, extensive, and challenging remain to be its biggest impediment.

Spiral Progression of the Content is Learner-Centered, Advanced and Sophisticated

Respondents found the spiral progression of the content as learner-centered and steers holistic learning. In spiral progression approach, 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 (Ferido, 2013). Chemistry instruction in the K-12 allows the students to update retained knowledge from the four areas of science namely: chemistry, biology, earth science and physics from grade 7 to grade 10. Since chemistry instruction is ladderised, each grade level receives a piece of each subject area and so updating is made easier. It improves learning since students were given a jumpstart in science as they enter high school education for having all these subjects in every year. As shared by the respondents:

> *In the K-12, every grading period we're given a chance to teach the four said subjects areas… so lessons were refreshed. There is a possibility that the students can recall what is taught from the previous grade level. (R2)*
>
> *Even if it''s just the first time for the grade 7 students to be exposed to chemistry... It's nice that the module's way is to expose the learner first before forming a concept. Just like in our lesson about mixtures and substances. They first identify the substances and mixtures at home and stores so they can have basic ideas about the topic before formulating a concept. (R9)*
>
> *The strategies are okay since you can apply all the teaching strategies [in the K-12 chemistry instruction]. (R5)*
>
> *I think, spiral approach is strength of the K-12, since the teachers are encouraged to make efforts to study these four different areas of science. (R7)*
>
> *In my case, I really need to study deeper about those topics but for some teachers who really want to explore, it is a challenge. (R11)*

Additionally, spiral progression seems to lead to a more advanced, sophisticated chemistry content through the involvement of varied teaching strategies. This also serves as a challenge to non-majors as they needed to learn chemistry as it being a part now of their teaching load. In particular, it is felt that when focusing upon progression, it is the nature and sequencing of learning the activities that need to be highlighted by those responsible for ensuring progression in schemes of work (Chapman, 2002). Teachers recounted that there is a growing set of results on how these approaches lead to improved student learning (Froyd & Simpson, 2010).

Spiral Progression of the Content is not Concentrated, Extensive and Challenges Instruction

Interestingly, science teachers revealed their disappointment as they narrated their participation in the spiral progression of chemistry instruction in the K-12 framework that it is not concentrated, extensive, and challenges instruction. Most of the respondents of this study reported how the curriculum does not spiral, despite documents saying it does. While others expressed their approval of the ladderised style of the content, most of the respondents stated that the approach is not at all ladderised in manner since the knowledge learned from the previous grade level does not serve as a pre-requisite for the succeeding lesson.

The content standard allotted per year level is limited and is problematic and since the subject is changing quarterly, focus is very minimal, lacks depth, and lacks concentration, which is not aligned with what spiral progression should be. In spiral progression, as more facts and principles on each topic are encountered, the understanding grows in breadth and depth (Ferido, 2013). As indicated by some respondents:

In my opinion, the spiral approach is just fine. But then I just wished that they made sure that the previous topics can be easily linked to the current one. Because there were times that the topics from the previous level are not the prerequisites of the current lesson. So what we do is we have to teach first the prerequisites before we can teach the intended lesson for that grade level. (R2)

Since every grading period we change from one area of science to another, the instruction lacks depth that results to poor retention. Therefore the students' focus in chemistry instruction is too shallow (R12)

The spiral approach of the content challenges instruction since it tests teachers' self-efficacy and competence. Public opinion overwhelmingly favored "ensuring a well-qualified teacher in every classroom" as the top education priority (National Science Board, USA, 1999). Indeed, teachers—once viewed as central to the problem of student underachievement—are now being recognised as the solution. In teacher preparation, there is a "multiplier effect" that can span generations. While a sound undergraduate science education is essential for producing the next generation of scientists, it is equally critical for future teachers of science. The statement "you can't teach what you don't know," surely applies (National Science Board, USA, 1999).

Teachers are not well trained and lack the necessary preparation in using the spiral approach. Respondents expressed the opinion that if the teachers are not competent and prepared, least possible learning can exist for the students. Furthermore, chemistry is best taught by teachers who specialised in chemistry. Spiral progression requires heavy preparation since every teacher must learn and teach the four science subject areas. With some of them being non-majors make it even harder.

