



**Doctor of Philosophy in Education
(Biology Education)**

Lea C. Garcia

**Biology Teachers' Pedagogical Content Knowledge and Decision Making in Implementing
the Inquiry Approach: A Multi-Case Study**

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Date of Submission
31 May 2021

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Lea O. Garcia, 31 May 2021

APPROVAL SHEET

This dissertation of LEA C. GARCIA attached hereto entitled BIOLOGY TEACHERS' PEDAGOGICALCONTENT KNOWLEDGE AND DECISION MAKING IN IMPLEMENTING THE INQUIRY APPROACH: A MULTI-CASE STUDY in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Education (major in Biology Education) is hereby accepted.

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Acknowledgement

With the sleepless nights typing all the pages of this manuscript, I came to realize how I started and finally finished this goal of earning a doctoral degree. It was a difficult and tiring, yet a meaningful journey involving the ordeal of passing all the academic subjects while doing the responsibilities of a teacher and a mother as well. Finally, this is it. Thus, I would like to express my sincerest thanks and gratitude to the following people who helped me endure the stress and pressure of completing this work.

First and foremost, to the Lord Almighty for providing me all the wisdom and knowledge, and in all times of troubles, difficulties, confusions and worries, “*you stood by me and gave me strength,*” and you said, “*ask and it will be given to you, seek and you will find, knock and the door will be opened to you.*” And with these that you gave me, I give back to you all the honor and glory;

To Dr. Josilyn Soler Solana, Schools Division Superintendent, Division of Laguna, for approving my request to implement this investigation in the two (2) public schools in Laguna, and Dr. Redella Vista, Division Science Supervisor (High School) Division of Laguna, for allowing two (2) teachers from each of the identified schools to be the subjects of this investigation, for Mr. Nelson R. Umali and Dr. Reynaldo D. Villaluz, principals of the participating schools for allowing me to stay in their library and laboratory rooms during the interviews of the teachers;

To Dr. Ricardo ‘Baggy’ T. Bagarinao, my dissertation adviser and professor in two (2) graduate courses, for giving me the idea of using inquiry instruction in the classroom, for giving suggestions to improve my paper, for providing guidance and encouragements during the writing of the paper, for boosting my morale in moments of confusions and worries, for editing many parts of the paper, for keeping me in the right direction to be able to finish everything and for giving his

time for my consultation on some concerns regarding the paper. Despite his busy schedule, he was always around to talk with me;

To the members of the panel, Dr. Rosanelia T. Yangco, Dr. Monalisa M. Te-Sasing and Dr. Maria Ana T. Quimbo, for giving their comments and suggestions to be able to make a good manuscript and for guiding me in the right direction;

To Dr. Maria Helen D. Catalan, dissertation reader/critic, for generously providing me guidance on the technical aspect of this manuscript, for imparting her expertise in improving and revising my manuscript, for arranging time to meet me via zoom to give me several tips and advises on how my data should be properly analyzed and presented, for giving me motivation and for her words of encouragement;

To the former UPLB Chancellor Fernando C. Sanchez, Jr., for allowing me to take a study leave of absence with pay in order to focus on the data gathering and writing of the paper. To my UPRHS family, for the moral support; the Science Department for bearing with me in moments of laughter and for taking over my school responsibilities and tasks during my absence; To Prof. Abriel S. Bulasag, for always being available whenever I would ask him about my paper and to Prof. Marife R. Maquera, for taking care of the Scholarship Committee while I was on study leave;

To my friends Edna Burgos, for finding ways on how I could find somebody to help me in the data gathering; Hany Pearl, for the video recording; Malou Rebulanan, for editing my paper and my cousin, Dr. Ruth Ortega, for sharing her expertise in qualitative research, explaining the use of the effective tool in the analysis; for serving as my second reader and for also editing my paper.

To my best friend, lover, and ever supportive husband, for giving unconditional love, for taking the initiative in helping meet my spiritual needs, by praying with me especially in moments

of sleepless nights; by spending time together in God's Word on Sundays; to pray together for my continuous endurance and wisdom, and by looking for ways to encourage me spiritually.

To my children, Ian, Argee and Ginelle, for cheering me up with their laughter, kisses and hugs, for doing me favors needed for the completion of my paper and for always being there for errands.

To all of you, thank you very much.

Lea C. Garcia

DEDICATION

I dedicate this manuscript to the following dear
people who are now in the hands of the Lord

my father
MR. EPIFANIO G. CABAUATAN
(1929-2011)

my mother
MRS. FELICITAS C. CABAUATAN
(1933-2000)

My UPOU Professor
DR. AMELIA M. PUNZALAN
(1952-2015)
distinguished science educator

Abstract

GARCIA, LEA C. University of the Philippines Open University. May 2021. Biology Teachers' Pedagogical Content Knowledge and Decision Making in Implementing the Inquiry Approach: A Multi-Case Study

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This study was conducted to determine the general pattern of the PCK of four (4) Grade 8 science teachers who used the inquiry approach in teaching cell division and Mendelian Genetics, find out how they developed their PCK, enumerate the active components of their PCK when using the inquiry approach, determine their mental construct of the inquiry approach, describe how they practice the inquiry approach, and find out the general pattern of their decision-making process. Through interviews, classroom observations, and analysis of artifacts, the data were collected and analyzed using constant comparative analysis.

The analysis of multiple sources of data identified the general PCK pattern in which the four PCK components (i.e., knowledge of content, knowledge of instructional strategies, knowledge of students' understanding of science, and knowledge of assessment) were integrated and used in teaching cell division and Mendelian genetics. The highest frequency of integration done by all the teachers was between knowledge of instructional strategies and knowledge of students' understanding of science. The PCK pattern observed was that before the lesson, teachers do any activity as an instructional strategy (knowledge of instructional strategy). During the lesson, teachers teach the content (knowledge of content) through the use of cooperative learning, models and multimedia materials, and a variety of activities (knowledge of instructional strategies). This teaching of content facilitates student learning (knowledge of students' understanding of science) and develops critical thinking and conceptual understanding. After the lesson, in the context of slow learners, assessment follows, which is through giving

extra work or remedial class (knowledge of assessment). While the three teachers (Ace, Ces, and Des) start with a motivational activity, Teacher Bes starts the lesson with another approach. Results also identified emergent themes of the PCK components. For knowledge of content, the identified theme was clear discussion of the basic concepts of cell division and Mendelian genetics. The identified emergent themes for knowledge of instructional strategies were use of cooperative learning, starting a lesson with motivational activities, use of models and multimedia materials, and use of a variety of activities. The identified emergent themes for knowledge of students' understanding of science were developing or stimulating students' critical thinking by asking questions, use of multi-assessment tools, teaching to develop conceptual understanding, critical or analytical thinking skills, and problem-solving skills, and correction/prevention of misconceptions. Finally, for knowledge of assessment, the identified theme was giving extra work or remedial class to slow learners.

In general, there were four (4) approaches that the teachers used to develop their PCK, namely, institution-initiated trainings, self-study, consultation with colleagues or peer consultation, and self-reflection. Meanwhile, all the teachers expressed all the PCK elements with the active prevalence of knowledge of instructional strategies and knowledge of students' understanding of science because it was in these components where there were observations of many active student interactions. Results also reveal the teachers' mental constructs of IBA, namely, inquiry approach is a paradigm shift, student-centered, and motivational, and promotes higher order thinking skills. However, they also viewed the approach as resource and time consuming and requires good prior knowledge and skills of students. Two teachers (Ace and Des) followed the 4As: Activity, Analysis, Abstraction, and Application in teaching cell division and Mendelian genetics as they discussed completely the concepts based on the DepEd's

learning competencies. Teacher Ces discussed almost completely the concepts of cell division and Mendelian genetics while Teacher Bes discussed the concepts incompletely. Finally, the teachers followed the four (4) models of the decision-making process in different instances. Teacher Ace's decision-making process followed the Incremental model in a specific instance and Rational Comprehensive Model in another instance. Teacher Bes followed the Incremental Model, Bounded Rationality Model, and Rational Comprehensive Model in different instances. Both Teachers Ces and Des followed the Incremental Model and Bounded Rationality Model in different instances, too.

Results also reveal that based on their educational background, Teachers Ace and Des consistently had a high level of PCK as they discussed the different topics of cell division and Mendelian genetics completely. On the other hand, the number of years of teaching and professional development programs attendance did not influence the teachers' PCK level. Nevertheless, as the teachers have individual differences (educational background, number of years of teaching/teaching experience, number of professional development programs), they were able to make the necessary decision making when they used IBA in teaching cell division and Mendelian genetics.

Based on the results, it can be concluded that the relationship between PCK and the inquiry approach holds true not only for pre-service teachers and experienced teachers but also for beginning teachers. It can also be concluded that the teachers decide to implement the inquiry approach because of its useful effects to the teacher and students despite the presence of some limitations. After an in-depth analysis of the teachers in terms of their PCK and inquiry instruction, it can be concluded that the number of years of teaching/teaching experience does not guarantee expertise. Moreover, it was found out that there is a relationship between PCK and

the decision-making process of the teachers. With regards to the PCK components, the teachers were observed to show specific decision-making process/es in specific instances to implement the inquiry approach. Only the educational background influenced teachers' PCK level. The four (4) knowledge bases according to a combined model of PCK of Chick et al.(2006); Cochran et al. (1991), Sothayapetch et al. (2013), and Magnusson (1999) were useful in studying about the teachers' PCK and decision making. Finally, the result shows a relationship between the teacher's mental construct of IBA and practice. How the teachers formed their mental constructs relied on how they discussed the topics.

A continuous professional development program is suggested but the professional development program to be undertaken (in terms of taking-up a higher degree) should exactly match with what the teacher is teaching so that content knowledge is completely taught to the students. Professional development programs may also involve short courses on teaching through the inquiry approach. It is also recommended that the findings be used to design assessment instruments to measure teachers' inquiry-based science teaching competencies. This will help in setting up professional development inquiry-based science teaching programs for teachers.

Instructional designers may use the results in revising the module in Grade 8 science in terms of content, illustrations, and activities. Moreover, it is also recommended that a list of competencies for effective teaching using the inquiry approach be compiled based on the findings of the study. With peer consultation as observed to be one of the factors that contributes to teachers' decision to adopt IBA, it is recommended that collaboration among teachers be strengthened in this time of pandemic. It is also recommended that IBA activities be integrated into the modules that are distributed to the students. Constant comparative analysis is a powerful tool that can be used for large amounts of data focusing on comparisons between interviews and

observations. It is then recommended for other teachers to use it apart from the available qualitative and quantitative tools. It is also recommended that a detailed memo-writing during the entire analysis process be used to write down ideas, assume associations, and make theoretical reflections related to each of the emerging categories.

Recommendations for future research are in line with the K-12 implementation that will investigate PCK and decision making in teaching using the inquiry approach across grade levels.

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Chapter 1

INTRODUCTION

Background of the Study

The implementation of the K-12 curriculum by the Department of Education (DepEd) in 2016 seeks to improve the quality of education throughout the Philippine education system. It produces globally competitive graduates, answers the need for a 12-year education system with international standards, aims for graduates with increased competency and better global opportunities, and presents a holistic view of 21st century teaching and learning. Known as Republic Act 10533, the Act focuses on a teaching and learning reform through an implementation of a variety of approaches. One important approach is the inquiry approach. The inquiry approach is learning that is driven more by a learner's questions than by a teacher's lessons (Morino Institute, 2012). In the K-12 curriculum, teachers have to use the inquiry approach by following the 4As - Activity, Analysis, Abstraction, and Application. These 4As are incorporated in the teacher's lesson plan. In the lesson plan, teachers use the first A for any activity that may introduce the lesson or may enrich the lesson, the second A is for analysis of the lesson in the activity wherein the content is discussed, the third A is for abstraction of the general idea about the lesson and the last A is for application of the concepts grounding the lesson or activity.

Their incorporation however requires teachers to have a good grasp and better understanding of the pedagogy and content knowledge of the subject matter (Bueno et al., 2011). This is necessary because pedagogical content knowledge (PCK) helps teachers create inquiry classrooms, which could enhance students' understanding of science or students' scientific reasoning (Magnusson et al., 1999). According to Kartal et al. (2012), the teachers' PCK helps

them to blend the scientific content knowledge, the concepts of inquiry, and pedagogical skills while taking into account the students' abilities and interests. The authors added that with PCK, teachers could easily develop a learning environment where inquiry approach is one important core of learning.

The development of PCK is of utmost importance because teachers are expected to combine or apply diverse teaching strategies in teaching science. It means that they should have a better understanding of the content, teaching strategies, and students' learning process to be able to achieve the teaching and learning goals of science. This has been expected from all science teachers, even before the implementation of the K-12 curriculum. When the K-12 curriculum was implemented in 2016, there was more focus on the use of the inquiry approach. Since the implementation indicates a change in teaching methodology (such as from lecture method to inquiry approach), it is possible for teachers to experience difficulty in adopting the change, especially if their preparation is insufficient to implement the new strategy. This could be aggravated by the challenges associated with inquiry approach implementation. According to Agron et al. (2010), most inquiry-based activities require more time to prepare and teach, and teachers will not be able to do these easily considering the tight schedule for the day. Moore (2014) added that support in terms of funding, supplies, resources and even support to undergo training for professional development may be lacking. Variation in the belief system of teachers is also a challenge for inquiry approach implementation (Chan, 2010). The teacher's foreseen difficulty and these challenges may affect the teachers' decision to use the inquiry approach in the K-12 curriculum implementation. This is critical because there are already inquiry-based learning materials developed in support of the curriculum. On the other hand, teachers' PCK may influence their decision to use the inquiry approach in teaching science. A few authors reported

indications of a positive correlation between PCK and teaching decisions. According to Jones and Moreland (2003), good teacher knowledge of subject content was found to have a positive effect on decision making related to changing pedagogical strategies for creating better learning opportunities. Harlen and James (1997) support this statement as they commented that teachers cannot provide experiences and activities that guide student progress toward the understanding of ideas if they themselves do not know what the ideas are. They added that if teachers have generally sound pedagogical skills, they will rely on these to carry them through difficult aspects of the subjects they teach, but this can limit student learning in the area. Similarly, Corcoran and Goertz (1995) also report that teachers often lack the subject matter knowledge needed to incorporate appropriate pedagogical decisions. In the review of a past research, Gess-Newsome and Lederman (1993) noted that teachers with well-developed pedagogical skills still experience difficulty in responding appropriately to student ideas when they move outside their area of content expertise.

Although these studies and those of a few others (e.g., McNergney et al., 1988; Wasson, 1998; Saad et al., 2002; Carpenter et al., 1998) indicate a positive relationship between PCK and the teacher's decision, there is lack of information and in-depth analysis on how teachers decide to use the inquiry approach in teaching science, given a specific pattern of PCK. The studies mentioned focused their analysis on the PCK and decision making in mathematics at the grade school level. There is still a paucity of information as to what dimension or component of the teachers' PCK is active when employing the inquiry approach in their classrooms. In addition, information on how teachers perceive or construct the inquiry approach as a teaching strategy, and what specific inquiry approach they use given their PCK as well as the mental construct of

the inquiry-based approach (IBA) are limiting. These information gaps led to the conceptualization of the study.

Statement of the Problem

PCK is important in teaching science as inquiry. The teachers' subject matter knowledge, knowledge of student understanding, knowledge of instructional strategies, as well as knowledge and beliefs about teaching and their learners all influence their decision-making ability during pre-lesson planning, which subsequently influence their communicative approach in the classroom (Shannon, 2006). An in-depth analysis on how PCK influences teachers' decision making in adopting a specific strategy is wanting. The study was therefore conceptualized to answer the following research questions:

1. What is the general pattern of the PCK of the participating biology teachers who use the inquiry approach in teaching cell division and Mendelian genetics?
2. How did they develop their PCK?
3. What components of their PCK are more active when using the inquiry approach in teaching Cell division and Mendelian genetics?
4. What is their mental construct of the inquiry approach?
5. How do they practice the inquiry approach in teaching cell division and Mendelian genetics?
6. What is the general pattern of the decision-making process of the biology teachers in using the inquiry approach?

Significance of the Study

The proposed study contributes to the understanding of the educational theories of social constructivism, prospect, and bounded rationality, where the teacher's rational decision to use the inquiry approach is bound within the realm of relevant information, PCK, prior knowledge and

experiences. The inquiry approach is grounded on the constructivist's point of view and, thus, the information on why and how teachers implement it in teaching Science could add to the existing knowledge on the inquiry approach as a social constructivist approach. The use of the inquiry approach as a social constructivist approach holds that learning occurs by integrating experiences with current knowledge, and in the process of implementing it, new knowledge and understanding develop. The teacher's decision to adopt the inquiry approach in the teaching of science could contribute to the Prospect Theory, which holds the assumption that the valuation of attributes and the employment of different decision-making skills yields a functional concept of choice behavior pattern. The teacher's reasons for deciding the implementation of the inquiry approach could add to the existing knowledge on bounded rationality, which holds the assumption of making a rational choice to use the inquiry approach in the teaching of science under time constraints and other pressures or factors.

For teachers, curriculum designers and/or developers

Knowledge on the teachers' decision to use the inquiry approach given their PCK could guide other teachers to evaluate their own conception and practice of the inquiry approach vis-a-vis their PCK. This way, they would be able to determine and understand what they have and do not have, which could further improve their handling of the subjects they teach.

Instructional designers and/or developers could also integrate such information in the development and/or revision of the curriculum. Teachers' mental constructs and applications of the inquiry approach could be used as a guide to how the curriculum should be implemented in various teaching and learning set ups or environments. Otherwise, they could provide insights on how the specific inquiry approach can be used to address students' difficulties in learning specific biology concepts given the teacher's conception of the approach.

For school administrators

The results of the study would also guide school administrators in determining the kind of professional development programs for the teachers. For instance, a PCK pattern toward pedagogy may help school administrators plan for activities that could enhance content knowledge of the teachers. This way, the teachers will not only understand and know how to use a variety of teaching strategies but also improve their content knowledge. In addition, they would be able to guide the teachers on what to improve in the way they practice the inquiry approach.

For pre-service teacher education

The results of the study may serve as a basis for teacher education institutions (TEIs) to update their pre-service education curricula, where development of knowledge of content will be given emphasis. As the study indicates, teachers' knowledge of content plays a vital role in IBA adoption and implementation. Further, TEIs may strengthen provision of support along this line through mentoring.

For other stakeholders

The study could provide information to non-inquiry approach practitioners on what to consider if they decide to adopt the inquiry approach as a teaching strategy. Likewise, administrators of non-inquiry approach adopting schools would be guided in identifying the enabling mechanisms so that their teachers might be motivated to use the approach in teaching Science.

Scope and Limitations of the Study

The study used a qualitative multi-case study in determining and analyzing the PCK, decision making, and practice of the inquiry approach of four (4) Grade 8 science teachers from two (2) selected public secondary schools in Laguna. Both schools are recognized by DepEd to

offer Engineering and Science Education Program (ESEP), which started in 2010. The teachers were selected based on the number of years of teaching and practice of the inquiry approach.

Data was collected through interviews, classroom observations, and analysis of artifacts such as lesson plans and tests. Data collected included the teacher's PCK, conception and practice of the inquiry approach, and their process of decision making in relation to the inquiry approach used. Using the theories of social constructivism, prospect, and bounded rationality, the data was analyzed through constant comparative analysis..

Chapter 2

REVIEW OF RELATED LITERATURE

The first section of the review of literature provides an overview of the inquiry approach and the K-12 curriculum. The second section gives an overview of the nature and development of PCK, including its taxonomies, various models, methods in capturing it and its relationship with the inquiry approach. The last section provides information on decision making including factors, methods and ways to assess it, and its possible relationship with the inquiry approach. Constant comparative analysis as used in this multi-case study is also discussed. A synthesis of the literature review is likewise presented. All this information serve as a background for understanding and appreciating the context of this multi-case study on biology teachers, with different lengths of teaching experience, in terms of their PCK and decision making in the inquiry approach implementation. The large amount of literature aimed to establish the framework of the study.

The Inquiry Approach and the Philippine K-12 Curriculum

It was Joseph Schwab (1960; 1966) who had an influential voice in establishing the view of science education through inquiry. He emphasized that teachers should present science as inquiry and that students should use inquiry to learn science subject matter. He added that the application of the inquiry approach involves the use of innovative activities such as laboratory activities or experiments to lead rather than to follow the classroom phase of science teaching. This means that students should “be inquisitive or curious first” before being introduced to the formal explanation of scientific concepts and principles. The importance of doing a laboratory work as an inquiry-based activity was demonstrated in the study of McDermott (2006) among physics teachers who recognized it as one that develops student’s critical thinking and reasoning.

With such result, inquiry could be defined as “a pedagogical method that combines hands-on activities with student-centered discussion and discovery of concepts” (Uno, 1990).

Waters and White (2015) define the inquiry approach as a teaching method that combines the curiosity of students and the scientific method. This combination enhances the development of critical thinking skills while learning a subject such as science. As curious critical thinkers, when learners encounter problems they do not understand, they formulate questions, explore problems, observe, and apply new information. The learners follow the generally accepted scientific method when they seek answers and obtain a deeper understanding about the new information.

Inquiry instruction was also born out of the long-standing dialogue about the nature of learning and teaching. In particular, the work of Jean Piaget, Lev Vygotsky, and David Ausubel was blended into the philosophy of learning known as constructivism, which was then used to shape instructional materials (Minner et al., 2009). These constructivism-based materials are commonly classified under the inquiry approach. Such materials include hands-on activities as a way to motivate and engage students while concretizing science concepts. According to the constructivist approach, there is emphasis that knowledge is constructed by an individual through active thinking. Active thinking is defined as selective attention, organization of information, and integration with or replacement of existing knowledge. Moreover, social interaction is necessary to create shared meaning. Therefore, an individual needs to be actively engaged both behaviorally and mentally in the learning process so that learning will take place. As constructivist approaches permeated much of the educational practice in the 1970s, it became particularly prominent in science education through the focus on inquiry. The term inquiry has figured prominently in science education, yet it refers to at least three distinct categories of

activities - what scientists do (e.g., conducting investigations using scientific methods), how students learn (e.g., actively inquiring through thinking and doing into a phenomenon or problem, often mirroring the processes used by scientists), and a pedagogical approach that teachers employ (e.g., designing or using curricula that allow for extended investigations). However, whether it is the scientist, student, or teacher who is doing or supporting inquiry, the act itself has some core components. These core components, as “essential features of classroom inquiry” (Brunsell, 2010), include the following:

- (1) Learners are engaged by scientifically-oriented questions.
- (2) Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically-oriented questions.
- (3) Learners formulate explanations from evidence to address scientifically oriented questions.
- (4) Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
- (5) Learners communicate and justify their proposed explanations.

In relation to this, Seif (2011) summarized the highlights of inquiry instruction in Table 1:

Table 1. Highlights of the Inquiry Approach (Source: Seif, 2011)

Teacher's Role	Classroom Processes	Student Outcomes
Identify and clarify issues and questions with students	Question census, engaging activities to introduce key questions	Student involvement and engagement, ownership of question
Help students find and process information	Conduct inquiry, use search engines, read text as an inquiry document	Learn inquiry skills, note taking skills and reading for understanding and finding key information
Help students to think deeply and flexibly	Use activities that support interpretation, analysis, compare and contrast, think creatively	Learn to be more creative, think outside the box, think logically, effective writing
Help students draw conclusions/apply learning to new situations	Use activities that help students synthesize info, write summaries, solve new problems	Learn to synthesize and summarize, write and organize information, use problem-solving skills
Help students communicate with schools	Use activities that support making presentation, communicating orally, writing papers	Learn to make presentations, communicate results orally, Write and organize information

Colburn (2000) points out that students engaged in science inquiry will demonstrate the following behaviors:

- "Describe objects and events."
- "Ask questions."
- Construct explanations."
- "Test explanations against current scientific knowledge."
- "Communicate their ideas to others."
- "Identify their assumptions."
- "Use critical and logical thinking."
- "Consider alternative explanations."

Elementary education has not been lengthened under the K-12 program unlike secondary education. However, the medium of instruction has changed significantly (Okabe, 2013). It is now ‘Mother Tongue-Based Multilingual Education’ for Grades 1-3, since Tagalog is not the only language spoken in the Philippines and there are more than 170 languages. Along with Tagalog and English, eleven other languages will be used. With this reform in the elementary, younger children will be able to follow the classroom instruction. Two studies in the United States (Ramirez, Yuen, & Ramey, 1991; Thomas & Collier, 1997) and one in the Philippines (Walter & Dekker, 2011) concluded that minority language students who gained literacy in their first language experienced higher academic achievement than students who learned in a second or third language. Also, from Grades 4 – 6, the language will shift to Tagalog. The recent development, which is a big change in the Philippine educational system under the K-12 program, is in secondary education. The change in structure involves the lengthening of the years of education, adding two years to make it six years and having the junior and senior high schools.

Based on the DepEd’s basic curriculum guide, it is in Grade 3 where the practice of inquiry method of teaching starts. In the classroom, the teachers follow the general principle of providing materials and setting the environment for the children to experiment, discover, ask

questions, give answers and receive positive feedback from the teacher. In so doing, the students learn to design and conduct investigations, use different strategies to obtain information, and communicate results. Further, students learn the skill of properly collecting and organizing data, formulating explanations or models based on their investigations, analyzing and evaluating information, and making decisions based on sound judgment and logical reasoning. However, science typically receives very little time in primary classrooms, with teachers often lacking the confidence to engage in inquiry-based teaching because they do not have a sound understanding of science or its associated pedagogical approaches (DepEd, 2003). Moreover, students become less prone to ask questions as they move through the grade levels, listening instead and repeating the answers. However, this did not stop some government and private institutions from considering the inquiry approach as an important reform in the basic education. In fact, the use of the inquiry approach as a method developed toward 2006 when the Science Education Institute of the Department of Science and Technology (DOST-SEI), together with the University of the Philippines' National Institute for Science and Mathematics Education Development (UP NISMED) and the Philippine Council of Mathematics Teachers and Educators (MATHTED) published the frameworks of science and mathematics education in the country (Marchadesch, 2012). As indicated in its publication, there is still an emphasis on the development of inquiry skills. Toward the implementation of the K to 12 curriculum in 2012, the inquiry-based approach was retained as a new reform in understanding and applying scientific knowledge, performing scientific processes and skills, and developing and demonstrating scientific attitudes and values.

Kinds of Inquiry Approaches

The common classroom setting in the Philippines may demonstrate the use of different inquiry approaches as teachers expose the students to inquiry-based activities such as open-ended, student-centered, hands-on activities (Martin-Hansen, 2002; Colburn, 2000). The authors enumerate four (4) approaches to inquiry-based instruction, namely, Structured Inquiry, Guided Inquiry, Open Inquiry, and Learning Cycle.

Structured Inquiry. Sometimes this is referred to as direct inquiry. It is a guided inquiry mainly directed by the teacher. In this approach, the teacher establishes parameters and procedures for inquiry by providing the students with a hands-on problem to investigate. The teacher also provides the students with the procedures and materials necessary to complete the investigation. As the problem is investigated, students discover relationships between variables and make generalizations from the data collected leading to the discovery of expected outcomes. The advantage in using this approach is that it allows the teacher to teach students the basics of investigation. Further, the teacher also teaches the techniques in using various equipment and procedures that can be used in more complicated investigations. In short, structured inquiries provide students with common learning experiences that can be used in guided or open inquiry. For example, in a biology lesson about the cell, students examine the parts of a cell using a model or through experimentation and later on, compare and contrast plant cells with animal cells. From this activity, the students will understand how cells are organized to form specific structures.

Guided Inquiry. In this approach, the teacher helps students develop inquiry investigations in the classroom. Usually, the teacher chooses the question for

investigation, as well as the necessary materials. Students are expected to devise their own procedure to solve the problem. For example, in the lesson, Cell Structures, the students are asked to demonstrate their understanding of the basic structures of cells and the essential functions in cells. As an input, the students build a model of a factory where each factory part is compared to a specific cell part in terms of functions.

Open or full inquiry. This has been defined as student-driven or student-centered or student-initiated approach. Students formulate their own problem and procedures to solve. Open Inquiry is analogous to doing science. It begins with a student's question, followed by the student (or groups of students) designing and conducting an investigation or experiment and communicating results. This approach most closely mirrors scientists' actual work. Science fair projects are often examples of Open Inquiry in which the teacher announces "The Science Fair", an opportunity for the students to conduct their personal investigations into basic science.

Learning Cycle. In this approach, students follow guided inquiry procedures followed by teacher-led discussion of their findings. For example, the concept of photosynthesis is introduced. The idea is that students are exposed to the concept prior to its introduction. The students eventually return to the inquiry setting and apply the newly acquired knowledge to a new situation. For example, they could be given materials to observe the rate of photosynthesis and be asked to analyze the factors that influence the photosynthetic reaction. In short, in this approach, the students are involved in an activity that introduces a new concept. Afterwards, the teacher informs the students of the formal name of the concept. Students transfer knowledge of the concept through application in a different context.

French and Russell (2002) included several abilities for inquiring in this paragraph:

Although there are variations of inquiry-based instruction (e.g., open-ended, guided, structured), they share all or most of the following characteristics: inquiry-based instruction places more emphasis on the students as scientists. It places the responsibility on the student to pose hypotheses, design experiments, make predictions, choose the independent and dependent variables, decide how to analyze the result, identify underlying assumptions, and so on. Students are expected to communicate their results and support their conclusions with the data they collected. In inquiry-based labs, the concepts behind the experiments are deduced during the lab; the results are unknown beforehand, although predictable, because the students designed the experiments. Results that do not support the students' hypotheses are not viewed as a failure but as an opportunity for the students to rethink any misconceptions in their understanding of concepts.

According to Khan (2007), there are several processes associated with inquiry in science:

- (1) Identifying a problem and gathering information;
- (2) Making predictions;
- (3) Making sense of observations and finding patterns in information;
- (4) Using analogies and physical intuition to conceptualize phenomena;
- (5) Analyzing and representing data;
- (6) Postulating potential causal factors;
- (7) Working with evidence to develop and revise explanations;
- (8) Generating hypothetical relationships between variables;
- (9) Evaluating the empirical consistency of information;
- (10) Formulating and manipulating mental or physical models (modeling);
- (11) Coordinating theoretical models with information; and
- (12) Sharing what has been learned from the inquiry with others.

Based on their study, Espinosa-Bueno et al. (2011) selected seven pedagogical activities related with the inquiry process, which are presented in Table 2.

Table 2. Pedagogical Activities Associated With the Inquiry Process

A. Identify and consider questions that can be answered through inquiry.
B. Define and analyze properly the question to be solved and identify its relevant aspects.
C. Gather bibliographic information to be used as evidence.
D. Form evidence, to develop explanations to the posed question.
E. Think about everyday problems and display relevant historical aspects.
F. Design and conduct a scientific investigation through a set of actions.
G. Communicate by means of argumentation what has been learned through inquiry

The Department of Education enumerates the three domains of learning science (*i.e.*, understanding and applying scientific knowledge, performing scientific processes and skills, and developing and demonstrating scientific attitudes and values), from which the design of the K-12 curriculum is based. These domains are generally acquired through multi/interdisciplinary approach, science-technology society approach, contextual learning, problem/issue-based learning, and inquiry-based approach. Science content and science processes are intertwined in the K to 12 curriculum and it follows that without the content, learners will have difficulty utilizing science process skills since these processes are best learned in context. The new curriculum is organized around situations and problems that challenge and arouse students' curiosity in order to motivate them to learn and appreciate science as relevant and useful. Rather than relying solely on textbooks, varied hands-on, minds-on, and hearts-on activities will be used to develop students' interests and let them become active learners. In general, the K to 12 science curriculum is learner-centered and inquiry-based, emphasizing the use of evidence in constructing explanations. This is the conceptual framework indicated in Fig. 1, as followed by DepEd in its implementation of the K-12 curriculum in 2016 where the inquiry approach is emphasized.

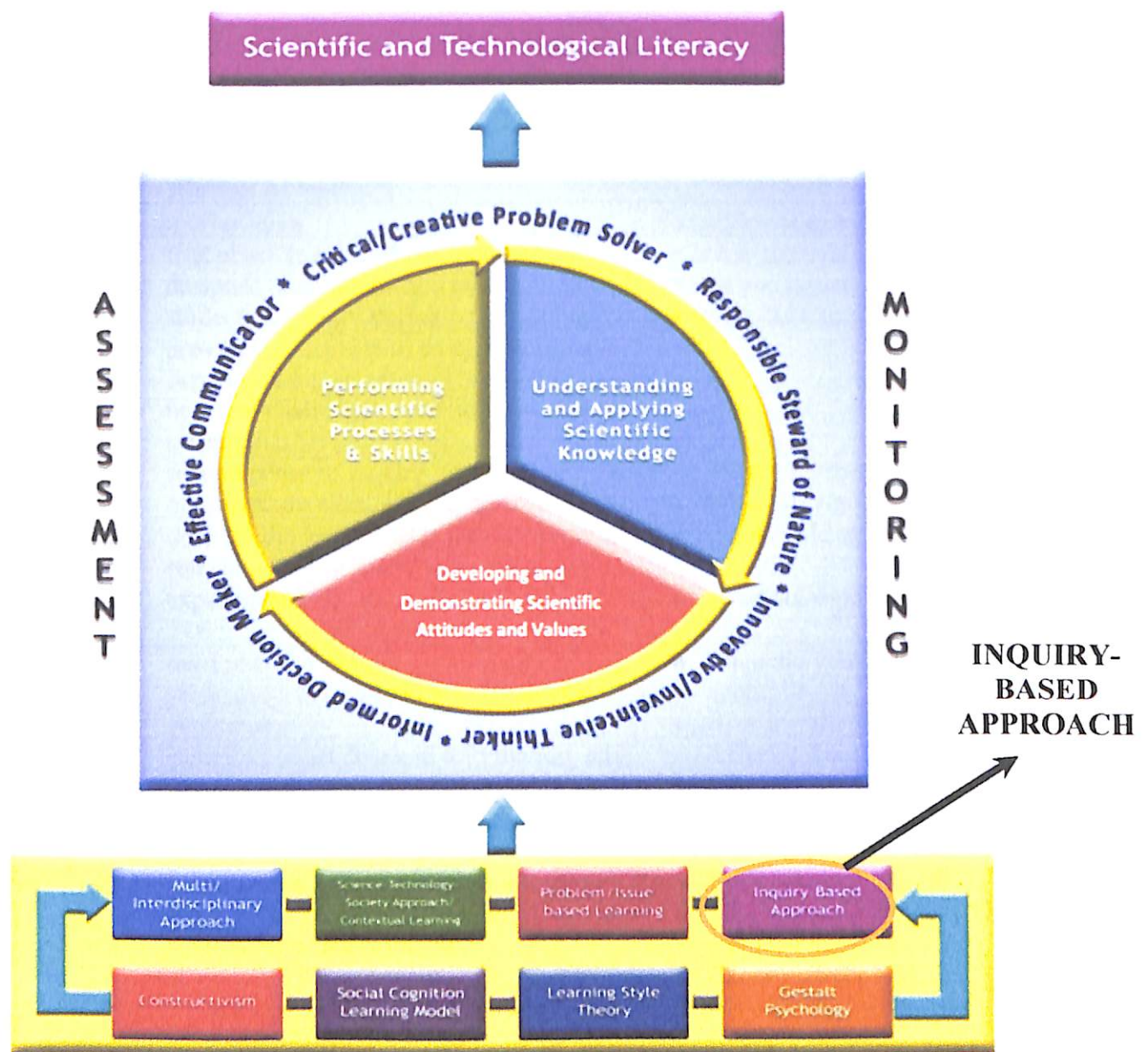


Figure 1. The DepEd's Conceptual Framework of Science Education

Implementing the Inquiry Approach in the Classroom

It is not enough that the inquiry approach as a new reform in science teaching was implemented in the K-12 curriculum in 2012. What is more important to know is the teacher's practice inside the classroom. Implementing inquiry should be a natural process of teaching that supports the nature of science and employs the natural curiosity of students. According to Colburn (2000), teachers implement inquiry as a continuum, beginning with structured inquiry and progressing through guided inquiry to finally encouraging open inquiry. Davis (2002)

reported that there are four phases within each of the inquiry approaches. Each phase is characterized by questions that guide students to make their own discoveries. The phases of inquiry are summarized in Table 3.

Table 3. Summary of the phases of inquiry

Phase	Characteristics	Examples of questions asked
Initiation	<ul style="list-style-type: none"> ● first phase in all levels of inquiry ● designed to stimulate and motivate students' curiosity through questioning ● provides students with an opportunity to experience a phenomenon or something new that challenges a previous belief or assumption 	<ul style="list-style-type: none"> ● Have you ever seen...? ● Did you notice...? ● What did you observe...?
Exploration Phase	<ul style="list-style-type: none"> ● second phase of inquiry ● questions are eliminated or narrowed down to those types of questions students can actually physically answer through experimentation or research 	<ul style="list-style-type: none"> ● What happened when...? ● What did you...? ● What could we do to find out...? ● What questions do you have...?
Experimentation Phase	<ul style="list-style-type: none"> ● third phase of inquiry ● students form into groups to conduct an experiment ● students collect data and information, and then formulate a method of presentation. 	<ul style="list-style-type: none"> ● What did you find out about...? ● How is it the same as or different from...? ● What do you know about the characteristics of...?
Presentation Phase	<ul style="list-style-type: none"> ● last phase of inquiry ● groups or individuals take the information gathered in the experiment and put it into some form of presentation (<i>PowerPoint</i> or project display boards) ● the group or individual will share the data with an audience and allow time for questions concerning procedures, data, information, etc. 	<ul style="list-style-type: none"> ● Can you explain why...? ● Why do you think...? ● What other factors may be included in...? ● Can you find a way to...? ● How did you arrive at a solution to...?

Challenges to the Implementation of the Inquiry Approach in the K-12 Program

The inquiry approach as a new reform may improve the educational system of any school. According to Adelman and Walking-Eagle (1997), in order for a reform to be successful, practitioners must establish a culture of change. In the implementation of the inquiry approach in teaching science, there are challenges to be considered in measuring its success.

School culture. As the inquiry approach is introduced as a new strategy, a school culture should be maintained among the staff members by interacting with each other, the

students, and the community at large (Hargreaves, 1997). The culture also involves teachers having time to learn about, implementing, and reflecting on the new reform. In order to change teacher thinking and behavior, training is required and this takes time. Not only is some sort of professional development necessary for teachers to understand the introduced new reform, but they also need time to understand what is expected of them and reflect on it. The school culture also considers quality leadership of the principal in order to make collaboration with respected teacher leaders regarding the new reform.

Support. Problems associated with support include inadequate funding, lack of administrative support, and system or school policies. Any system or organizational policy to be implemented should be funded. For example, the fund should be spent for holding trainings and workshops for the familiarity of teachers with the inquiry approach. However, even if funding is adequate, it is possible that other support barriers may exist. Moore (2014) expressed concern, stating that administrators should not only support the change with supplies and resources, but also by providing time for collaboration about the implementation of the inquiry approach. The role of the administration was emphasized in the study of Berge and Clark (2006). The authors said that although administration plays an active role in new reforms in schools, educators need time to process the changes so that continued modifications are made.

Time. Time is an important factor to consider in teaching using the inquiry approach. As observed in classes (Agron et al., 2010; Marshall et al., 2009), it is difficult to shorten the time to discuss the required concepts in an inquiry-based manner. Likewise, it takes more time to allow students to do inquiry-based activities such as creating experiments,

discussing and then analyzing data. Moreover, due to the tight schedules of the teachers during the school day, most of the activities involved with inquiry-based methods take up a great deal of time to develop and/or prepare for use the next day. This preparation requires more of the teacher's personal time, apart from the teacher's other duties such as being a class adviser or club adviser, leading to more stress (Johnson, 2005). Additional time is also needed for teacher collaboration with other teachers when implementing the inquiry approach (Glickman et al., 2009; Johnson, 2005).