I am not chemistry major. But at least I have a little bit idea about it. I find it hard. It is really hard for me because I really have to research on it. It's like I'm groping with the lessons that I need to teach. I am studying as well that's why I also have several hand outs. (R9)

For teachers it is indeed tasking because from physics, I have to teach first general science and then biology then chemistry before we could reach the physics part. So we have to prepare with those 4 areas of science. That's already four preparations! (R11)

Spiral progression of the content is not followed due to laboratory and instructional material problems. Ultimately, the government's ability to secure resources to implement the K-12 curriculum and at the same time address the unresolved shortages in educational inputs will determine the country's quality of education in the future. Sufficient laboratory materials, modules, and books are required to facilitate learning. But this is lacking in the classrooms of our public high schools. As the respondents mentioned:

The only weakness is the materials available in the laboratory are not enough. That's why some of the activities are not possible to do. (R4)

The difficult part is the availability of the materials. If only the materials are complete, it is easier to teach, right? (R4)

On Pedagogy

In this study, the experiences of the science teachers in the K-12 curriculum as to pedagogy were explored and two major themes have been identified. While some teachers recognised the learning environment of K-12 chemistry instruction as being dynamic, realistic and productive, most of the teachers commented the other way around. The idea that this approach still requires competent and highly specialized teacher and sufficient facilities in order for learning to take place in this kind of environment emerged as a general feeling among the participants. It has been reported by Edomwonyi-Otu & Avaa (2011) that teacher-related factors and school environment such as attitude, time, remuneration, laboratory adequacy, and others exert remarkable influence on students' positive achievement in chemistry. These factors directly and indirectly points to areas which have to be addressed in order to enhance the learning outcomes of students in chemistry. If the government and other stakeholders in education could improve on the learning environment of students and motivate teachers who are the curriculum implementers, students performance will possibly improve. Teachers' strong competence and preparedness creates the prerequisite for the professional autonomy that makes teaching a valued career (Sahlberg, 2010).

Chemistry Instruction in ihe K-12 is Dynamic, Realistic, and Productive

K-12 chemistry instruction focuses on real-life situations and ushers improvisation and localisation. The research highlighting the benefits of authentic learning, together with a growing interest in providing students with more engaging, thought-provoking learning opportunities, has prompted teachers at all grade levels to experiment with incorporating inquiry-based learning into their curriculum. But interest alone does not directly translate into effective implementation of new models. Indeed, "learning by doing" has a somewhat checkered track record, in part because teachers often lack the information, support, and tools necessary to fully integrate and support this alternative approach to teaching and learning (Barron & Darling-Hammond, 2008). As the respondents articulated:

Because before, we have few activities. Now, it seems like all the activities and we're just facilitators. (R7)

Sometimes, there's none so we improvised. If the students could not improvised it we look for substitute activities, besides it's just the same. (R9)

If we can improvise it, we do it. But if we can't I just download some videos from YouTube. That's what the Grade 9 is watching. (R10)

K-12 chemistry instruction employs inquiry-based learning and performance-based learning though the utilisation of varied strategies. Friesen and Scott (2013) suggests that inquiry-based approaches to learning positively impact students' ability to understand core concepts and procedures. Inquiry also creates a more engaging learning environment (Friesen & Scott, 2013).

We are also doing lecture discussions, demonstrations, experiments. We are also doing some presentation with the use of ICT, technology; usually that's what we use. (R2)

For matter, even though it is easy, I still used video presentation, lecture then video presentation, groupings and activities, experimentation. (R3)

We watched a video for the periodic table. Multimedia. Acids and bases, we conducted something about the eggplant to be used as indicator. So it's already available at their household. They made their own indicator. (R4)

As one important element of the K-12 curriculum, inquiry-based learning was employed in chemistry instruction. Inquiry-based learning offers promise in supporting students to become thoughtful, motivated, collaborative, and innovative learners capable of engaging in their own inquiries and thriving in a world of constant change (Student Achievement Division-Ontario, 2013). There is little doubt that starting the learning process from the students' own point of interest, or at least with their understanding of why they should learn a specific topic, might serve as a powerful tool for a meaningful learning process. Orion (2007) suggested in his study that the learning process should start with a "meaning construction" session, where students could discover what interested them about a particular subject. As the teachers acclaimed:

> *About tracking the path of the periodic table of elements. Students are not aware on the development so they research the topics in details. So they will learn the contributions of the scientists, the old arrangement of the elements in periodic table to the modern arrangement. So in that particular topic, they will learn through paper and pencil and more on research. (R2)*
>
> *At group activities. Usually you will goup your students then you will give those questions. But usually the students lack knowledge about the lesson. That is why it is important to make rounds to give them more information about it, that even though the questions were very simple, you have to make extra effort for them to understand what you want them to learn. (R8)*

Chemistry Instruction in the K-12 Requires Competent and Highly Qualified Teachers and Sufficient Facilities

Some teachers are teaching chemistry but they are not graduates of chemistry (Edomwonyi-Otu & Avaa, 2011). There is a growing consensus that science teachers must have a strong science background (Ware, 1992). However, given the lack of science content in some science teacher training programs, and the belief that a good textbook or a "teacher-proof kit" is a cost-effective way to circumvent the poor science background of many teachers, it is not a position accepted by all (Ware, 1992). Non-majors need to educate and update themselves again in order to deliver satisfactory chemistry teaching. They need to self-study prior to teaching so that more accurate information would be given to the class. Ideally, teachers should also accept some responsibility for the continual upgrading of their own knowledge and skills. An additional chemistry course is also needed for upgrading chemistry skills that is needed in chemistry instruction such as computation or mathematical skills. As some of the respondents expressed:

> *They have to learn a lot. Say for example they have to take non-major courses but it will be difficult. Because it's four components… For example, you are teaching Biology. Biology is very different from Physics and Chemistry. You need memorization on that because in Physics and Chemistry, it's more on application. So they need to self-study or do other ways if we really want to have a higher standard because it's spiral… It seems exciting. But, in my age, maybe I'll stay here in Grade 7. Because familiarity-wise, unlike if I will go to higher level, I need to study again. I don't' want that because I'm lazy. (R6)*

Activities in K-12 chemistry instruction were skipped; concepts were discussed instead due to insufficient laboratory and instructional materials. Some students felt they would have performed better if exposed to practical lessons inreal time (Edomwonyi-Otu & Avaa, 2011). At times, activities were not performed due to unavailability of materials. Chemistry is a subject that involves a lot of demonstrations and can only be effectively taught in the laboratory for easy access to instructional materials; however, most schools lack essential facilities (Edomwonyi-Otu & Avaa, 2011).

Students are better able to evaluate and reflect on their own learning and the collective learning of the class when they have been part of the learning process from the beginning, having played an active role in the initial planning and identification of the main learning goals. In fact, a key feature of inquiry-based learning is the practice of revisiting initial theories and ideas, both as individuals and as a class, and reflecting on the ways in which current understanding differs from the former. In this way, students begin to experience learning as an ongoing process, not an end point (Student Achievement Division-Ontario, 2013). As claimed by some of the respondents:

> *Others let their students bring things if they could find it from their home. But if it's really not available we skipped it and just discuss it. (R3)*
> *I'm skipping some activiies because we lack materials. I just discuss the lesson if materials are not available because we can't skipped it. And if sometimes I saw a video that is related to our lesson, I let them watched it. I let them do research and present it to the class. So there, there's still a lesson. (R7)*

Possible outcomes of experiment in the K-12 chemistry instruction were discussed by teachers instead of students learning by themselves due to the insuffiency of materials. In lieu of experiments, internet materials or videos are used instead. Teachers demonstrate experiments instead and so the student-centered characteristic as claimed by the DepEd's K-12 is not happening in chemistry instruction. The study of Owoeye & Yara (2011**)** has proven that school facilities were the most potent determinant of academic achievement. Facilities in terms of qualifications of personnel, who are directly involved in the pedagogy; laboratory, library, school buildings, chairs/tables, administrative blocks, chalk-board, school maps, and the like are very crucial to high academic attainment. The study indicates that achievement is a function of availability of facilities to students. Experience cannot be ruled out in this study, however, as an important factor in achieving academic excellence. It has been established that facilities are potent to high academic achievement of students.

On Assessment of Student Learning using KPUP

This study probed the experiences of science teachers in the K-12 framework as to the usage of KPUP as an assessment. Two themes emerged in the process. As some respondents classify KPUP as a favorable assessment, most of them contested it to be an unfavorable evaluation.

Science teachers found KPUP as a favorable assessment since they are now starting to master how to construct questions for each category. Teachers are using self-made rubrics as well as rubrics from a sourcecontextualised to the capacity of the learners in assessing the student's performance. They are becoming more familiar in categorising questions into knowledge, process, understanding and product and performance. K-12 teachers understand standards-based assessment and all other terminologies connected to it. Further, they are developing a more positive view of it.