Time is also needed for professional development of teachers. Learning the inquiry approach for science teaching is not easy. It takes time for teachers to adopt it. For instance, Johnson (2005) emphasized that time to undergo training for the implementation of the new curriculum or methodology is necessary because teachers with a strong content and pedagogical background tend to be more successful in adopting a new reform. The importance of time for teachers to be trained was also pointed out by Marshall et al. (2009) adding that the inquiry process is complex, requiring much training for teachers to fully engage students with inquiry.

Belief System. The teacher's belief system may take different forms. For instance, a teacher's attendance and participation in professional trainings, support and collaboration can all be connected to what teachers believe is most effective in the classroom.

Similarly, Haney and McArthur (2002) said that the teacher's beliefs may affect the atmosphere of the classroom in terms of adopting a new reform. According to the authors, these beliefs of teaching and learning tend to be self-perpetuated. This is the reason why belief systems are difficult to change the earlier they are formed. For Chin-Chung and Ching-Sing (2012), the teacher's belief is paramount to the willingness to

adopt a change in the reform. In the case of Chan (2010), case studies of eight primary school teachers were investigated regarding their beliefs in the inquiry approach implementation and it was found out that different teachers held diverse beliefs about the inquiry approach. Such variation in teachers' beliefs was found to affect teachers' implementation of the inquiry approach.

Self-efficacy. This explains how people develop and maintain certain behaviors such as the behavior in adopting a change in the curriculum. It is classified into two dimensions-- personal self-efficacy, which measures one's beliefs by one's ability to perform a certain task (Bandura, 1997) and, outcome expectancy, which measures one's belief that the task will produce a specific result. It is important to increase self-efficacy because it is correlated to skills needed to attain certain goals and motivation to reach desired goals (Bandura, 1997; Pajares, 2002). A relationship exists between self-efficacy and teacher behavior (Lakshmanan et al., 2011; Powell-Moman & Brown-Schild, 2011) as indicated in their study, which aimed to reveal how self-efficacy may have influenced implementation of the inquiry approach. Results show that higher levels of teacher self-efficacy translate into desired teacher behaviors in using the inquiry approach that led to the improvement in student achievement in terms of performing inquiry-based activities.

Factors for Adoption of IBA

Professional Development

Maintain a continuous professional learning on IBA. Continuous professional development for pre- and in-service teachers should be maintained in order to sustain the adoption of IBA. Lunsford et al. (2007) reported that by providing pre-service teachers with basic to complex levels of inquiry, teachers could progressively develop scientific

and critical thinking, as well as the production skills of complex inscriptions. Riegler-Crumb et al. (2015) revealed that after participating in Hands on Science (HoS) courses, the prospective teachers' attitudes became positive toward inquiry, while the comparison group indicated a decline in favorable attitudes to science. In addition, recent research and projects related with continuous professional development have aimed to develop teachers' cooperation and collaboration by establishing links within and between school networks as well as other local and regional stakeholders (Bolte, Holbrook, Mamlok-Naaman, & Rauch, 2014; Smith, 2014; Snow-Gerono, 2004). In so doing, the teachers could be given the chance to work together, share ideas and resources, and reflect on innovative teaching practice in the classes (Loucks-Horsley et al., 2009).

There are teacher trainings that have been suggested as an effective way to increase teachers' motivation and readiness to adopt new approaches, such as inquiry into their teaching. Different authors have brought out several aspects to be considered by the teacher educators that would make the teacher trainings most effective. Capps and Crawford (2013) stress the importance of teachers engaging in authentic scientific investigation, supporting teachers in using the inquiry approach, and supporting the reflection of teachers. Based on their study results, Voet and De Wever (2017) argue that to achieve positive effects on students, teachers' attitudes toward the inquiry approach and perceived competence to teach IBA, trainings should focus on (1) stimulating active learning, (2) changing beliefs, and (3) providing a practical guide. There is evidence that positive effects can be achieved through specially-designed teacher training courses. For example, Ertikanto et al. (2017) report success with a teacher training program implemented in Indonesia that was designed to follow Bandura's stages of social learning

(learning by observing) - attention, retention, production, and motivation. The effect was observed in the teachers' inquiry skills. Perez and Furman (2016) found that a 10-month professional development course in Peru, which engaged teachers in designing inquiry-based lessons, had a positive impact on the teachers' practice of inquiry. The authors concluded that the factors that counted for the change were the teachers' revised views, engaging in inquiry activities themselves and trying out the inquiry approach within their classroom.

Build a culture of inquiry through collaboration. Many teachers may think that inquiry is for science only. Inquiry is not exclusive to science or science teaching. Teachers from the secondary level and from the elementary level can and often use inquiry-like strategies. They need and want the moral and collegial support of working with other teachers on innovative and, what they consider, risky projects. They also need the sense that inquiry has its counterparts in other disciplines aside from science. A culture of inquiry in schools, where teachers work collaboratively, can contribute to the quality of inquiry-based education (Verhoef et al., 2020). According to the authors, self-efficacy in collaboration with colleagues in inquiry-based working in the school facilitates the contribution teachers can make to a culture of inquiry. Self-efficacy in teacher competencies concerns the teacher's feeling that she/he is capable of teaching well. Butler et al. (2015) support that the vast majority of teachers increases in efficacy, which could be associated with their engagement in collaborative inquiry, and which, in turn, had potential to fuel on-going change efforts. Thus, a culture of inquiry in which there is inquiry-based collaboration is necessary (Snow-Gerono, 2004, Katz and Dack, 2013, Godfrey and Brow, 2019). Collaboration with teachers involves participation in a

research group, involvement in a research project or communication on inquiry-based approach. When the majority of teachers in a school are working on a common goal, the level and amount of professional talk goes up (Deluca et al., 2017) and teachers begin to support each other in a common effort to change the way they teach and how their students learn.

School Support

Update the available school resources. An important impediment to implement IBA is lack of appropriate teaching resources. An important resource is a textbook. Traditional textbooks are often not conducive to inquiry-based teaching. Yang et al. (2019) reported that current textbooks do not present balanced dispositions to use inquiry process skills, and inquiry-based tasks in current textbooks do not reflect a proper understanding about scientific inquiry. These findings call for revisions of inquiry-based tasks in textbooks and indicate the ambiguous understanding about inquiry that may be held by the textbook authors. High-quality inquiry-based tasks in textbooks are actually paradigms and practical guides for inquiry-based instruction. Thus, administrators need to upgrade the textbook to use by making an effort to check if it is a good IBA textbook (Pingel, 2010). Administrators should emphasize inquiry-oriented materials when approving textbooks and instructional materials as they have an opportunity, an obligation, and often the authority to influence the procedures and criteria used.

Administrators also need to ensure that teachers have appropriate equipment to manipulate, supplies, and consumable supplies that are replaced regularly. For example, it is not enough that there is the microscope that can be used to examine cells, often to observe the difference between plant and animal cells and where students may be

instructed to prepare wet mounts and do simple staining. All of these are important skills to have in order to use the microscope correctly, but it does not give students the chance to do science. More than using the microscope, teachers should teach the students to collect evidence through experimentation using the microscope in which they ask a question, design a procedure to answer that question, record data, analyze the data, and draw conclusions (Styer, 2012). For the other supplies like chemical solutions, there is a need to update them by checking on their expiry date. For instance, in using a staining solution for observation of mitosis and meiosis stages, teachers should check if the staining solution still works, otherwise there will be no scientific inquiry on the differences between mitosis and meiosis in terms of chromosome behavior. Even simple and small supplies along with models should be checked for implementation of any inquiry-based activity. Fitzgerald et al. (2019) found out in their study that the lack of good models and the lack of good resources enabling the capacity for change are important barriers for inhibiting IBA use.

Use more technology tools to extend learning opportunities. The different technology resources such as computers, mobile devices like smartphones and tablets, digital cameras, social media platforms and networks, software applications, the Internet, etc. are used in daily classroom practices to facilitate the teaching-learning process. Likewise, modules are used to facilitate the discussion (especially during this pandemic time). However, more technology tools can be used to extend learning opportunities. The presence of a dedicated online space to share, questions, ideas and thoughts available both during and after class time makes it possible for teachers to foster a community of learners. Apart from the usual video conferencing such as Zoom and Google classroom as

LMS (Learning Management System), South (2017) suggests using other web-based tools such as BB Collaborate, Microsoft Teams or Google Meet, or an improved LMS as a platform where students can ask questions, seek responses, inquire on something and have conversations about content, both in and out of school. The constant use of message boards and digital communication can get the entire class involved in group conversation and collaboration at a level that each student is comfortable with. In incorporating these types of tools and strategies to drive learning through inquiry, teachers should never again have to “call on” students to participate. Moving toward student-centered learning design provides many opportunities for students to be involved in ways that feel good to them.

Whitman (2018) remarks that with the digital era taking over, it is important to include digital and online tools into the learning process, where students rely on smart devices and internet more than on conventional learning methods. Keeping up with this trend is what allows the teacher to better understand students and their needs. Moreover, these tools make the learning process in an inquiry environment more interactive and allow easier flow of information, which makes the teacher's job more meaningful and much easier. In addition, Murali (2020) states that the use of technology in education has improved students' academic performance drastically. Although traditional classroom teaching may still be prevalent, many educational institutions are coming forward in embracing technologies such as digital whiteboards, flipped classrooms and chromebooks replacing textbooks.

Evaluation Measure

Measure inquiry instruction using a standard protocol. To ensure that inquiry instruction is maintained in the classroom, one mechanism that can help support teachers in improving the quality of inquiry-based learning facilitated in the classroom is the Electronic Quality of Inquiry Protocol (EQUIP) (Marshall et al., 2008). This protocol provides a reliable, valid measure of the quality of inquiry being facilitated and is focused on four major pedagogical constructs - instruction, curriculum, discourse, and assessment (Marshall et al., 2010). The descriptive rubric associated with EQUIP allows teachers, instructional coaches, administrators, and researchers alike to measure and discuss what occurred or has been occurring and then allows individuals to chart tangible, intentional steps that can be undertaken to improve the overall quality of instruction (Marshall et al., 2010). Each of the 19 indicators, that comprise EQUIP's four constructs, is designed to measure a critical aspect associated with the quality of inquiry that occurs during a lesson; each details four possible levels of performance (Pre-inquiry—Level 1, Developing Inquiry—Level 2, Proficient Inquiry—Level 3, and Exemplary Inquiry—Level 4). EQUIP was written and validated so that Level 3 is the target for high quality inquiry. Further, preliminary data suggest that the quality of inquiry (measured by EQUIP) is an excellent predictor of both student science content and process knowledge (measured by Measures of Academic Progress test; NEA, 2004). In helping teachers to transform their practice to higher quality inquiry-based teaching, Cassie Quigley et al., (2011) found that it is most helpful when teachers target 2-3 indicators (e.g., Order of Instruction or Questioning Level) at a time to improve. This allows them to be more focused and intentional about the improvements until the new skills become automated in

their practice. As one begins using EQUIP, it is helpful initially to establish a baseline of teaching performance. This can be done by videotaping and then scoring the lesson later, by having a peer teacher or head of the department observe a lesson and then score the performance, or by working with a team of teachers to analyze and score the lesson (similar to a lesson study with EQUIP used to focus the discussion). The scores, when used in conjunction with the rubric, help articulate what occurred during the lesson. For teachers, EQUIP provides a framework to make their instructional practice more intentional as they strive to increase the quantity and quality of inquiry instruction. For researchers, EQUIP provides an instrument to analyze the quantity and quality of inquiry being implemented, which can be beneficial in evaluating professional development projects.

Benefits of the Inquiry Approach Use to Teachers and Students

Teachers are challenged to adopt the inquiry approach as a new reform in basic education. The challenge may entail positive effects that benefit the teachers and the students as well. Some of these effects are presented.

School-wide understanding of the inquiry approach. According to Schagen (2011), good orientation on the use of the inquiry approach promotes a shared school-wide understanding of a new reform. The author found that effective school-wide involvement usually leads to a better shared understanding of the school's curriculum at the classroom level. The initiatives of DepEd in holding trainings and seminar-workshops about the inquiry approach are what teachers need in order to be equipped with the details of its implementation.

Improvement of student academic achievement. The implementation of K-12 in 2012 has challenged the teachers to do the inquiry approach and for this, the teachers have become more accountable for student academic achievement (DepEd, 2003). There is motivation for the teachers to increase student performance in formal assessment. For many teachers, the traditional ways of teaching are not producing the desired results, hence the new approach is considered. DepEd emphasizes that science teaching must involve students in inquiry-oriented investigations wherein they interact with their teachers and peers. Likewise, active science learning means shifting emphasis away from teacher's presenting information and covering science topics.

Improvement of student's understanding, thinking and skills. Learning from inquiry allows better understanding of concepts (Gardner, 1999). For example, specific content such as photosynthesis has much more relevance for the learner if set in a larger context of understanding the interrelationship of the components of photosynthesis - sun, green plants, and the role of carbon dioxide and water. Industrial development as a social studies content set in the context of interrelating changes in the human-designed world can add new perspectives to this important natural process. Because of inquiry learning, the students can still learn both science and social studies contents, but through a series of well-planned experiences, they will grasp the larger conceptual context and gain greater understanding. Some skills are also developed in inquiry learning. Within a conceptual framework, inquiry learning and active learner involvement can lead to important outcomes in the classroom. Students who actively make observations, collect, analyze, and synthesize information, and draw conclusions are developing useful problem-solving skills. These skills can be applied to future "need to know" situations that students will

encounter both at school and at work. Another benefit that inquiry-based learning offers is the development of habits of mind that can last a lifetime and guide learning and creative thinking. Thus student's thinking is improved and developed.

Paradigm shift challenge. The adoption of the inquiry approach is a challenge among teachers. Doing this approach means getting away with traditional approaches. The inquiry approach pays particular attention to the standards that describe what students should know and be able to do with respect to scientific inquiry (Fuchs, 2005). In this approach, the real-life context of the classroom lessons is engaging, and the knowledge gained can be applied immediately to students' lives. In this paradigm shift, the teachers are able to design and sequence specific learning experiences. Further, there is also focus on different inquiry-based and hands-on activities where students are empowered to become more active in the learning process (Goodwin & Adkins, 1997).

Means for professional development. Teaching through the inquiry approach is considered a means for professional development (Schagen, 2011). This is because the teachers can engage in new and different teaching practices. Doing inquiry-based activities offers a new window through which teachers get a glimpse of what new teaching strategies look like in action. In addition, by using the inquiry approach, teachers can change how they think about teaching and embrace new approaches that stimulate students to solve problems, reason, investigate, and construct their own meaning for the content. Finally, teaching inquiry-based activities can encourage reflection that will stimulate teachers to improve their practices by focusing on student learning through inquiry.

Status of the Inquiry Approach Adoption

Some initiatives from the private sector may have been done regarding the adoption of the inquiry approach in basic education, however, there is no available document to account for this. What is presented is the initiative from the French government regarding the implementation of the inquiry approach that aims for possible adoption across the globe. There is also the presentation on the adoption of the inquiry approach in the Philippines. The presentation will give an overview of the status of inquiry approach adoption.

Global Adoption. What is considered to be adopted globally is *La main à la pâte* (*Lamap*), which is learning by doing, an inquiry-based science teaching program launched in 1996 by Georges Charpak, winner of the Nobel Prize for Physics in 1992. It started in 2000 when the French Ministry of Education decided to implement a 3-year ambitious “national plan of renewal of science teaching” at the primary level, inspired by *La main à la pâte*. Since then, *Lamap* continues to innovate, support teachers and contribute to the elaboration of new national standards and best practices for science education in France, moving in 2006 from primary to middle school (Grades 6 & 7) (Saltiel & Delclaux, 2010). This *Lamap* story is an example of how the initiatives of a group of scientists and many partners were able to contribute to the transformation of science education in a highly centralized educational system and to rapidly collaborate at international level with many countries. The program was later launched by the French Ministry of Education in primary schools and since then, the number of schools adopting this approach has multiplied.

Through the LAMAP approach in science learning, students are led to discover and learn science spontaneously and naturally, as they construct knowledge by being

exposed to situations that arouse their curiosity toward natural phenomena. Moreover, the students are stimulated to ask questions and discover the answers as they move through the process of scientific investigations. The LAMAP program not only encourages active participation in science lessons, but also develops the spirit of teamwork among children. By introducing students to argumentation, LAMAP purports to give a better understanding of words that are spoken, written and read. Through encouraging students to debate among themselves when they solve problems, LAMAP also encourages constructive citizenship.

A typical *La main à la pâte* lesson follows the inquiry principles. It starts with a question inviting the students to advance their own hypotheses. Investigation, free expression, argumentation in groups, and experiments are then used to develop reasoning and curiosity (Sarmant et al., 2010). Moreover, the students acquire a new awareness of the utility and explanatory powers of scientific principles and the logic of science. Further, they discover the value of teamwork and acquire the skills needed to prepare and carry out an experiment. Since the end of the national priority given to science in 2003, progress has been constant although slow. In 2010, it was estimated that about 50% of primary schools followed more or less the new science curriculum, but only 10% of teachers were able to apply inquiry teaching, with a continuum of classroom practices existing between full practice and really inadequate ones (Saltiel & Delclaux 2010).

For many years, *La main à la pâte* has been widely implemented abroad and its expertise is regularly solicited in order to inform and train foreign delegations, to organize training sessions abroad, to contribute to the renewal of science teaching in many countries and to make its resources available to its partners. This action falls within

the framework of the many relationships maintained by the Academy of Sciences with a number of other academies throughout the world. Since 2010, the French government with the help of some international agencies, has been offering seminar-workshops on inquiry-based science education (IBSE) catering to teachers/educators in some parts of the globe. For example, in 2012, the Southeast Asian Ministers of Education Organization (SEAMEO), an inter-governmental organization established in 1965 among the governments of Southeast Asian countries to promote cooperation in education, science, and culture in the region organized a seminar-workshop about the inquiry approach. Among the participants were those from Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Timor Leste, Thailand, and Vietnam. Likewise, in the last five years, the French government has been offering the same workshop which the government opens to educators under DepEd and its counterpart in some parts of the globe.

Local Adoption. In the Philippines, the inquiry approach is adopted as a teaching strategy across disciplines. This means that it is applicable to any particular subject area by integrating it in specific topics. Learning through inquiry is a universal human phenomenon. As such, the general guidelines for the inquiry approach are expected to hold for any discipline (Ibañez & Ocampo, 2010). However, it is expected that differences emerge from variations in the nature of inquiry across disciplines. Teachers and experts in different fields often vary in how they frame their inquiries, in the tools and methods they use to investigate their questions, in the resources they explore, and in their perception of what constitutes good evidence. Based on the DepEd's conceptual framework of science education, the inquiry approach is highly recognized

and recommended as one important teaching strategy. For this, it is expected the inquiry approach will be used in the teaching of a particular topic in science.

Concepts and Processes of Inquiry

There are specific tools used by the teachers in their practice of the inquiry approach, which include observation, experimentation, and communication for observing and explaining natural phenomena. Teachers follow a logical order, starting with observations, identifying questions, implementing a set of procedures, and usually, finishing with formulating conclusions. Colburn (2000) points out that inquiry means dealing with concepts and concerns that affect humans every day. These concepts are not independent but are intertwined and multidisciplinary, providing students with a multitude of opportunities to become involved with science. Each concept includes one or more processes that teachers must consider in the development of an effective science curriculum. These concepts and their accompanying processes are presented in Table 4.

Table 4. Concepts and Processes of Inquiry

Concept	Processes
A. Discovering	Observing; Classifying; Measuring; Inferring
B. Valuing	Communicating
C. Exploring	Predicting; Experimenting

In order to be effective, science teachers must incorporate each of the three concepts into every aspect of the curriculum. Thus, it requires attention to the processes that promote these concepts. These processes ensure that any science lesson or unit taught by the teachers using the inquiry approach appeals to the curiosity of students and addresses the goals of inquiry instruction.

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Inquiry is "hands-on" and "minds-on." In the classroom, science instruction must involve students in inquiry-based investigations where students collaboratively interact with peers, and teachers through the concepts and processes of inquiry. As the inquiry approach is used in science teaching, students are able to make connections between prior knowledge and new information gained from a variety of sources and past experiences. Based on this, Colburn (2000) emphasized that the inquiry-based approach is recognized as a highly effective method for learning so that teachers must be able to select strategies and activities that consider the learning styles and needs of students, as well as the content of instruction. With the inquiry approach, teachers make the students engage in problem solving, planning, decision making, discussions, and questioning.

The Concept of PCK

PCK was originally introduced by Shulman (1987) as the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners. PCK is also the knowledge of the transformation of several types of knowledge for teaching (including subject matter knowledge), and that as such, it represents a unique domain of teacher knowledge (Magnusson et al., 1999). This finds support to what some authors (Baxter & Lederman, 1999; Park et al., 2011) have pointed out, whereby PCK is a unique knowledge processed only by individuals within the profession of teaching. Consequently the concept of PCK is useful to help the teachers' understanding of what teachers know, what teachers should know, and how they might develop it.

The concept of PCK focuses on two crucial points in teaching, namely, understanding and representation (Shulman, 1987). PCK is very significant to teaching practice because it

provides teachers with pedagogical reasoning based on specific content, specific learners and context. Based on content knowledge and general pedagogical knowledge, PCK carries some traits of these two categories of knowledge. Several researchers have defined and perceived PCK in different ways when examining the concept from different perspectives. While some researchers (Gudmundsdottir, 1987b; Shulman, 1987) stressed the central role of content knowledge in PCK, others emphasized its pedagogical nature (Cochran, DeRuiter & King, 1993; Cochran, King, & DeRuiter, 1991). Generally, PCK is defined as a construct of several components associated with transforming content knowledge into pedagogically powerful strategies, but PCK components need to be identified in a specific subject. Documentation of a number of studies has been made to identify PCK components in different subjects like English (Grossman, 1990), Mathematics (Lee & Luft, 2008), Science (Magnusson et al., 1999) and Physical Education (You, 2011). These researches contributed to the conceptualization of PCK, which consists of a domain. According to the authors, domain refers to the general components of the effective transmission of knowledge from teachers to students regardless of the knowledge area. In this regard, PCK contains some components that apply to all content areas.

The Taxonomies of PCK

Woolfolk (1993 in Veal, 1999) defined taxonomy in the field of education, as a 'classification system'. One PCK taxonomy of Cochran et al. (1991) involves the incorporation of four components: knowledge of subject matter, knowledge of students, knowledge of environmental contexts, and knowledge of pedagogy. These are presented using two Venn diagrams that show how the four components overlap, and how PCK is centralized within the overlaps (Fig. 2).

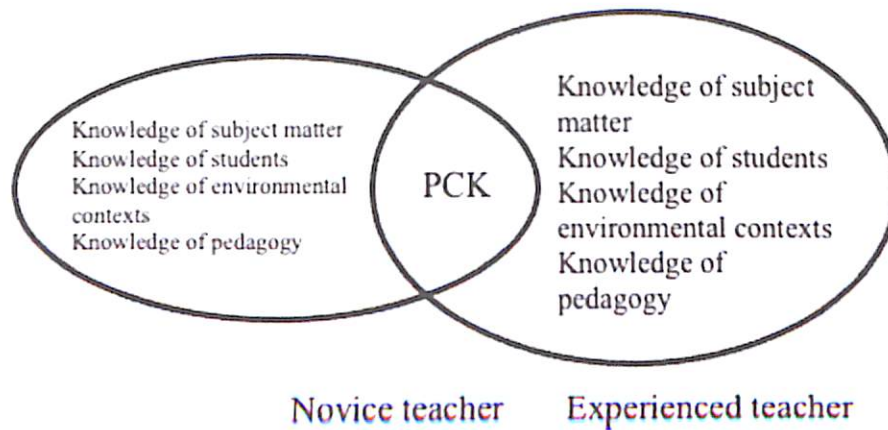


Figure 2. PCK Taxonomy using a Venn Diagram

All the four components are integrated in each diagram. The first diagram is for a novice teacher while the second and larger diagram is for an experienced teacher, symbolizing the ‘extra knowledge’ gained from years of experience as seen in a greater overlap, symbolizing increased integration of the four components; thus greater PCK development.

Veal and MaKinster (1999) presented two taxonomies that offer a relatively comprehensive categorization scheme about PCK development in teacher education. The general taxonomy of PCK addresses the distinctions within and between the knowledge bases of various disciplines, science subjects and science topics (Figure 3). The foundation of this taxonomy describes the general teaching skills or pedagogy that should be developed by all teachers, which include planning, teaching methods, evaluation, group work, questioning, wait time, feedback, individual instruction, lecture, demonstration, and reinforcement. Such strategies are not related to any specific content area, and can be used across content areas. The details of levels within this taxonomy are summarized in Table 5.

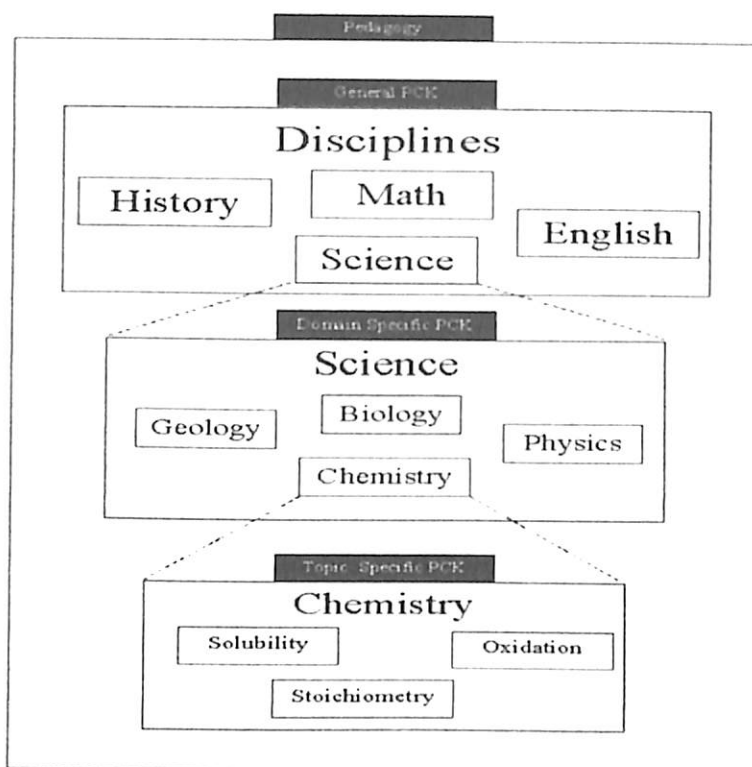


Figure 3. The General Taxonomy of PCK

Table 5. The Levels of the General Taxonomy of PCK and Characteristics

Level	Characteristic
General PCK	<ul style="list-style-type: none"> • More specific than pedagogy, because the concepts and strategies employed are specific to the disciplines of science, art, history, math, or English. • The same as what Magnusson, Krajcik, and Borko (in press) called subject-specific PCK strategies, where subject meant the content area of science • General PCK orientations might be applied to other disciplines, but the processes, purpose, and content or subject-matter would not be the same
Domain-specific PCK	<ul style="list-style-type: none"> • More distinct than general PCK, because it focuses on one of the different domains or subject matters within a particular discipline • Positioned between disciplines and domains of science to represent a different level and specificity of subject-matter and pedagogy
Topic-specific PCK	<ul style="list-style-type: none"> • Most specific and novel level • A teacher who has knowledge in this level of PCK could have a solid repertoire of skills and abilities in the previous levels

The taxonomy of PCK attributes (bird's eye view and side view) (Figure 4a & Figure 4b)

details a hierarchical structure for pedagogical content knowledge and its attributes. The central location of pedagogical content knowledge signifies its importance. The surrounding attributes

(assessment, context, environment, nature of science, classroom management, curriculum, pedagogy and socio-culturalism) are all connected, representing an integrated nature of the epistemological components.

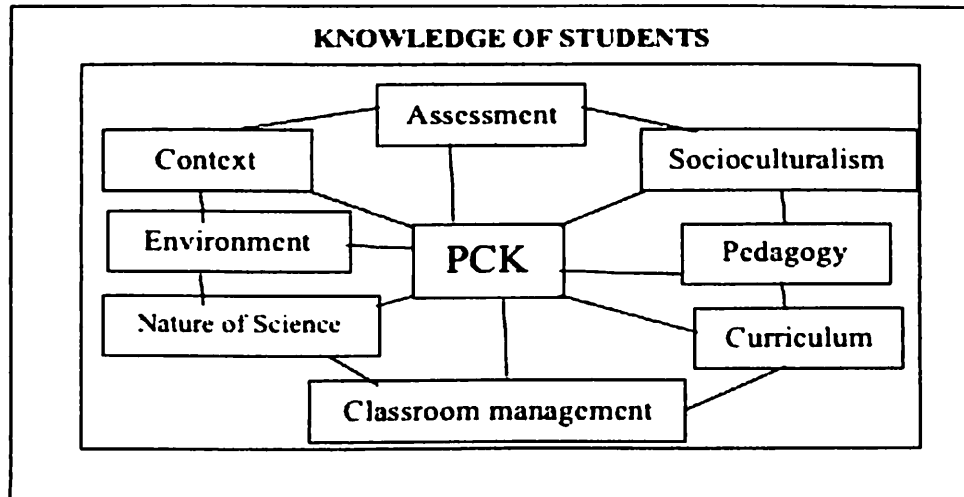


Figure 4a. Taxonomy of PCK Attributes, bird's eye view

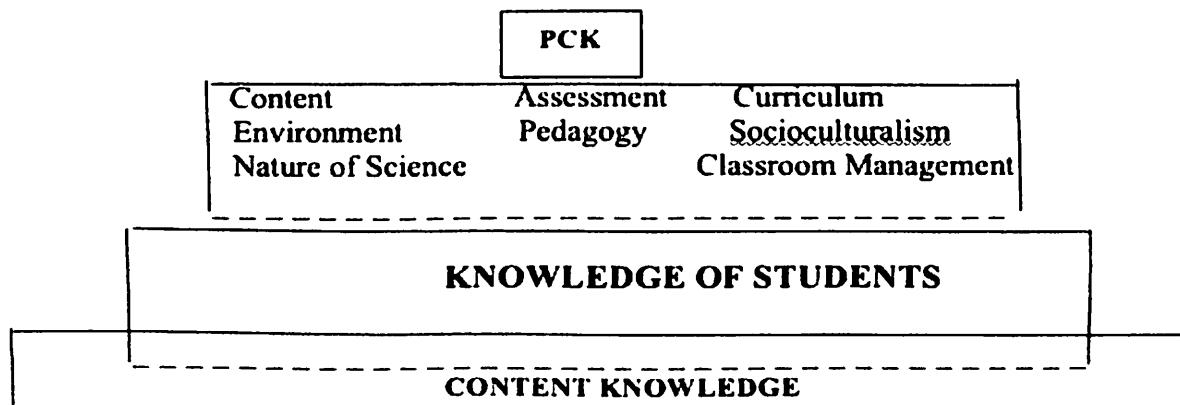


Figure 4b. Taxonomy of PCK Attributes, side view

In this taxonomy, the hierarchical structure suggests that a strong content background is essential to the development of PCK. The attribute a science teacher needs in developing PCK is a strong and thorough knowledge of their students because only after a teacher understands or realizes the importance of the student component of teaching, can the other attributes of pedagogical content knowledge be learned or developed. The knowledge of the students' component, which includes understanding possible student errors and misconceptions, has more

significance compared with pedagogical knowledge (Figure 4b), which portrays content knowledge and knowledge of students as embedded in one another. It is because student errors and misconceptions are more easily recognized when a teacher knows the content topics and concepts. Finally, only after a teacher develops a solid understanding of his/her students can he/she apply any of the other eight attributes appropriate to the students. This does not imply that a prospective teacher does not already possess some of the other eight attributes; rather, the teacher develops and integrates the eight attributes into a coherent manner more readily when content knowledge and knowledge of students have been developed. The eight embedded PCK attributes are not arranged in a hierarchical manner because they can be developed and understood by the teacher at any time during their teaching career. The attributes are inter-related; thus, the development of one can simultaneously trigger the development of others.

The PCK Model

The concept of PCK utilized by Chick, Baker, Pham and Cheng (2006) involves aims for learning, student thinking, student misconception, procedural knowledge, resources, classroom technique, purpose of content knowledge, evaluation of student learning and representations. The PCK model of Sothayapetch et al. (2013) emphasizes student thinking, student's misconceptions, the understanding of procedural knowledge, knowledge of resources, aims for learning, classroom technique, the purpose of content knowledge, evaluation of student learning, representations and student understanding of conceptual knowledge. The model of Cochran et al. (1991) can be incorporated to involve knowledge of subject matter, knowledge of students, knowledge of environmental contexts, and knowledge of pedagogy. The Magnusson et al. (1999) model has been the most common in usage because the components of the model are easy to use at all steps of education. Based on these models, the PCK model used in the study includes four

(4) knowledge bases: (1) knowledge about content knowledge, (2) knowledge about students' understanding of science, (3) knowledge about assessment in science, and (4) knowledge about instructional strategies for teaching science. Table 6 summarizes the PCK Model with corresponding knowledge bases given specific PCK categories according to Chick, Baker, Pham and Cheng (2006), Sothayapetch et al. (2013), Cochran et al. (1991) and Magnusson et al. (1999).

Table 6. The Model of PCK used in the Study

PCK Category	Knowledge of	Definition: A Teacher
Aims for learning Student thinking	Content Knowledge Students' Understanding of Science	Describes a goal for students' learning Discusses or addresses students' ways of thinking about a concept or recognizes typical levels of understanding
Student's misconceptions	Students' Understanding of Science	Discusses or addresses the way to prevent misconceptions about a concept
Procedural knowledge	Instructional Strategies	Displays skills used for solving scientific problems
Resources	Instructional Strategies	Discusses or uses the resources available to support teaching
Classroom technique	Instructional Strategies	Discusses or uses generic classroom practices
Purpose of content knowledge	Content Knowledge	Discusses reasons for content being included in the curriculum or how it might be used
Evaluation of student learning of conceptual knowledge	Assessment	Assesses student's understanding of a scientific concept
Representations of concepts	Content Knowledge	Discusses materials, pictures, or diagrams used to introduce a scientific concept
Student's abilities and learning strategies, learning styles, attitudes and motivations	Students' Understanding of Science	Discusses other student attributes related to learning

Inquiry Approaches for PCK Development

The examples of inquiry-based teaching methods that may enhance PCK development include project work, experiments or laboratory activities, demonstration, modelling, simulations, reflective discussion and problem-based methods. These methods are categorized as inductive strategies. The inductive strategy is based on the constructivist theory, which holds that individuals construct meaning and understanding through their prior knowledge and then apply this knowledge in new current situations (Chen, 2001).

Several specific inquiry-based activities are presented to demonstrate their significance in PCK development.

Project Work. Some authors have pointed out that an example of an inquiry-based activity in science classes is project work (Keenan & Wood, 2004; Rabago, 2011; Mehta, 2015). Doing a project work provides an opportunity for a student to define a problem, to plan his/her work, search appropriate resources, carry out plans, and draw conclusions. Some of the projects can be completely theoretical and may involve only library work. According to Shamsudin et al. (2013), the project approach in inquiry-based science education focuses on the work given by the teacher for the students to carry out in groups. Ideally, there should not be more than three students to a group and the group is required to invent a project for their discovery content purpose (Hiang, 2005). Previous studies reveal that project work benefits students in a number of ways - it allows for more meaningful understanding of science concepts amongst students, enhances students' academic performance (Ojo, 2007), and enables learners to engage in the processes of evaluating science content to be learned, anticipating how that knowledge could be used, as well as applying the science content in authentic situations (Kanter, 2010). Further,

project work also helps teachers in the development of their science content knowledge (CK), as well as their science pedagogical content knowledge (PCK) as they prepare and facilitate students' work (Kanter & Konstantopoulos, 2010).

Experimentation. Experiment is the core of doing investigation in the science classroom. Teachers carry out an experiment to encourage students' interest in learning science. In doing an experiment, students often find the opportunities to manipulate objects, test hypothesis, and work together to solve or prove something. Moreover, through experiments, students are usually able to 'see' or 'relate' concepts better, hence contributing to sound science conceptions. An example is a study of Olympiou (2011) who found that through an experiment, the use of a blended combination of physical manipulative (PM) and virtual manipulative (VM) enhanced students' conceptual understanding about the topics on light and colour. In addition, Demeo (2005) also noted that through experiments, the teacher's use of manipulative skills helped produce more "mature" type of science education than using traditional laboratory instruction. Doing an investigatory project is also an experimental work, which is a part of science teaching. According to Mehta (2015), investigatory project making involves the inquiry approach, which allows the students to demonstrate the mental and physical behaviors of scientists. The students also learn more science concepts and skills. Further, they learn a practical, useful approach to solving problems and answering questions. The inquiry process in an experiment involves observing a process or event, formulating questions based on observations, developing a workable hypothesis, devising a strategy for testing it, analyzing and drawing conclusions from collected data, and communicating findings to others. Thus, doing an experiment develops the teacher's content knowledge and PCK.

Demonstration. McFarland (2005) noted that demonstration is very helpful in promoting students' learning via proving the existence or the truth of something through evidence. Although teachers need to put in a lot of work to design, set up and think of the best possible way to carry out a demonstration, the end result can be extremely positive. Moreover, lecture demonstration can become an important component of overall teaching strategy to provide a concrete, visual way to help explain a topic. The author also found out that through demonstration, the nature of classroom interaction tends to be less unidirectional. It is because the students become more actively involved in asking questions about the science content. Miller (1993) noticed that, when using demonstration, he spends more time looking at students' expressions compared to the time he spent on writing on the chalkboard. Through using demonstration as a teaching method, Miller discovered that the method replaces teachers as source of knowledge. Further, when using demonstration, the teacher becomes more creative, while students learn to respect diversity and work collaboratively.

Modelling. Gilbert (2004) opined that aside from learning skills and techniques to help the students, the teachers develop good teaching models as part of their PCK. Through well-designed learning activities, they can help the students to construct a mental model of concepts consistent with the scientific models being studied. Studying a teacher's teaching models is a good place to investigate their PCK. Some researchers (Carney & Levin, 2002; Gilbert, 1991; Harrison & Treagust, 2000) believe that models are essential to the production, dissemination, and acceptance, of scientific knowledge. In biology, models serve as representations of abstractions and entities that are created so that they can be treated as objects (e.g., flows of energy as lines). Models also include

representations both of abstractions and of the material objects on which they act at the same time (e.g., of energy flows in the Krebs cycle). Models can be of a system or a series of entities in a fixed relation to each other (e.g., of the organs of the human body). Models can also be of an event, a time-limited segment of behavior of a system (e.g., of the migration of an ion across a semi-permeable membrane, of human gestation and birth).

Gilbert (2004) added that models can be simplified depictions of a reality-as-observed, produced for specific purposes, to which the abstractions of theory are then applied. They can also be idealizations of a possible reality, based on the abstractions of theory, which are produced so that comparisons with reality-as-observed can be made. Moreover, models can be used to: make abstract entities visible, provide descriptions and/or simplifications of complex phenomena, be the basis for both scientific explanations of and predictions about phenomena. Models used to acquire knowledge in Biology serve a lot of purpose.