> *I'm starting to like it though. (Laughs) It's true. Because previously whenever you give a quiz, you will record the assessment. And then, when the student failed the test, you have to repeat it. Isn't it the instruction in the new curriculum is to re-teach? (R8)*
> *But when a student has his different ways to learn, there is a greater chance to get a higher grade. For example, the student has a poor memory but well in process, skills and understanding, he can explain the topic well, performance is given a better weight in K-12 therefore there is a greater chance that the student will pass the subject. Unlike before when a student is slow, he will never get a chance to get a high grade. (R2)*

Contrastingly, most of the teachers expressed their disappointment in this approach to assessment and considered it as unfavorable assessment. Teachers found KPUP to be complicated and problematic. Directions given were not clear and so science teachers were confused on the proper classification of questions into its appropriate category. Teachers' knowledge about KPUP is very minimal to the point wherein they are not sure if the things that they are currently doing in their classrooms are the right procedure or the other way around. For these reasons, science teachers prefered the old curriculum's assessment than KPUP.

> *It's vague. For example we need to take a test. We still need to know what is for knowledge, what is for process and for product we really need to chose the most tangible for that project. And then for the understanding (R4)*

Conclusions and Recommendations

The findings suggest that (1) although the spiral progression of the content is learner-centered, advanced, and sophisticated, it is not concentrated and extensive; (2) chemistry instruction in the K-12 curriculum is dynamic, realistic, and productive, but it requires competent and highly qualified teachers and sufficient facilities; and (3) KPUP is a favorable assessment as teachers are now starting to master how to use it, but at the same time they still find it to be complicated and problematic.

This is a pilot study about chemistry instruction in a certain district in the Province of Cavite, which is a small town with four high schools–one central school and three "barrio" or rural schools. It would indeed be quite advantageous to explore the experiences of current science teachers in the other bigger districts within the division of Cavite or even in other parts of the Philippines for a bigger data pool and a larger population. This study also raises questions about the instruction of the other disciplines of science such as biology, physics, and earth science in the K-12 curriculum. The results of the study will provide the government and other stakeholders with ways to further improve K-12 or at the least provide science teachers with enough insight in order to tackle the spiral progression in a more positive manner.

References

Adeyemi, T. O. (2008). The influence of class size on the quality of output in secondary schools in Ekiti State, Nigeria. *American-Eurasian Journal of Scientific Research, 3*(1): 7-14

Barron, B., & Darling-Hammond, L. (2008). Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning. *Powerful Learning: What We Know About Teaching for Understanding.* San Francisco, CA: Jossey-Bass.

Chapman, D. W. (2002). Management and Efficiency in Education: Goals and Strategies. *Education in Developing Asia*. Manila: Asian Development Bank.

Department of Education (DepEd) Order No. 31 (2012). *Policy Guidelines on the Implementation of Grades 1 to 10 of the K to 12 Basic Education Curriculum (BEC) Effective School Year 2012-2013*. http://www.deped.gov.ph/orders/do-31-s-2012.

Department of Education (DepEd) Order No. 73 (2012). *Guidelines on the Assessment and Rating of Learning Outcomes under the K to 12 Basic Education Curriculum*. http://www.deped.gov.ph/orders/do-73-s-2012.

Department of Education (DepEd)-Bureau of Secondary Education (2002). *Implementation of the 2002 Basic Education Curriculum*. http://www.deped.gov.ph/orders/do-25-s-2002.

Edomwonyi-Out, L., & Avaa, A. (2011). The Challenge of Effective Teaching of Chemistry: A Case Study. *Leonardo Electronic Journal of Practices and Technologies 18*, 1-8.

Erduran, S., Ardaç, D., & Yakmaci-Guzel, B. (2006). Learning to teach argumentation: case studies of preservice secondary science teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, *2*(2), 1-14. https://doi.org/10.12973/ejmste/75442

Ferido, M. (2013). *The Spiral Progression Approach in Science*. http://www.ceap.org.ph/upload/download/20137/137150183_1.pdf.

Friesen, S., & Scott, D. (2013). *Inquiry-based learning literature review*. https://inspiring.education.alberta.ca/wp-content/uploads/2014/04/Inquiry-Based-Learning-A-Review-of-the-Research-Literature.pdf.