- Models provide an environment for interactive student engagement.
- Working with models can enhance thinking abilities.
- Models and model development are useful for helping students learn quantitative skills such as graphing, graphical analysis, and visualization.
- The knowledge gained while using models and the understanding of model development and implementation are transferable to other disciplines.

Simulations. Simulation activities provide students the opportunity to visualize and model what they have learned. Thus, any simulation activity improves their chances of

understanding, and especially makes students' modeling dynamic. Simulations allow learners the opportunity to model, explore, and try out a variety of strategies. Games and modeling activities can elicit curiosity, create a demand for knowledge, and enable students to discover knowledge through exploration (Edelson, 1998). Simulations provide powerful new opportunities for learning. Role playing is an example of a simulation. This teaching method was designed by Shaftel (1970) in order to help students study their social values and reflect on them. It helps students collect and organize information about social issues, develop empathy with others, and attempt to improve their social skills. As the method asks students to "act out" conflicts, to learn to take on the roles of others, and to observe social behavior, the students learn to synthesize and summarize, write and organize information, and use problem-solving skills, which are important aspects of inquiry (Seif, 2011). With appropriate adaptation, this teaching method can be used for students of all ages.

Reflective discussion. Reflection, including personal beliefs/perceptions and personal practical experience, is part of PCK (Morine-Dershimer & Kent, 1999). It is a teaching method that encourages students to think and talk about what they have observed, heard or read. Weeks (2015) supports the fact that it is an inquiry approach where the teacher or student initiates the discussion by asking a question that requires students to reflect upon and interpret films, experiences, or illustrations. As students question and recreate information, they clarify their thoughts and feelings. The questions posed during reflective discussion encourage students to relate story content to life experiences and to other stories that will elicit personal interpretations and feelings.

Problem-based Method. This is an approach to learning that focuses on the process of solving a problem and acquiring knowledge. The approach is also inquiry-based when students are active in solving the problem (Martin-Hansen, 2002). It is a student-centered pedagogy in which students learn more about a lesson through the experience of solving an open-ended problem. In this approach, students learn both thinking strategies and knowledge. Working in groups or individually, students identify what they already know, what they need to know, and how to access new information that may lead to the resolution of the problem. The teacher's role is to facilitate learning by supporting, guiding, and monitoring the learning process. Moreover, the teacher must build students' confidence to take on the problem, and encourage them while also stretching their understanding.

Teaching of Core Ideas in Biology Education

Because the inquiry approach may be related to PCK, teachers need to be informed about the core ideas (as content knowledge) that need to be taught through a particular teaching method (as pedagogy). Campbell and Reece (2001) enumerates the core ideas that represent overarching principles in the biology curriculum as follows.

- The cell is the basic unit of life in living organisms.
- All cells come from other cells.
- Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.
- Homeostasis is an organism's ability to remain stable and stay alive by making changes to maintain a dynamic equilibrium.

- All life grows and changes over long periods of time through the processes of evolution and natural selection.
- Biological systems interact, and these systems and their interactions possess complex properties.
- The interaction of living and nonliving elements of nature constitutes an ecosystem, and each one of the interactions is important to maintaining the balance of the ecosystem.
- Living systems store, retrieve, transmit, and respond to information essential to life processes.
- DNA is a chemical code that makes up the hereditary material that is used to pass traits on from parent to offspring.
- The process of evolution drives the diversity and unity of life.

Gilbert and Treagust (2009) pointed out that all these core ideas require the use of representations to mentally engage the learners with the phenomenon to which the representation relates to. Representations are very significant in understanding the core ideas. According to Shulman (1987), PCK includes the most useful forms of representation of topics, the most powerful analogies (through experimentation), illustrations (through modelling), examples (through project work), explanations (through simulations and experimentations), and demonstrations. These are the ways of representing and formulating the subject that make it comprehensible to the students. In addition, PCK also includes an understanding of what makes the learning of specific topics easy or difficult involving the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons.

Stump (2001) suggested that science pedagogy may be viewed as a repertoire of instructional representations. This implies that by shifting the emphasis from methods or strategies of teaching to instructional representations, the focus of teaching science moves from the teacher to the science, and the connection between what the teacher knows and what the teacher does is tightened. To develop appropriate instructional representations, teachers must understand the content they are representing, the ways of thinking associated with the content, and the students they are teaching. An example of teaching a biology core idea using an inquiry approach is presented in Table 7.

Table 7. An Example of Teaching Core Ideas in Biology Using the Inquiry Approach

Core idea	Specific Idea to Discuss	Possible Representation
DNA is a chemical code that makes up the hereditary material that is used to pass traits on from parent to offspring.	Concept of the DNA	Illustration by Making a DNA model
	Concept of Cell Division	Explanation using Simulation
	Concept of Mendelian genetics	Explanation through an Experimentation

How Humans Make Decisions

The implementation of the inquiry approach as a new reform is an important decision to make among educators, particularly the administrators and teachers. Presented are the foundations of decision making.

Decision making is a daily activity for any human being. However, decision making may be different from one person to another. According to Hackett and Taylor (2013), children are wholly ill-equipped for decision making because they lack knowledge, experience and perspective. Moreover, children are impulsive and easily persuaded. It doesn't get much better during adolescence, when teenagers are driven by raging hormones, underdeveloped self-identities, peer and cultural pressure. The authors added that it is possible that the biggest

obstacle is neurological, where the prefrontal cortex, the part of the brain associated with executive functioning, does not fully develop until the early 20s. Thus, the process of decision making is case-dependent. Executive functioning directly influences decision making because it regulates, controls and manages our thoughts, emotions and behavior. It also influences our reactions to new, ambiguous and difficult situations. It helps us weigh risks and rewards and short- and long-term consequences. Moreover, executive functioning assists people in planning, organizing and executing decisions, and, importantly, it can prevent people from making rash and potentially harmful decisions.

Von Scheve (2012) has demonstrated that adults are often affected by psychological, emotional, social and situational influences in making decisions. He also demonstrated the powerful effect that cognitive biases have on one's decision making. Cognitive biases involve the tendency to draw conclusions and make decisions based on limited information or self-interest. Such biases can lead to irrational decisions at every level of society.

A man's decision making is also influenced by emotional states. For instance, feeling stressed or rushed alters one's decisions. This means that the decisions made are affected by one's mood. Different decisions are made based on whether one feels happy, contemplative or disgusted. Decisions are also significantly influenced by social forces, such as friends, family, cultural messages or societal norms. Decision making is also associated with the emotionally laden information (*i.e.*, information that is threatening in some way) that goes directly to the emotional center of the brain (amygdala and related structures). As this suddenly happens, one needs to receive and act on threatening information right away, otherwise, something bad may happen.

Unfortunately, the rapid decision making associated with triggering the fight-or-flight reaction that served humans well during primitive times is generally ineffective at helping one to make good decisions about complex issues in modern times. There are no direct neurological pathways to the prefrontal cortex and this implies that all emotional information goes through the primitive emotional brain. Thus, the prefrontal cortex is at a severe disadvantage in contributing to decision making, because the information it receives is "old news," secondhand and tainted by emotions.

According to Eraut (1994), people decide in three (3) ways. Intuitive decision making is often backed as describing a hunch, going with the flow, or adopting the first plausible options that come to mind. This type is made very quickly or in a flash of insight after mulling over the problem. Although it sometimes appears random, it is often based on a great deal of accumulated experience, and the ability to rapidly draw on the experience of a previous situation is an acknowledged aspect of expertise. The more complex or pressured the situation, the more likely that decisions will be made in an intuitive mode. However, its main weakness is lack of critical control over the decision-making process. The second type is analytical decision making, which requires time to think, a reliable information base and knowledge base to organize the decision-making domain through the use of theoretical principles. Its greatest advantage comes when it is strongly backed by research-based knowledge. In between the intuitive and analytical ideal types is deliberative decision making, which involves conscious, critical thinking at varying degrees, depending on the time available and the extent of the relevant knowledge bases of the decision makers. The mental processes involved in this mode include recognizing and organizing relevant ideas, subjecting them to critical scrutiny, and integrating them into decision approaches or

options, and there is only a limited amount of formal logical processing of unquestioned evidence and theory.

Models of Teachers' Decision Making

As decision making is a component of the inquiry approach implementation, there is the need to understand how the process is done. Decision making is a process of making a choice from a number of alternatives to achieve a desired result (Eisenfuhr, 2011). This definition has three key elements. First, decision making involves making a choice from a number of options.

Second, decision making is a process that involves, more than simply, a final choice from among alternatives. Finally, the "desired result" mentioned in the definition involves a purpose or target resulting from the mental activity that the decision maker engages in to reach a final decision. Decision making is one of the most important activities in which school administrators and teachers engage in daily. The success of a school is critically linked to effective decisions (Lunenburg, 2010).

Decisions are very significant to move on with a certain situation or to carry out a particular action. Carr-Hill et al. (2015) said that people make decisions on just about anything that has something to do with their life – political choices, personal choices, career decisions, financial decisions, medical decisions, and relationship decisions, among others. Decision making is a process involving choices. The process generally consists of several steps - identifying problems, generating alternatives, evaluating alternatives, choosing an alternative, implementing the decision, and evaluating decision effectiveness. In basic education, the implementation of the K-12 curriculum that incorporates the inquiry approach is considered a new reform that challenges the teachers to make a decision in the teaching of science.

There are models of the decision- making process that may be observed among teachers as they adopt a new reform. Gelder (2009) enumerates two as rational comprehensive and incremental models while Lunenburg (2010) includes the bounded rationality model. The rational comprehensive model characterizes decision makers as completely rational – searching through perfect information to make optimal decisions. This model assumes that the decision maker can identify the problem, that the decision maker’s goals, values, and objectives are clear and ranked in accordance with their importance, that alternative ways of addressing the problem are considered, that the cost and benefits or advantages and disadvantages of each alternative are investigated, that alternatives and their consequences can be compared with other alternatives, and that the decision maker will choose the alternative that maximizes the attainment of his or her goals, values, and objectives. However, problems are not always clearly defined; problems have to be formulated in a way that enables people to make decisions about them. To define the problems, decision makers must have vast amounts of information. Further, there is the need for the ability to predict the future consequences of decisions made. Although this model of decision making assumes that there is one (unitary) decision maker, many people, interests and institutions are usually involved. As applied in the present study, the adoption of the inquiry approach in science teaching may not only be the decision of the teachers but also the decision of DepEd authorities as evidenced by the availability of inquiry-based learning materials in support to the K-12 curriculum.

The incremental model assumes that the selection of goals and objectives is intertwined with the scientific analysis of the problem. In this model, decision makers only consider alternatives for dealing with a problem that differs marginally (incrementally) from existing policies. This suggests that they do not completely remake policy every time they make a policy

decision, but instead, refashion existing policy. In this model, problems confronting the decision maker are continually redefined and constant ends-means and, means-ends adjustments are made to better manage policy. Incremental decision making is remedial, not holistically-devised or future-oriented. The inherent imperfections of decision makers and the social and organizational systems in which they are imbedded impose limitations. One limitation is their ability to process information needed to make complex decisions (bounded rationality), which restricts them from finding solutions that are less than optimal. This minimum criterion is clear. In bounded rationality, you do not have or you are not willing to invest much time to make the decision.

Table 8 summarizes the three (3) models of decision making.

Table 8. Decision Making Models

Type of Decision Making Model	Use/Function/Application
Rational Comprehensive Model	<ul style="list-style-type: none"> • Consists of a structured four-step sequence <ul style="list-style-type: none"> - Identifying the problem - Generating alternative solutions - Selecting a solution - Implementing and evaluating the solution
Incremental Model	<ul style="list-style-type: none"> • You are trying to maximize your outcome • Confined to small changes from existing policies and procedures • Emphasis is on correcting or improving existing policies and actions
Bounded rationality	<ul style="list-style-type: none"> • Remedial • Based on premise that decision making is not rational • Decision making is characterized by <ul style="list-style-type: none"> - Limited information processing - Use of rules of thumb or shortcuts - Satisficing

Factors Influencing Teacher’s Decision Making

The influence of DepEd authorities is considered a factor in the decision of teachers to implement the inquiry approach in the classroom, but there are also other factors that may affect

a teacher's decision making. The factors that impact decision making include past experiences, a variety of cognitive biases, an escalation of commitment and sunk outcomes, individual differences, including age, educational background, cognitive abilities and socioeconomic status, and a belief in personal relevance.

Past experiences. A teacher's past experiences can impact future decision making (Julisson et al., 2005). A past experience is any skill or field of knowledge acquired or learned previously. This implies that past decisions influence the decisions made in the future. If the past decision has turned out to be positive and beneficial, it will follow that individuals are bound to make similar decisions in a similar situation. However, teachers tend to avoid repeating past mistakes (Sagi & Friedland, 2007), since future decisions made based on past experiences are not necessarily the best decisions. Thus, past mistakes serve as learning experiences, so people tend not to repeat the same decision that turned out to be a failure. For example in teaching, if lecture method seemed to be a failure in one classroom discussion, then the teacher may decide to shift to another teaching method.

Cognitive biases. There are several cognitive biases that influence the decision making of teachers. Cognitive biases are thinking patterns based on observations and generalizations that may lead to memory errors, inaccurate or wrong judgments, faulty logic or reasoning (Evans et al., 1983; West et al., 2008), and false assumptions. Cognitive biases include, but are not limited to: (a) belief bias, which is the making of decisions based on stock knowledge; (b) hindsight bias, which is the tendency to see events as inevitable once it occurs; (c) omission bias, in which, generally, the teachers have a propensity to omit information perceived as risky; and (d) confirmation bias, in which teachers observe what

they expect from observations (Marsh & Hanlon, 2007; Nestler & von Collani, 2008; Stanovich & West, 2008). In decision making, the influence of cognitive biases on teachers causes them to over rely or lend more credibility to expected observations and previous knowledge, while dismissing information or observations perceived as uncertain, without looking at the bigger picture. While this influence may lead to poor decisions, sometimes, the cognitive biases enable individuals to make efficient decisions with the assistance of heuristics (Shah & Oppenheimer, 2008). Heuristics are mental shortcuts that ease the cognitive load of making a decision and examples include using a rule of thumb, educated guess, an intuitive judgment, stereotyping or common sense. The authors argued that heuristics reduce work in decision making in several ways. Heuristics offer the user the ability to scrutinize a few signals and/or alternative choices in the decision-making process. Further, heuristics diminish the work of retrieving and storing information in memory, streamlining the decision-making process by reducing the amount of integrated information necessary in making the choice or passing judgment. Social pressures, individual motivations, emotions, and limits on the mind's ability to process information can also contribute to cognitive bias. Günter and Cuyckens (2003) reported that cognitive biases are also related to the persistence of superstition, to large social issues such as prejudice, and they also work as a hindrance to the acceptance of scientific non-intuitive knowledge. Thus, the teacher's decision to use a teaching strategy may also be hindered.

Individual differences. Research has indicated that some individual differences such as age, socioeconomic status, educational background and cognitive abilities may influence the decision-making process of teachers (Bruine de Bruin et al., 2007). According to the

authors, there is a significant difference in decision making across age; that is, as cognitive functions decline as a result of age, decision-making performance may decline as well. Further, the authors said that older people may be more overconfident regarding their ability to make decisions, which inhibits their ability to apply strategies. In addition, with respect to age, there is evidence to support the notion that older adults prefer fewer choices than younger adults (Mikels et al., 2009). Moreover, Bruine de Bruin et al. (2007) reported that people in lower socioeconomic status groups may have less access to education and resources, which may make them more susceptible to experiencing negative life events, often beyond their control; as a result, such individuals may make poorer decisions.

The educational background of teachers is based on the teacher's content knowledge (Dietrich, 2010). Teacher's knowledge in the areas of content, pedagogy and knowledge of the learners and their characteristics is the foundation for teaching. It is the essence of how teachers comprehend, reason, transform, and reflect on instructional practices (Shulman, 1987). Thus, a teacher's educational background influences his/her decision to use a variety of teaching strategies, by being able to gain an understanding of how particular topics or issues are organized, represented and adapted to the diverse interests and abilities of learners. This is necessary to provide quality instruction for students. Further, when teachers have a good understanding of what their students know and can do as influenced by their educational background, they are able to identify appropriate content, sequencing and pacing lessons, modify or extend activities for students' particular needs, and choose effective methodologies and representations. In science, it was found that teachers with deeper content knowledge were more likely to

pose questions, suggest alternative explanations, and propose additional inquiries than those with weaker knowledge (Lloyd, 2002; Manouchehri & Goodman, 2000; Sherin & Van Es, 2002).

Teachers' experiences are also a significant part in the teacher's educational background. Bentley (2007) asserts that decision-making abilities can be influenced based on the teacher's variation and duration of teaching experiences. With teaching experiences, *i.e.*, years of teaching, the teachers are able to decide on materials, instructional approaches, and assessments to use in order to meet the instructional needs of all students. According to Rice (2010), the impact of experience is strongest during the first few years of teaching; after that, marginal returns diminish. Based on a number of research studies that the author considered, it was confirmed that on average, brand-new teachers are less effective than those with some experience. Further, teachers show the greatest productivity gains during their first few years on the job, after which their performance tends to level off. On one hand, on average, teachers with more than 20 years of experience are more effective than teachers with no experience, but are not much more effective than those with 5 years of experience (Ladd 2008).

Pre-service and in-service experiences are aspects of professional development that are still part of a teacher's educational background (Crowther et al., 2000). Ganzer (2000) includes professional workshops, field experiences and other formally-related meetings as examples of the professional development experience. Professional development generally refers to ongoing learning opportunities available to teachers and other education personnel through their schools and districts, to enhance and build on their instructional knowledge (Van Driel & Berry, 2012) Professional development also

aims to gain increased experience in the teacher's professional growth through examination of their teaching ability (Glattenhorn, 1987). Mooler (2003) emphasized that field experiences provide the pre-service teachers the opportunity to practice instructional decision making and do reflections based on their own learning experiences. Further, pre-service teaching field experiences provide more effective ways of integrating educational learning theory with teaching practice. The author added that the practices of pre-service and student-teachers often reflect the way in which they themselves learned. According to Berg & Smith (2016), as teachers learn to reflect on their practice of teaching, they enhance their learning about teaching, increase their ability to analyze and understand classroom events, establish an inviting and thoughtful environment, become self-monitoring, promote personal and professional development, develop self-awareness and knowledge and improve coping strategies. The authors added that with pre-service and in-service experiences, the decision making of teachers is through reflective learning and teaching, where they decide to try new strategies and ideas and implement new activities and approaches on the spot. Further, there is development of reflective skills such as the ability to use self-directed critical thinking inquiry skills, apply contextualized knowledge about teaching and learning that can be applied in similar situations (e.g., when to change instructional strategies or lesson pacing), question, take risks in learning, reflect on one's own learning process, know how to ask questions that help students engage and think deeply, value students as individuals capable of learning, reacting, responding, assessing, and revising, while teaching. As the teacher's content knowledge and reflective skills are developed, for a while, the teacher would choose reflective learning probably because they already experience its benefit. Being reflective is not permanent, because according

to Berg & Smith (2016), teachers need to improve their ability to reflect on practice by using a variety of methods such as portfolio development, journal writing and the like. Moreover, teachers who reflect on their own practice employ a constructivist perspective. They constantly review significant events that take place in the classroom and try to clarify and improve their understanding of teaching and learning. In a study of beginning teachers by McCombs in 2003, the teachers reported that the process of reflection and self-assessment helped them identify areas for improvement and assisted them in implementing practices to be more effective in reaching students.

Escalation of commitment and sunk outcomes. Another factor that influences decision making is an escalation of commitment and sunk outcomes, which are unrecoverable costs. According to Julisson et al. (2005), there are some individuals who invest large amounts of time, money, and effort into a decision which they feel committed to. The authors added that such individuals will tend to continue to make risky decisions when they feel responsible for the sunk costs, time, money, and effort spent on a project. This situation is also true for some teachers who value commitment. This means that a teacher may decide to use a specific teaching strategy because she is committed to do such especially if the teacher has already spent time and effort to prepare the said strategy.

Belief in personal relevance. This means that when people believe that what they decide matters, they are more likely to make a decision. This is a practice among teachers who make decisions on something that they strongly believe in (Dietrich, 2010). Thus, teachers may decide to use or not to use a teaching strategy. Whatever choice is made by the teacher, instructional decisions are reflected in lesson plans and in classroom practices (Ibañez & Ocampo, 2010). Understanding these instructional decisions entails

an understanding of the teacher's choices and the rationales behind those choices – for they represent the beliefs the teachers hold.

Case Study Methods and Instruments in Assessing PCK and Decision Making

The *why* and *how* of PCK and decision making on the inquiry approach implementation, not just the *what*, *where*, *when*, or "who" was investigated through the qualitative case study method, to gather an in-depth understanding of human behavior and the reasons that govern such behavior. The strategies in this qualitative method include structured and semi-structured interviews, case studies, narrative study, classroom observations, informal conversations, focus groups, open-ended survey questions, journal entries etc. The following information presents the usefulness of the case study method in studying about PCK and decision making in relation to the inquiry approach use.

PCK and Inquiry Approach. Some authors have indicated that the use of the inquiry approach can help develop a teacher's PCK. Thus, PCK has a direct relationship with the said approach. Using a variety of qualitative methods, the findings from a study of Nuangchalem (2012) about examining pre-service teachers' PCK indicated that the inquiry approach can enhance PCK and its result can be used also for teacher preparation program. Similarly, Tas and Heywood (2012) said that the use of the inquiry approach is important for teachers to link content and pedagogical knowledge and develop it. Further, teachers use the inquiry approach to develop pedagogical content knowledge and embed understanding of inquiry (Tambyah, 2008). The author added that the use of an inquiry-based approach involves the planning of practical activities that show new, critical understanding of science concepts.

Other case studies were conducted to show that PCK and the inquiry approach are related. For instance, Lehane et al. (2014) conducted a case study involving 12 pre-service science teachers from Ireland to capture their PCK using Content Representation (CoRe). The CoRe is a tool that proposes research questions on how the teacher selects the contents reflecting strategies, methodologies and socio-economic and cultural aspects. In this study, the CoRe was altered slightly to have a more inquiry focus in order to develop inquiry orientations. Through multiple sources of data such as lesson plans, reflections, observations and interviews used to evaluate the action of inquiry in the classroom, the qualitative methods of data collected revealed the presence of inquiry in the teachers' thinking and approaches. When interviewed, the pre-service teachers revealed that involvement in this study steered their thinking toward inquiry and ultimately led to the decision of doing inquiry in the classroom. Further, pre-service teachers shared their experiences of being involved in the development of the CoRes. The study assumed that the experiences of the teachers in the study would help them make a transition from being an expert student to a novice teacher. Although the assessment of a case study is very subjective, this method was found effective in terms of the overwhelming positive transition. Similarly, the use of the case study method was effective in documenting and assessing the PCK of five (5) experienced high school and college Mexican teachers (Bueno, et al., 2011) in relation to the use of the inquiry approach. Just like the previous study, the CoRe was modified into "inquiry CoRe" by incorporating a set of seven inquiry activities. Through interviews, it was observed that all teachers used inquiry to modify their students' way of thinking, mainly through question posing. The assumption in this study involved the teacher's ability to

demonstrate the given seven inquiry activities. Some of them employed research as their main tool to promote scientific inquiry but others mentioned the lack of time to do it. In this study, the method was only limited to interviews and no mention of documents being analyzed was further made. This is one of the limitations of the case study method being biased though a thick description on the teachers' PCK in relation to the inquiry approach was documented. Similarly, the biased nature of the case study method was demonstrated in a study conducted by Chapoo et al. (2014), who investigated the understandings and practices that comprise a biology teacher's PCK. In this research, only a single participant was evaluated in terms of her PCK through writing a content representation (CoRe), teaching in the classroom, and discussion during the interview. Although biased, the case study method was able to determine the extent and nature of her PCK in relation to the model of Magnusson et al. (1999). As the findings may not also be generalized because of its very small size, the findings were able to expose the teacher's understanding and practice of PCK, which supported teaching and learning science based on constructivism. The study assumed that being an experienced teacher, the participant would be able to demonstrate her PCK in the teaching of Biology. The use of CoRe for evaluating PCK of teachers involving a case study method was also effectively used in other studies (Loughran, Berry, Mulhall, 2004, 2008, 2011; Loughran, Milroy, Berry, Gunstone, & Mulhall, 2001).

Using triangulation of data sources (interview, PCK grids and PCK discussion/feedback group discussion), Scheuch and Keller (2012) derived a PCK tool for reflection in professional development of in-service and pre-service teachers based on the hexagon PCK model of Park and Oliver (2008). The case study method involved in this

study included the educational and emotional background of the teachers which are considered unnecessary and inefficient by many specialists. Although the information gathered maybe too thick and thus, difficult to analyze, the case study method used was able to address the need for evaluating the PCK attributes of teachers involving (a) orientation to teaching science; (b) knowledge of students' understanding; (c) knowledge of curriculum/structure; (d) knowledge of instructional strategies and methods; and (e) knowledge of assessment; and teacher's efficacy.

Another usefulness of the case study method is demonstrated in the study conducted by Juttner and Neuhaus (2013) who measured 11 biology teachers' PCK by analyzing (1) the teachers' knowledge about student understanding(or lack of understanding) of several topics in Biology and (2) knowledge about instructional strategies like the use of models or experiments. The results could not be generalized since only two PCK components were evaluated. This is one weakness of the case study; but through the think-aloud interviews with American and German biology teachers, the results of the study demonstrate the scope for adapting the conceptual framework of these items to measure biology teachers' PCK in other countries.

On PCK and Decision Making. As presented mostly in studies involving mathematics instruction, there is also a relationship between PCK and decision making. There are related studies that have been documented about this. For instance, in investigating a correlation between K-8 teachers' mathematical pedagogical content knowledge for teaching and quality of instruction, Hill et al. (2008) concluded the existence of a powerful relationship among the teacher's PCK on mathematics and decision making around the adoption of a teaching material. Similarly, Anthony and Walshaw (2009)

found a relationship between secondary teachers' mathematical PCK in terms of the big ideas that they need to teach and the decision to implement a mathematical learning material. The relationship aims to have in-depth knowledge and clear ideas about how to build procedural proficiency and how to extend and challenge student ideas. The authors added that teachers with limited knowledge tend to structure teaching and learning around discrete concepts instead of creating wider connections between facts, concepts, structures, and practices. With limited knowledge, a sound decision making in the implementation of a new learning material may be lacking and this may affect the strengthening of conceptual understanding. On the other hand, teachers with good PCK may produce a sound decision-making process.

However, the information is limiting in science education. Particularly, there is paucity of information about the in-depth analysis on how teachers make a decision in the adoption of the inquiry approach in teaching science. Eames et al. (2012) studied the PCK of two science teachers in terms of instructional decision making, where generalizations could not be made also, since only two teachers were involved in the study. However, using a case study method through an interview, the authors were able to identify curricular and instructional decisions (Hollon et al., 1991, p. 149) that teachers make inside the classroom.

Thus, a qualitative researcher holds that understanding comes from exploring the totality of the situation, which often has access to large reams of "hard data", and begins with propositions proceeding in a scientific and empirical way throughout the research process (e.g., Taylor et al. (2016). However, qualitative methods produce information only in the particular cases studied, and other ` general conclusions are considered

propositions or informed assertions. Moreover, qualitative methodologies limit the size of the population that can be investigated.

When qualitative methods cannot be used, quantitative methods can be done to seek empirical support for a given set of research hypotheses. For example, the study of Parmigiani in 2012 used a Likert questionnaire that was administered to teachers (N=411) of Italian basic schools (pupils aged between 3 and 14 years old). The study aimed at highlighting the individual and group decision making of the teachers. Using Cronbach alpha (α) for reliability of the instrument, the findings indicate the main modalities for teachers' decisions when they work individually or in groups. For group decisions, there was emphasis on the level of teachers' involvement during meetings and how the participants process the information; while for an individual's decision, there was emphasis on the main features of instructional decisions and types of heuristics and biases teachers use during instructional activities. Another study by Olorunsola and Olayemi (2011) was conducted to examine teachers' involvement in the decision-making process and its relation to their personal characteristics in secondary schools in Ekiti state. A teacher's decision-making questionnaire (TDMQ) was administered in five local government areas of the state, which were randomly selected through the multistage technique. Through the descriptive analysis of the data using frequencies, percentage; t-test, ANOVA, Scheffe post hoc for data analysis, results reveal that secondary school teachers in Ekiti State are significantly involved in decision-making processes.

Other Techniques Used. In the other studies of PCK, the multimethod assessments that include a variety of techniques such as concept maps and portfolio are used. Concept maps have been used to measure knowledge of structures represented by key concepts

and the relationships between terms. The use of concept maps has been criticized for being too restrictive, because only particular ideas are used. However, concepts are very useful for the initial analysis of data. On the other hand, a portfolio is an authentic tool for assessing PCK and decision making. Khan and Begum (2012) said that in the portfolio, teachers provide their learning evidence, which demonstrate their progress and attainment of knowledge from their experiences. Shulman (1987) believes that portfolio is a structure document where teachers record their learning as well as the students' work samples. According to Campo (2012), portfolios are developed through reflective writing, thoughtfulness and serious conversations. In addition, a portfolio is a container of documents that provides evidence of someone's knowledge, skills and/or disposition. It is also a good way of collecting or recording one's learning. Moreover, a portfolio is a source where a teacher can judge his/her own performance and how much he/she has done or learnt. In a portfolio, a teacher may record his/her pedagogical knowledge and professional activities for a certain period of time. It also demonstrates and evaluates a teacher's understanding, achievements and successes, and displays professional growth in the field of teaching. Through the portfolio, a teacher may reflect on his/her past and present practices, which may help the teacher learn from mistakes through reflection. Thus, a portfolio not only provides evidence of knowledge and skills, but also represents someone's beliefs and values of teaching and learning through critical reflection.

Constant Comparative Analysis as a Qualitative Methodology

As identified in the literature, making constant comparisons and applying theoretical sampling are necessary strategies used for developing grounded theory. Kolb (2012) reported that the constant comparative analysis is used to develop concepts from the data by coding and

analyzing at the same time. The author added that this method “combines systematic data collection, coding, and analysis with theoretical sampling in order to generate theory that is integrated, close to the data, and expressed in a form clear enough for further testing. Constant comparative methodology incorporates four stages: “(1) comparing incidents applicable to each category, (2) integrating categories and their properties, (3) delimiting the theory, and (4) writing the theory” (Glaser & Strauss, 1967, p. 105). Throughout these stages, the researcher continually sorts through the data collection, analyzes and codes the information, and reinforces theory generation through the process of theoretical sampling. The benefit of using this method is that the research begins with raw data; through constant comparisons, a substantive theory will emerge (Glaser & Strauss, 1967).

Boeijie (2002) proved the usefulness of constant comparative analysis as he identified the criteria for a systematic analysis process among multiple sclerosis patients and their spousal care providers. The criteria included (1) the data involved and the overall analysis activities; (2) the aim; (3) the results and (4) the questions asked. Similarly, Hewitt-Taylor (2001) described the application of constant comparative analysis by exploring on the use of self-directed learning (SDL) in pediatric intensive care nurse education. The study involved a six-month case study of a pediatric intensive care course (ENB 415) using documentary analysis, repeated interviews with teachers and students, observation of course processes and selected lessons and student learning diaries. The study also included the survey of seven centers offering the same course. A field study was used to record additional data and personal reflections.

In another study, Mercan (2015) used the constant comparative analysis in the study of secondary Physics, Chemistry, and Biology (PCB) teachers’ views about in-service training related to curricular change through semi-structured interviews. The results indicate that in-

service training was insufficient - the new curricula were not introduced to them adequately.

Some teachers expressed positive views toward the in-service training and few were concerned about the incompetence of the trainers and the low quality of the training programs. Few teachers also felt that they need to be up-to-date with the new curricula and establish ways of cooperation among teachers.

Teaching Experience as a Factor in Decision Making

Many factors may be used to see the variation among the teacher's PCK, decision making and the inquiry approach implementation, which will provide opportunities for deeper analysis. One factor is teaching experience. Its use is based on findings that teaching experiences may influence decision - making abilities of teachers (Bentley, 2007). According to Ladd (2008), on average, teachers with more than 20 years of experience are effective in making quality decisions about science instructional practices. Finucane and Lees (2005) opined that there is a significant difference in decision making across age. As such, it is very interesting to study the teachers' approaches to teaching science, along with different attitudes toward curriculum reform (Luft & Roehrig, 2007; Wallace & Kang, 2004). Meanwhile, the grouping consisting of beginning teachers and of experienced teachers is patterned on previous studies about the relationship between the number of years of teaching and teacher competencies (Layfield & Dobbins, 2002; Talbert & McLaughlin 1993; Veeman, 1984). This selection is significant because the teachers having different teaching experiences and working in different types of schools may tend to hold different decision- making processes and to have variation in their PCK in terms of implementing the inquiry approach.

Differences Between Beginning and Experienced Teachers

There are specific differences between these groups of teachers.

Beginning Teachers. Novice teachers are those with little or no classroom experience. They are often student teachers or teachers who have less than 2 years of teaching experience (Gatbonton, 2008). Novice, beginning or new teachers may be interchangeably used. These teachers are often limited in their repertoire of instructional strategies. As Magnusson et al. (1999) emphasized, knowledge of instructional strategies is an important domain in the transformative model of PCK. Thus, it implies that use of good instructional strategies in teaching a science concept is very important for developing PCK.

Many teachers enter the teaching field directly from university or college teacher preparation programs, where they mastered minimal pedagogical knowledge or skills. As an observation, the teachers are not often taught how to establish the positive, organized learning environment necessary for them to teach and for students to learn. Some teachers enter the field with almost no formal teacher training, or even alternative certificate programs. In the Philippines, a requirement for a graduate of the basic education program (Bachelor of Science in Secondary education or Bachelor of Elementary Education) is passing a Teacher's Licensure Exam to be able to teach in the classroom. Therefore, it is assumed that not all who have passed the Licensure Examination for Teachers (LET) have had initial teacher education programs. This means that through trial and error, new teachers may develop a repertoire of teaching strategies. This haphazard process of strategy development may take several years, by which time, many struggling, unprepared new teachers have already left the classroom. Further, without high-quality preparation to ready them for the challenges of the classroom, new teachers will either teach as they have been taught, or be given current teacher attrition trends, or, they will not teach

at all. Keeping quality teachers means giving them the necessary support system of pedagogical knowledge needed to succeed in the classroom.

Professional development for new teachers should be built on a framework of research-based instructional strategies (Freiberg, 2002). These skills help new teachers bridge theory and practice and create high-quality learning environments in their classrooms. The strategies fall into three categories: organizing, instructing, and assessing (Table 9).

Table 9. Strategies for Professional Development of New Teachers (Freiberg, 2002)

Type of Strategy	Characteristics
Organizing Strategies	Include planning, lesson design, time use (time management, time on task, and pacing, for example), advance work, and classroom management
Instructing Strategies	Student-centered strategies such as lecture, demonstration, questioning, discussion, guided practice, independent practice, grouping, role play, simulation, and reflective inquiry
Assessing Strategies	Strategies to assess both student learning and their own professional learning

Freiberg (2002) points out that new teachers usually find organizing strategies the most difficult to master. From planning to classroom management, organizing strategies are hidden from most classroom observations. Consequently, the student teacher, intern, or new teacher who observes a master teacher's classroom in the middle of the year often misses the advance work and classroom management strategies that the master teacher used during the first few days of school to set the tone for a positive learning environment. The novice teacher observing a veteran teacher's classroom sees the outcome of effective planning - a smoothly functioning lesson; but is not privy to the veteran teacher's lesson planning processes. Organizing strategies help create the necessary conditions for learning and teachers can acquire these skills systematically

rather than depend on trial and error. The discussion of the three most important organizing strategies, namely, planning, advance work and classroom management follows.

During planning, new teachers spend much more time than their veteran counterparts do, often staying up late at night to plan the next day's lesson (Hobson et al., 2009). In this case, mentors can help new teachers with instructional planning - particularly unit planning, which allows the novice to see the bigger picture and plan backward from the end of the unit. In addition, during instructional planning, veteran teachers make decisions on the basis of learner, content, and context, addressing the questions: Who are my learners? What information, ideas, and concepts do I want my students to grasp? Under what conditions will instruction occur?

A complete lesson planning consists of the four components: initial, active, in-flight, and follow-up planning. During initial planning, teachers visualize the lesson; that is, they think through the lesson, anticipating their teaching and the students' responses. Active planning involves pulling together materials and resources for the lesson.

While initial and active planning occur before teachers present the lesson, in-flight planning occurs during the lesson and usually reflects changes in the day, such as a fire drill or a last-minute adjustment in the school schedule. In-flight planning also involves being able to change the lesson on the spot for more substantive reasons -- when students are not engaged in the activity, for example. Compared to new teachers, experienced teachers recognize the need for in-flight lesson corrections and can draw immediately from a repertoire of strategies to make such modifications. During follow-up planning, they may reflect on the lesson and write down what went well and what

changes they need to make. For new teachers, follow-up planning is crucial to build an instructional repertoire for future lessons.

Good classroom management is a requirement for a quality teaching. When classes are poorly managed, disorder and chaos steal time from learning. Poor management can lead to student discipline problems. Sustained student misbehavior often inhibits teachers from using the engaging, interactive instructional approaches that foster student achievement and active learning, including cooperative grouping, learning centers, projects, experiments, and the use of manipulatives (Brophy, 1999; Cohen, 1994; Freiberg, Connell, & Lorentz, 2001). These authors claim that classroom management is more than discipline. It involves, among other things, the development of classroom rules and rational consequences for breaking them. Classroom management can also be measured by a teacher's ability to share control and promote student self-discipline.

Assessing strategies involve effective teachers' assessment of both student learning and their own professional learning. New teachers struggle with both types of assessment. Most new teachers have a limited repertoire of assessing strategies and few prior experiences with alternative assessment. Even maintaining student grades (in a gradebook or with grading software) is an unknown quantity to first-year teachers and is rarely taught in college methods courses or new teacher in-service training. Thus, novice teachers must explore formal and informal measures of learning and practice constructing various assessments. Most new teachers only have experience with the assessment measures that their teachers used when they were students - multiple choice, true/false, and short-answer essay tests. Assessing strategies, like instructing strategies, require a range of options to reflect students' diverse learning abilities - from rubrics that provide

standards against which students can measure their work to portfolios that include pre- and post-activity student writing.

Experienced Teachers. Experienced teachers are likely to need professional development that affirms the knowledge, experience, and intuitive judgment they have cultivated during their careers. At the same time, teaching experience does not necessarily result in expertise (Tsui, 2003, 2005) since some experienced teachers are not as receptive to professional development as are new teachers, even though they might benefit from opportunities to reflect on and enhance their knowledge and refresh their enthusiasm for.

School administrators and other teachers might define experienced teachers as those who have taught for many years, are able to motivate students and hold their attention, know how to manage their classroom effectively, and can change course in the middle of a lesson to take advantage of unforeseen opportunities to enhance student learning. However, literature tells that the definition of experienced teachers seems to hinge principally on the number of years taught; time-related criteria can range from 2 years or 3 years (Bastick, 2002) to 9 years or more (Atay, 2008; Bivona, 2002). Most commonly, studies identify experienced teachers as those who have approximately 5 years or more of classroom experience (Gatbonton, 1999; Martin, Yin, & Mayall, 2006; Richards, Li, & Tang, 1998; Tsui, 2003, 2005).