Froyd, J., & Simpson, N. (2010). *Student-centered learning addressing faculty questions about student centered learning.* http://ccliconference.org/files/2010/03/Froyd_Stu-CentredLearning.pdf.

Henson, R. (2001). Teacher Self-Efficacy: Substantive Implications and Measurement Dilemmas. *Annual meeting of the Educational Research Exchange*. Texas, USA: Texas A&M University.

Jolly, E. J., Campbell, P. B., & Perlman, L. (2004). *Engagement, capacity and continuity: A trilogy for student success*. http://www.campbell-kibler.com/trilogy.pdf.

Laureano, R.A., Espinosa, A.A. & Avilla, R.A. (2015). Effects of Grade 9 Science Learner's Material on students' self-regulation and achievement in chemistry. *Electronic Journal of Science Education, 19*(8), 28-58.

Magno, C., & Lizada, G. (2014). Guide in assessing knowledge, process, understanding, and performance/product. *Educational Measurement and Evaluation Review*, *5,* 118-127.

Monkman, D. (2001). *Science Curriculum Review Report.* British Columbia Ministry of Education. https://www.bced.gov.bc.ca/irp/reports/scireview.pdf.

Montebon, D. (2014). K-12 Science Program in the Philippines: Student Perception on its Implementation. *International Journal of Education and Research 2*(12), 153-164.

National Science Board, USA (1999). *Preparing our children: Math and science education in the national interest*. https://www.nsf.gov/nsb/documents/1999/nsb9931/nsb9931.htm.

Ojediran, I., Oludipe, D. & Ehindero, O. (2014) Impact of Laboratory-Based Instructional Intervention on the Learning Outcomes of Low Performing Senior Secondary Students in Physics. *Creative Education*, *5*, 197-206. https://doi.org/10.4236/ce.2014.54029

Orion, N. (2007). A Holistic Approach for Science Education for All. *Eurasia Journal of Mathematics, Science & Technology Education*, *3*(2), 111-118. https://doi.org/10.12973/ejmste/75382

Owoeye, J. O. & Yara, P. O. (2011). School facilities and academic achievement of secondary school agricultural science in Ekiti State, Nigeria. *Asian Social Science 7*(7), 64—74 https://doi.org/10.5539/ass.v7n7p64

Ramey-Gassert, L., Shroyer, M. G., & Staver, J. R. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level teachers. *Science Education*, *80*, 283–315. https://doi.org/10.1002/(SICI)1098-237X(199606)80:3<283::AID-SCE2>3.0.CO;2-A

Sahlberg, P. (2010). Rethinking accountability for a knowledge society. *Journal of Educational Change 11*(1), 45-61. https://doi.org/10.1007/s10833-008-9098-2

Salta, K. & Koulougliotis, D. (2012). Students' motivation to learn chemistry: The Greek case. *Proceedings of the New Perspectives in Science Education*. Florence, Italy, 8-9 March 2012. http://conference.pixel online.net/science/common/download/Paper_pdf/292-SSE20-FP-Salta-NPSE2012.pdf.

Southeast Asian Minister of Education, Organization, Innovation and Technology (SEAMEO INNOTECH) (2012). *K TO 12 TOOLKIT: Resource Guide for Teacher Educators, School Administrators and Teachers.* Philippines: SEAMEO INNOTECH. http://www.seameo-innotech.org/eNews/Kto12Toolkit_ao17july2012.pdf.

Senate of the Philippines Policy Brief (2011). *K to 12: The key to quality education?* https://www.senate.gov.ph/publications/PB%202011-02%20-%20K%20to%2012%20The%20Key%20to%20Quality.pdf.

Student Achievement Division-Ontario (2013). *The Ontario Student Achievement Division Student Success Strategy Evidence of Improvement Study*. http://www.edu.gov.on.ca/eng/research/EvidenceOfImprovementStudy.pdf.

Tschannen-Moran, M., & Woolfolk-Hoy, A. (2001) Teacher efficacy: Capturing an elusive concept. *Teaching and Teacher Education*, *17*, 783-805. https://doi.org/10.1016/S0742-051X(01)00036-1

Tuysuz, C. (2010). The Effect of the Virtual Laboratory on Students' Achievement and Attitude in Chemistry. *International Online Journal of Educational Sciences*, *2*(1), 37-53.

Ware, S. A. (1992). *Secondary School Science in Developing Counties: Status and Issues*. Washington, DC: World Bank, PHR Backgound Paper Series, PHREE/92/53.