As mentioned previously, the number of years of teaching does not guarantee expertise as a teacher. Some experienced teachers may be considered expert, while others remain “experienced non-experts” (Tsui, 2003, p. 3). In practice, the consideration that an experienced teacher is an expert may be subjective and arbitrary, and not all stakeholders may share this view. Further, teachers’ beliefs about expert instruction do not always

match their own instructional practices. For instance, Farrell and Lim (2005) examined the beliefs of two experienced teachers and discovered some discrepancy between what the teachers said they did in the classroom and what they actually did. Both teachers were observed to be using a teacher-centered, traditional approach in the classroom, although both reported employing student-centered strategies.

There are other studies indicating that experienced teachers share many attributes that distinguish them from novice teachers. Bastick (2002) found that experienced teachers in Jamaica were less extrinsically motivated (e.g., motivated by salary) and significantly more intrinsically motivated (e.g., motivated by the emotional rewards of working with children) than were novice teacher trainees. Similarly, the study of K–12 teachers' attitudes by Bivona in 2002 found that teachers with more than 10 years of experience had more positive attitudes toward teaching than did less experienced teachers. Moreover, Martin, Yin, and Mayall (2006) found that experienced teachers managed their classrooms more effectively than less-experienced teachers. They took more control than did novice teachers in establishing classroom routines and monitoring group work and were less controlling and reactive in dealing with individual student behavior. Likewise, Gatbonton (2008) found that novice ESL teachers in the K–12 programs were more preoccupied with student behavior and reactions than with pedagogy and student outcomes. It was also noted that experienced ESL teachers were more concerned with ensuring that learning was taking place and less concerned about students' negative reactions to class activities or to the learning process.

There are studies that have looked at experienced teachers' skills, knowledge, and confidence. For example, Akyel's (1997) study comparing experienced ESL teachers

with student ESL teachers found that experienced teachers considered a wider and more varied range of instructional options in response to student cues. They welcomed student initiations (i.e., student questions or comments that prompt a change in the direction or topic of a lesson) because they believed this would lead to meaningful communication in the class. They were less likely than student teachers to be concerned when students' initiations caused a divergence from their lesson plan. Another example is the study of Walls, Nardi, von Minden, and Hoffman in 2002 who found that expert teachers rely more on procedural knowledge (their own practical knowledge of what steps and techniques have worked well in the past), whereas novice teachers rely more on declarative knowledge (the theoretical knowledge they have gleaned from teacher training programs). Akyel (1997) concluded that experienced teachers are not as concerned as student teachers about adherence to rules and models in their teaching or about approval from external sources. On the other hand, novice teachers, see learner ideas and errors as possible obstacles and focus principally on maintaining the flow of their lesson plans. Much more than experienced teachers, they worry about the appropriateness of their instructional strategies. Mullock (2006), said that novice teachers are also more likely to engage in self-criticism. Finally, Gatbonton (2008) found that experienced teachers may be less concerned with promoting learners' acquisition of specific language items, such as using "s" with third person singular verbs in the simple present tense, than with ensuring that genuine and meaningful communication occurs. Richards and Farrell (2005, p. 7), point out that expert teachers tend to share the following characteristics, setting them apart from novice teachers:

- A rich and elaborate knowledge base
- Ability to integrate and use different kinds of knowledge

- Ability to make intuitive judgments based on past experience
- Desire to investigate and solve a wide range of teaching problems
- Deeper understanding of students' needs and student learning
- Awareness of instructional objectives to support teaching
- Better understanding and use of language learning strategies
- Greater awareness of the learning context
- Greater fluidity and automaticity in teaching
- Greater efficiency and effectiveness in lesson planning

Based on the previous literatures, it has been established that experienced teachers differ from novice teachers in their knowledge, skills, and beliefs. Thus, it may be inferred that they also differ from novice teachers in their professional development needs. Teachers continue to evolve as they remain in the teaching profession (Tsui, 2005), and several researchers (e.g., Zeichner & Noffke, 2001) have emphasized the importance of lifelong professional learning for teachers in all fields. Providing meaningful professional development for experienced teachers may be considered central to this goal. Challenging, role-changing, experimental activities may increase teachers' satisfaction and help them learn and grow. According to Richards and Farrell (2005), reflective and collaborative professional development activities can be particularly beneficial for experienced teachers. Moreover, Wallace (1991) argues that effective professional development includes mentoring and coaching, reflection, and opportunities to apply theory and research to practice.

Summary of the Literature Review

Research results show that PCK helps the creation of an inquiry classroom. However, there are also arguments on the strength and effectiveness of the inquiry approach, in both

theories and classroom practice. Within the practical challenges, difficulties arise from pedagogy requirements and other contextual constraints. Such have become the major obstacles teachers face and the major concern for the success of implementation of the inquiry approach.

On the other hand, many studies indicate the usefulness in the adoption of the inquiry approach (Abd-el-halick, et al., 2004; Callison & Barker, 2014; Kitota, et al., 2010; & Fuchs, 2005) in teaching science. Through this approach, the students are able to pose difficult questions and foster the desire and skills to acquire knowledge about the world. Moreover, students are given opportunities to take ownership of their own learning, a skill necessary for one to succeed in college and in most professional settings. Further, an inquiry approach allows students to draw connections between academic content and their own lives, which can be particularly important for culturally and linguistically diverse learners. Evidence shows that with a good grasp of understanding the concepts, inquiry develops, indicating that there is a direct relationship between PCK and the inquiry approach.

Evidence shows that there is also a relationship between PCK and decision making. This relationship was demonstrated in previous studies among science teachers (Eames et al., 2012) and among mathematics teachers (Hill, et al., 2008; Anthony & Walshaw, 2009) Decision making is considered as one important variable for making specific educational actions. Specifically for science, it is assumed that given a pattern of PCK, a teacher's decision making may play a crucial role in the implementation of the inquiry approach as one new method for teaching science. However, a problem becomes even more complicated as there are also pieces of evidence indicating that, teachers' decision making and the inquiry approach are not necessarily linked because the teacher's decision to adopt the inquiry approach may totally be influenced by the mediation of authorities in the basic education. Other than this factor, it is also

important to do an in-depth analysis of teacher's PCK in relation to the existence of other possible factors that may influence the teacher's decision to adopt the inquiry approach. Thus, this information confirms the prerequisite of further investigation of this study.

Conceptual Framework of the Study

Given the PCK with the four (4) components, there are important theories that are associated with how the teachers use it. To introduce a lesson, the teachers use motivational activities (Knowledge of Instructional Strategies) in the form of personal experiences. The basis is constructivism wherein the teachers act as more of a guide to helping students create their own learning and understanding. The teachers help them create their own process and reality based on their own past. The constructivism learning theory is generally based on the idea that students actually create their own learning based on their previous experience. This learning theory focuses on learning as an active process, personal and unique for each student (Hackathorna et al., 2011). The teachers teach the content (Knowledge of Content) as supported by different strategies (Knowledge of Instructional Strategies) which also facilitates student learning (Knowledge of Students' Understanding of Science). Students' learning of content through these two (2) knowledge bases is based on cognitive learning theory which impacts students because their understanding of their thought process can help them learn. In this theory, teachers give students opportunities to ask questions and think out loud. These strategies help students understand how their thought process works, and utilize this knowledge to construct better learning opportunities (Tennyson & Volk, 2015). Where the students interact with the teacher through discussions or interact with the other students is based on connectivism learning theory. This theory focuses on the idea that people learn and grow when they form connections. Teachers utilize connectivism in their classroom to help students make connections to things that

excite them, helping them learn. Teachers use instructional materials to make good, positive connections to learning. During discussion, the teachers help create connections and relationships with their students through interaction. Likewise, the teachers also create connections of students with their peer groups to help them feel motivated about learning. Student learning is evaluated through an assessment (Knowledge of Assessment) which serves as a reinforcement (for the slow learners) to help students better learn a concept. Students who receive such reinforcement are more likely to retain information moving forward, a direct result of the behaviorism theory. The behaviorism learning theory is the idea that how a student behaves is based on their interaction with their environment (Phillips, 2012).

Teaching science effectively depends on the content knowledge employed by the teachers. The teachers must be well versed with the biology content knowledge, as to ensure that correct concepts are taught to the students. Moreover, it is crucial that the teachers understand the purpose of teaching a certain content and the ways it should be developed (Lam, Kaur, & Lee, 2014). Teachers' KC (Knowledge of Content) may be influenced by individual differences, namely, educational background, number of years of teaching, and professional development programs attended (Rodrigues et al., 2003; van Dijk and Kattmann, 2007). Individual differences are personal characteristics that distinguish teachers from each other in the teaching process. According to Narayan (2016), education level/background, years of teaching experience and professional development training influence teacher effectiveness. Harris and Sass (2008) revealed that an advanced degree would improve the teachers' ability to assist their students' achievement by teaching the content effectively. According to Kosgei et al. (2013), education level and years of teaching experience influence the effectiveness of the

teacher. Moreover, prior professional development training has an effect on the productivity of the teachers (Harris & Sass, 2008).

Teachers find the transition from traditional method to IBA challenging. IBA is a student-centered instructional method that fosters the development of critical thinking. IBA is about the rigorous construction of knowledge and ideas rather than just the passive transmission of knowledge that is typified by traditional lecture pedagogy. Among teachers, there is resistance in the sustainable use of IBA because it is time-consuming and IBA activities are too difficult to implement. The teacher's decision may be mandated by DepEd or maybe influenced by individual differences. Whatever reason is available for the teachers to decide on the sustainable use of IBA is based on the theory of heuristic. According to Kendra (2021), heuristic theory is a mental shortcut that allows people to solve problems and make judgments quickly and efficiently. The application of heuristic theory is an ecologically rational strategy that makes best use of the limited information available to the teachers.

With the teachers' PCK components and specifically KC as may be affected by individual differences, a decision, (which may be also affected or not affected by the mentioned individual differences), is made for teachers' sustainable use of IBA. This is the conceptual framework of the study as indicated in Figure 5.

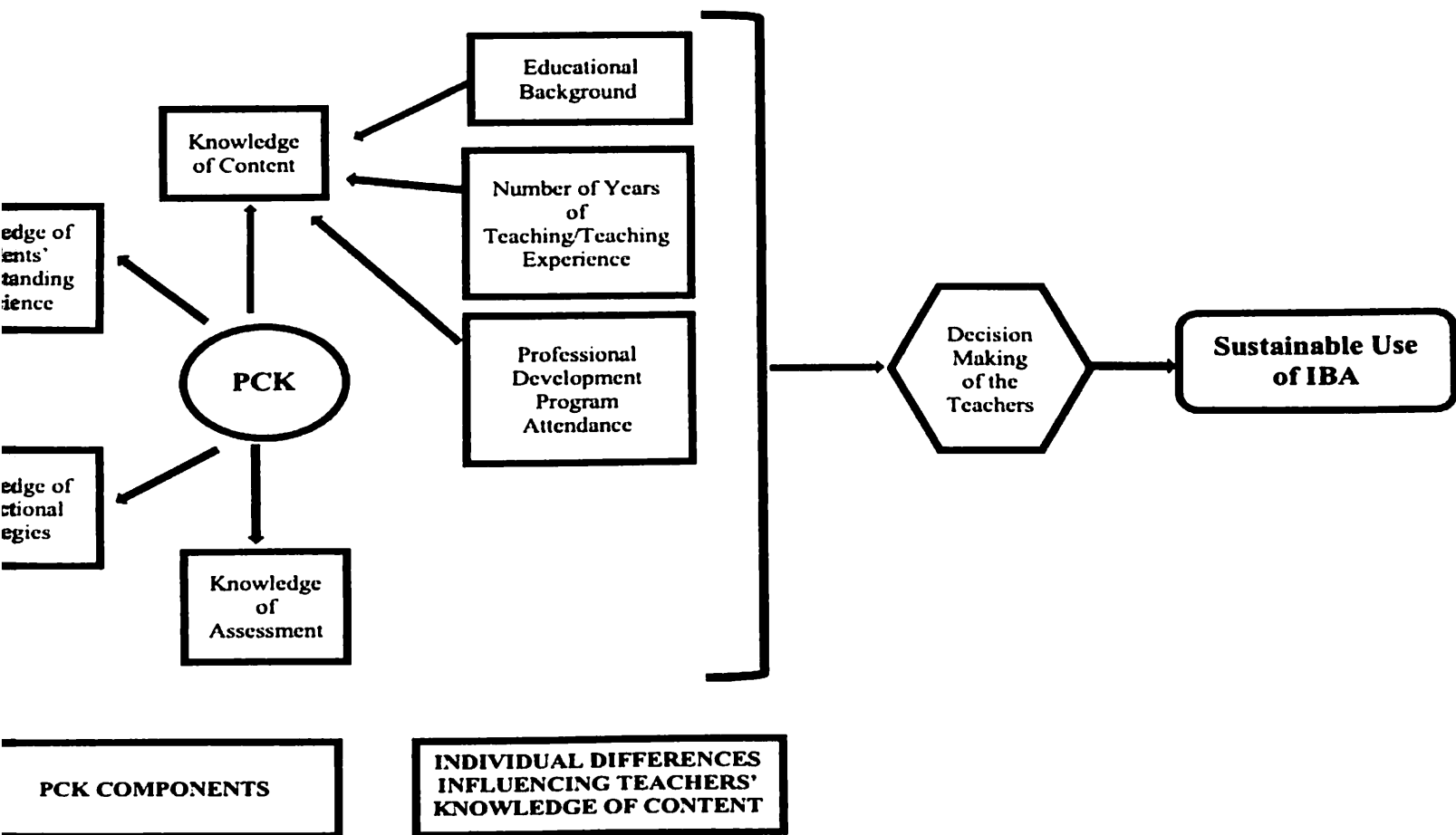


Figure 5. Conceptual Framework of the Study

Definition of Terms

Decision making is regarded as the cognitive process resulting in the selection of a belief or a course of action among several alternative possibilities. In the study, it refers to the decision of the cases in using inquiry approach in science in the classroom.

Past experiences involve a skill or field of knowledge acquired over months or years of actual practice and which, presumably, has resulted in superior understanding or mastery. In the study, past experiences involve the teachers' participation to previous seminars and workshops on inquiry-based strategies as well as the teaching experience in the previous school.

Individual differences include age, socioeconomic status, educational background and cognitive abilities that may influence decision making of teachers. In the study, educational

background, years of teaching and professional development program attendance are considered factors that may influence the PCK and decision-making process of the teachers.

Inquiry- based approach is a teaching method using inquiry and it is the teaching strategy used by the respondents. In the study, the teaching method involves the use of the 4A's- Activity, Analysis, Abstraction and Application.

Inquiry-based learning is the kind of learning expected of an inquiry approach. As inquiry approach is used by the cases inside the classroom, it is expected that all the students obtain an inquiry-based learning.

Teaching practice is the use of a particular teaching method or strategy in the classroom. In the study, the teaching practice of the cases is the use of inquiry approach.

Teaching experience refers to the number of years or length of service a teacher teaches in a particular school.

Beginning teachers are novice or new teachers who have less than 5 years of teaching experience.

Experienced teachers are teachers who have taught for more than five (5) years.

Mental construct is something solely born and existing only in the mind. Examples are things that do not reflect what actually exists in the world such as abstract concepts; abstract images (i.e. do not correspond to what is concrete, merely a representation). It is a view, a way of viewing, a viewpoint, or an association; and a belief system. In this study, the mental construct of a teacher involves views on the inquiry approach, limitations on its use, benefits and decisions to use the inquiry approach.

Levels of PCK consist of **high level**, which indicates a complete discussion of the content, **moderate level**, few components of the content are missing in the discussion, and **low level** where many components of the content are missing.

Chapter 3

METHODOLOGY

This section contains a discussion of the general methodology used in the study.

Specifically, it contains the discussion on the design of the study and the process of selecting the participating schools and teachers, data collection and analysis procedures.

Design of the Study and Case Selection

This research used a multi-case study design (Figure 6) to gain multiple perspectives of teachers' perceptions and decision making with regard to the use of the inquiry approach. It is a multi-case design in which four (4) cases were selected to develop a more in-depth understanding of the said phenomenon. Then, an empirical investigation on each of the cases was conducted through interviews, classroom observations and document analysis. After the thorough investigation, individual case reports were then prepared. Cross-case comparison (comparing one case to another case) was done to come up with conclusions and develop theories based on the observed cases. Finally, the summary of the report was prepared.

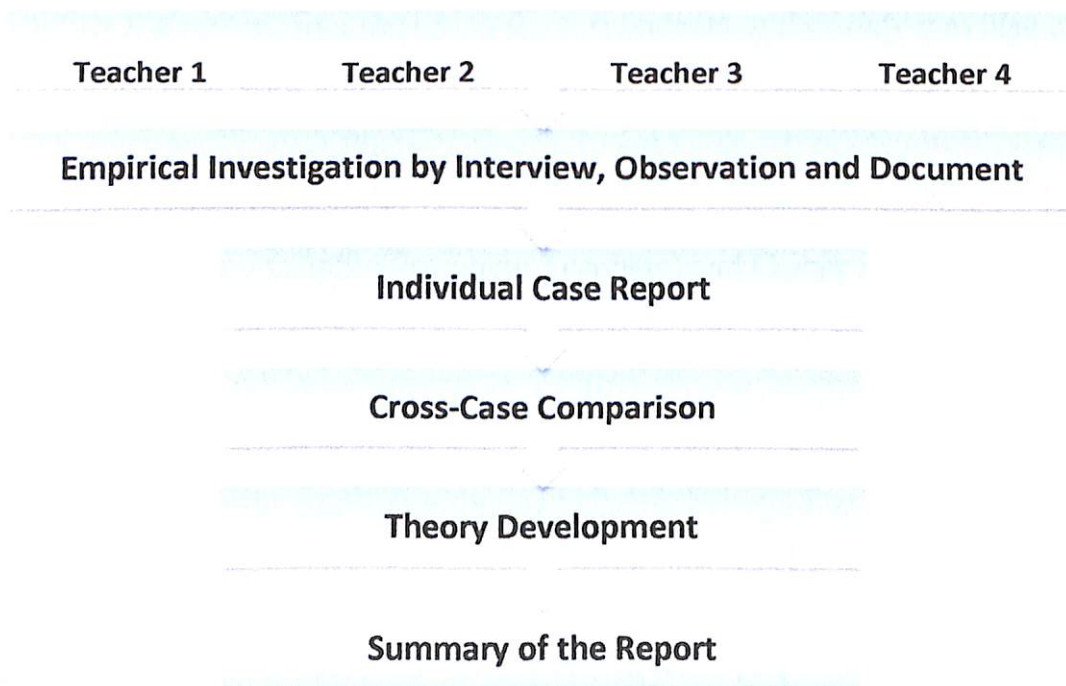


Figure 6. Multi-case Research Design of the Study

The study involved four (4) Grade 8 Science teachers from two public high schools in Laguna. The cases were selected based on the following criteria: (a) the school (or at least some of its teachers) has implemented the inquiry approach as a teaching approach; (b) the school has been offering the Engineering and Science Education Program (ESEP); (c) some of its teachers have been teaching the investigatory project making in which the inquiry approach is applied; and (d) it has participated in Regional and National Science Fairs, and has been consistent in winning these competitions.

The participants were identified through the help of the science coordinator of the selected school. Each teacher was selected based on the length of teaching. In particular, two (2) teachers were observed from each of the two selected target schools. One was from the group of teachers with 0-5 years of teaching while the other one was from the group of teachers with more than 5 years of teaching. This multi-case study involved beginning and experienced teachers for variation of ideas and opinions on PCK, decision making and inquiry approach implementation in order to obtain more meaningful conclusions.

Another framework for classifying the respondents of the study was also considered. This is based on the DepEd's Philippine Standards for Teachers (PPST) which classifies teachers into four (4) career stages – Career Stage 1 (Beginning Teachers), Career Stage 2 (Proficient Teachers), Career Stage 3 (Highly Proficient Teachers) and Career Stage 4 (Distinguished Teachers). Based on PPST, Teacher Ace and Teacher Des are Career Stage 1/ Beginning Teachers with the characteristics shown in Table 10.

Table 10. Career Stage 1/ Beginning Teachers Based on PPST

<i>Characteristics</i>	<i>Which Teachers?</i>
<ul style="list-style-type: none">• have gained the qualifications recognized for entry into the teaching profession.	Teacher Ace is a graduate of BS degree in Mathematics and Science Teaching (BSMST), major in Biology. Teacher Des is a graduate of BS degree in Secondary Education specializing on Biological Sciences.
<ul style="list-style-type: none">• have a strong understanding of the subjects/areas in which they are trained in terms of content knowledge and pedagogy.	Both have an expertise in Biology as it is their specialization/major.
<ul style="list-style-type: none">• seek advice from experienced colleagues to consolidate their teaching practice	Both make consultation with colleagues. Teacher Bes always seeks advice with colleagues.

On the other hand, Teacher Bes and Teacher Ces are Career Stage 2/ Proficient Teachers

(Experienced) with the following characteristics:

Table 11: Career Stage 2/ Proficient Teachers Based on PPST

<i>Characteristics</i>	<i>Which Teachers?</i>
<ul style="list-style-type: none">• professionally independent in the application of skills vital to the teaching and learning process	Teacher Ces has the ability to teach using authentic activities or teaching strategies. Teacher Bes manages to apply skills in teaching using technology (Smart TV).
<ul style="list-style-type: none">• reflective practitioners who continually consolidate the knowledge, skills and practices of Career Stage 1 teachers.	Teacher Ces as the Head practices this.

Data Collection Procedures

Data were collected through interviews, classroom observations, collection of artifacts and other relevant documents, and reflective journaling. Prior to data collection, a consent to conduct the study was sought from the Schools Division Superintendent, Department of

Education, participating schools, and teachers. A letter of consent was sent to the Department of Education's Schools Division Superintendent in Sta. Cruz, Laguna (Appendix A) requesting a permission to conduct the study in two public high schools in the province. Upon approval, the letter was presented to the Division Science Supervisor (Appendix B), and principals (Appendix C and Appendix D) of the target schools. The researcher sought the help of the science coordinator in identifying the teachers.

Prior consent of the selected teachers was likewise sought. The teachers were invited to participate in the research and when they agreed, the dates of the interview, classroom observations, and other data collection procedures were identified. All cases were handled with complete anonymity and confidentiality.

The data collected are described below:

1. Semi- Structured Interview/ Interview Guide

Teachers were interviewed separately. The interview was done prior to and after the classroom observation. In the first meeting/interview, data was collected on the teachers' PCK, decision making, and inquiry approach implementation. In the second meeting/interview, the information collected during the first meeting was validated. The time and place of the interview was arranged according to the convenience of the participants. The language used in the interview was also based on the participants' preference. The consent of the teachers to audio-record the interview was sought.

2. Non-Participant Classroom Observation

The non-participant classroom observation was done to observe how the teachers implemented the inquiry approach in teaching cell division and Mendelian genetics in the

classroom setting. The researcher did not, in any way participate, in the classroom activities or interact with either the students or teacher during content delivery. Observations were done for 10 days and class sessions were video-recorded. The researcher sought the teachers' consent before the video-recording of the classroom teaching. Since the teachers had the same teaching schedule (1:10-2:00 p.m. and 2:00-2:50 p.m.), the observations were done simultaneously in the two (2) schools. Two (2) groups of videographers and classroom observers were hired and trained to get as much data as possible. During the observation, the researcher and the other classroom observers also took down notes.

3. Collection of Artifacts and Documents

The teachers' lesson plans, copies of their tests, and models were requested from the participating teachers and these served as additional sources of data. The main sources of data were obtained from the interviews, classroom observations and instructional materials. These documents were photocopied with the consent of the teachers. Any information on the document that could lead to the identification of the participant was concealed or erased.

4. Reflective Journaling

Reflective journaling involved the writing down of the researcher's reflections, impressions, and feelings on the processes done in the study, in particular in the conduct of the study as a whole. The researcher maintained a journal where information and the various notes during the classroom observation were recorded. According to Morrow and Smith (2000), the use of a reflective journal adds rigor to qualitative inquiry, as the investigator is able to record reactions, assumptions, expectations, and biases about the research process.

Instruments and Data Collected

To facilitate data collection, the researcher developed the following instruments:

1.Semi- Structured Interview Guide

Two interview guides were developed depending on the time that they were implemented. One interview guide was developed for the interview scheduled prior to classroom observation while the other guide was for the interview scheduled after the classroom observation.

a. *Prior to Classroom Observation.* The interview guide before the classroom observation consisted of two parts. The first part involved the collection of information on teacher's perceptions. The questions were focused on collecting data on teachers' strategies in teaching cell division and Mendelian Genetics, planning the lesson, student characteristics to consider, forms and mode of assessments, etc.. On the other hand, the second part was composed of questions on the teacher's implementation of the inquiry approach. Specifically, it collected the following data:

- i. Teacher's idea/perception/views on the use of inquiry approach
- i.ii. Teacher's idea on the benefits or usefulness of inquiry approach
- ii.iii. Teachers' decision on the use of inquiry approach

b. *After the Classroom Observation.* The interview guide used after the classroom observation validated the observations before and during classroom observations. Follow-up questions were also prepared.

2. Classroom Observation

The general classroom observation guide (Appendix G) focused on the researcher's observations and impressions on the teacher's use of the inquiry approach in the classroom. It was a narrative of the teacher's actual teaching performance in her use of the inquiry approach. This narrative was also used in identifying the type of inquiry (as open/full inquiry, guided inquiry, structured/direct inquiry and learning cycle) as demonstrated by the teachers. To facilitate the classification, a guide made by Marin-Hansen (2002) and Colburn (2000) was used as reference.

3. Checklist of the Teacher's Artifacts and other Documents

All artifacts used by the teachers were collected (e.g. lesson plans, tests and the like). These were analyzed to check if the output demonstrates the use of the inquiry approach.

4. Summary of Reflective Journal Entries Form

The journal entries, as well as the checklist of general data and analysis procedures done during the semi-structured interviews and classroom observations were summarized in a matrix.

Data Analysis Procedure

The interview data were subjected to triangulation (with non-participant classroom observations and document/artifact analysis) and analyzed using Constant Comparative Analysis (Glaser & Strauss, 1967).

Constant Comparative Analysis was used to identify underlying themes in the data. The analysis was undertaken inductively, involving explicit coding and analytic procedures, resulting in the generation of a theory.

In using the Constant Comparative Analysis, certain conditions had to be in place. This analytic tool could not be arbitrarily used, but a specific set of conditions had to be met for the

tool to be deemed appropriate and meaningful. For the study, the following assumptions were made:

1. It can be applied in a small number of cases. The study involved four (4) cases. Given scarcity of time, energy and financial resources, this intensive analysis of a few cases may be more promising than the superficial analysis of many cases.
2. An interview with each of the four (4) teachers is one piece of data, which can be compared with all the other pieces of data for similarities and differences.
3. It analyzes data collected even in one round or single-round of interview. The study involved a single-round of interview.
4. The data to be analyzed critically to draw new meaning can be either from previous data or newly collected data. In the study, the interview served as the newly collected data.
5. Intensive analysis of the four (4) teachers in terms of characteristics, opinions, perceptions, behaviors through comparison predicts theory development.

Given these assumptions, the following procedures involving the Constant Comparative

Analysis were done.

1. Transcribing the interviews. After transcription, the researcher read through the entire set of data per teacher. The set of data per teacher was color-coded.
2. Chunking of each teachers' data. For each teacher, the researcher chunked the data into smaller meaningful parts.
3. Coding of each chunked data: The researcher labeled each chunk with a descriptive title or a "code" category using Atlasti, a software coding program.
4. Subcategorizing of the coded chunked data: The code category was divided into subcategories to represent the research questions. At this point, the researcher used

different colors (red for T. Ace, green for T. Bes, violet for T. Ces and blue for T. Des) corresponding to the subcategories to mark text in the interview transcripts, classroom observations and document analysis.

5. Comparing of data: The researcher compared the data of the second teachers (then, of the third and fourth cases) with the previous data so that similar chunks were labeled with the same code. The previous data was checked to see if there was an existing similar code.
6. Grouping of similar data: After all the data were coded, the codes were grouped by similarity and a theme was identified and documented.
7. Documenting the coded information: All coded information was documented.

The evaluation of the teachers' PCK was based on the DepEd's learning competencies for Cell division and Mendelian genetics in Grade 8 Science (Table 12) for the fourth quarter.

Table 12. DepEd's Specific Topics and Learning Competencies for Grade 8 Science

Topic	Learning Competencies
Organelle of the cell involved in cell division	Identifies organelles that are involved in cell division
Stages of mitosis	Describes and compares the processes of mitosis and meiosis and their role in the cell division cycle
Stages of meiosis	Compares the number of chromosomes of the daughter cells resulting from mitosis and meiosis
Mendelian genetics	Explains the significance of meiosis in maintaining the chromosome number Describes how the union of egg and sperm cells results in variation Identifies phenotypes as the expression of inherited characteristics

The researcher's daily impressions and reflections on the data collected, the methodology, and interactions with the case participants were written down in the reflective journal. The videos were viewed daily and were edited for at least 1 month to improve sound quality and remove unnecessary footage as needed.

The units of analysis were pedagogical content knowledge and decision making of the selected teachers, *i.e.*, Grade 8 teachers in two public schools where a case-by-case basis analysis was applied. Participatory interest of the teachers was sought and established through mutual understanding. The teachers were informed of the importance of their responses to the study, and as much openness, fairness and precision as possible were requested and appreciated. Teachers were informed that they could obtain a copy of the research results, should they so wish.

Data Validation

Two strategies were employed to validate the data, namely,

(a) Member checking. First, the *verbatim* transcripts of the interviews and the interpretations in the form of assertions and supporting quotes were provided to all the cases for member check. This allowed the researcher to be corrected by the participants. In this strategy, the teachers were asked to read their typed transcripts to determine if the researcher had “accurately described their experience”. Any discrepancy that a teacher reported to the researcher was noted and corrected in the final transcript.

(b) Peer Examination. Second, the findings were subjected to peer examination, in which the findings were given to a second reader for comments. Selected previously, the second reader verified the themes that emerged from the study. The reader has had previous experience in case studies and was familiar with the research methodology.

Chapter 4

RESULTS AND DISCUSSION

The Context of the Study

The Participating Schools

The two (2) participating schools, indicated in this study as School A and School B (to maintain confidentiality of their identities), are public high schools in Region IVA (CALABARZON). Both schools offer two (2) shifts, one in the morning and one in the afternoon. The morning session starts at 6:15 A.M. and ends at 12:30 P.M., while the afternoon session starts at 1:10 P.M and ends at 6:30 P.M. Both schools have two (2) pilot sections, which are under the Science, Technology and Engineering (STE) program while the rest of the sections are under the basic curriculum. The average class size in each school is 45. School A has nine (9) Grade 8 Science faculty members while School B has eight (8) Grade 8 Science faculty members.

Apart from the Department of Education Order s. 2014 on the writing of lesson plans or Instructional Plans (IP-weekly basis) following the format provided by DepEd, DepEd also released Department of Education Order No. 42, s. 2016 that aims to guide the teachers in preparing lessons through the Daily Lesson Log (DLL) or Detailed Lesson Plan (DLP). It is the choice of the teachers (in the NCR) to write either the Instructional Plan (IP) or the DLL/DLP (Dr. Isidro C. Aguilar, Chief, Curriculum Implementation Division, personal communication). All the teachers in the study opted to write their Instructional Plans which they always submit to their Science Head a week before the lesson proper. This Instructional Plan should contain the following components:

1. Learning objectives, which are specific objectives on knowledge, skills, and attitudes

2. Resources Needed, which pertain to the materials needed to achieve the learning objectives, e.g. reference materials, teacher's materials, learner's materials
3. Elements of the Plan, which include the activity, analysis, abstraction, and application of the lessons with specific teacher's action and learner's response
4. Assessment, which could be of any type that measures students' knowledge, process skills, understanding, and/or performance; and
5. Assignment, which could be either individual or group.

Although the participating schools need to use the materials provided by the Department of Education, there are some cases where teachers have to provide their own materials in teaching certain topics in Biology. Apart from the materials provided by DepEd, the teachers are likewise encouraged to use other resources to supplement the learning process (Dr. Isidro C. Aguilar, Chief, Curriculum Implementation Division, personal communication). For instance, in the cases investigated in the study, teachers have to look for learning materials for teaching Mendelian genetics, as well as cell division aside from the materials on cell division (Appendix M) provided by DepEd. The Department of Education Order No. 13, s. 2012 provides funds for the centrally-procured learning activity packages (LAPs), modules and other instructional materials (OIMs) to support the initial implementation of the K to 12 curriculum. This includes the release of the models and the Learner's Module (LM), the module for teaching science across all grade levels. The LM, which was designed following the inquiry approach, is the main textbook for Grade 8 Science (Appendix N). The material is composed of four (4) units. Each unit is composed of three (3) to six (6) modules with specific inquiry-based activity or activities per module. It is in Unit 4 (Living Things and Their Environment) where the Module on Cellular

Reproduction and Genetics is discussed. These topics are usually taught toward the end of the school year or during the fourth quarter.

All the teachers in these schools use the same module and each school has its own departmentalized examination in the form of a long test/summative test (Appendix O and Appendix P). The DepEd Chief said that the type of departmentalized examination depends on the discretion of the school principal, while the giving of short quizzes depends on the discretion of the teachers. Likewise, as imposed by the DepEd, the teachers have to use the LM for Grade 8 Science, however, the DepEd Chief pointed out that there is no prescribed list of teaching strategies that the teachers need to follow since differentiated strategies are always favored. As stipulated in DepEd Order No. 42, “recognizing the diversity of learners inside the classroom, DepEd allows the use of varied instructional and formative assessment strategies including the use of information and communications technologies (ICTs)” in teaching the basic concepts of science giving the teachers freedom to choose a specific teaching strategy so that quality instruction is carried out.

The Participating Teachers

From School A, the participants were named Teacher Ace and Teacher Bes, while from School B, the participants were named Teacher Ces and Teacher Des.

Teacher Ace

Teacher Ace is a female science teacher who has been teaching Science 8 for three (3) years. In school year 2015-2016, she handled four (4) sections of Science for Grade 8. Her official designation is Teacher I. In 2008, Teacher Ace graduated with a BS degree in Mathematics and Science Teaching (BSMST), major in Biology. She has already taught for three (3) years in another school. When she started teaching in 2013 in School A, she only attended

one seminar on K-12 curriculum preparation and approaches, in which she remembered one session focusing on the inquiry approach in teaching science. Teacher Ace, with a modulated voice, discusses cell division and Mendelian genetics using representations in the form of models, pictures, personal illustrations and visual aids in textual form. Moreover, Teacher Ace usually employs cooperative learning or small group discussion (sometimes coupled with technology) in her classes and uses a variety of activities such as project work and problem-solving activities about genetics. During the interviews, she was approachable and was always relaxed. When there were things that needed to be clarified by the researcher, she was always available and so easy to deal with. She was very accommodating as the researcher talked with her on her vacant periods.

Teacher Bes

Teacher Bes is a female science teacher who has been teaching Science 7 and 8 for 19 years. In school year 2015-2016, she handled four (4) sections of Science 8 and one section of Science 7. Her official designation is Teacher I. According to the Science Head, with her 19 years in the service and her designation, she is considered as one of the science mentors of the school. In 1994, she graduated with a BS degree in Agricultural Education, major in Animal Science. She taught for one year in another school. She has earned some units in MA Education, major in Educational Management. From 2010-2015, she attended trainings and seminars on science teaching enrichment such as a seminar on secondary education curriculum focusing on science teaching approaches and a series of seminars in preparation for the K-12 curriculum implementation with emphasis on the inquiry-based approach. She keeps on updating herself on the inquiry approach, as she recently attended a series of seminar-workshops on enhancing Biology teaching in Genetics, Physiology, Ecology and Biodiversity for Grades 7, 8 and 9 with

focus on experiments, modelling, and hands-on activities. This was sponsored by the Biology Teachers Association of the Philippines (BIOTA) Chapter in the region.

Teacher Bes uses representations in the form of pictures, models, and visual aids in textual form. In addition, Teacher Bes usually employs the lecture style method and cooperative learning or small group discussion in her classes. She also prepares problem-solving activities for the students. In most of her discussions, she uses the lecture style method coupled with the use of the Smart TV. Teacher Bes has a soft speaking voice. Her soft voice is heard as she greets the students and checks the attendance as well as the seat plan of the students. Teacher Bes is also patient in noisy environments. Where there are noisy and passive students, as well as those with unnecessary behaviors, she waits for complete silence before she proceeds with the discussion. Teacher Bes shows too much dependence on the textbook/LM as she always tells her students to refer to the LM for the discussion of some specific topics. She always wants to collaborate with her colleagues about specific topics in biology. She has to consult them because she admits that if she does not do so, she will be at a loss, because teaching biology is not her expertise. She admits that she is not a graduate of a BS Biology course and so she believes she lacks the content knowledge about the said topics. She always collaborates and consults with colleagues especially if an activity from the LM is difficult to conduct or perform. In most of her discussions, Teacher Bes prefers to stay in front so that she will easily see the students at the back. Teacher Bes was not always approachable, as many times, she was not available for the researcher's consultation with her.

Teacher Ces

Teacher Ces is a female science teacher who has been teaching Science 8 for 10 years. She taught for one year in another school. In school year 2015-2016, she handled five (5)

sections of Science for Grade 8. Her official designation is Master Teacher I. In 2002, she graduated with a BS degree in Secondary Education, major in General Science. She finished MA in Administration and Supervision in 2014. She has attended a number of trainings and seminars in preparation for the K-12 curriculum implementation in order to enrich science teaching. With focus on the inquiry-based approach, some seminars she attended included Teaching Strategies, Seminar on Innovative Way of Teaching Science, Seminar-Workshop series on Enhancing Biology Teaching on Genetics, Physiology, Ecology and Biodiversity for Grades 7, 8, 9 Teachers, The joy of Teaching: Teaching from the Heart, Teaching Strategy Seminar for High School Teachers 2014, Innovative Teaching –Learning in the 21st Century: Trends, Tools and Tips.

Teacher Ces is the head teacher of Grade 8 Science. She always teaches with a smile, enthusiasm and a loud voice. She makes it a point that with her loud voice, all the students are attentive during discussions. She is very enthusiastic as she enters the room and greets the students with a loud voice. Similarly, after checking on the cleanliness of the room and the attendance for the day, her voice is always loud for the students to hear her easily. For students' learning, Teacher Ces uses a variety of activities such as story-telling activity, role playing activity and problem-solving activities on genetics. She usually employs cooperative learning or small group discussion with video presentation. Just like Teacher Ace, Teacher Ces uses representations in the form of personal illustrations, pictures, models and visual aids in textual form. Just like Teacher Bes, Teacher Ces shows ways to avoid too much class noise. To pacify the noisy students, Teacher Ces plays a video or makes her voice a little louder. She has a loud voice, is approachable, jolly and very easy to deal with. The students like her very much because of her happy face. She is always ready to give time when somebody wants to talk with her. Not

only the students, but also her colleagues in the Science department like her so much as revealed in one of the informal conversations of the researcher with three (3) of her colleagues.

Teacher Des

Teacher Des is a female science teacher who has been handling Science 8 for almost three (3) years. She is Teacher 1 and handles four (4) sections of Grade 8 Science. She graduated with a BS degree in Secondary Education specializing on Biological Sciences. In her almost three (3) years in School B, she has attended seminars on science teaching involving the inquiry approach such as seminars on Teaching Strategies in Science, Encouraging Children's Discoveries, Developing Critical Thinking Skills through the Art of Questioning and Differentiated Instruction in a Differentiated Classroom.

Teacher Des has a very soft voice as she greets her students at the start of her class, checks the attendance and asks the students to fix the chairs. She always starts the discussion with a prayer which is led by the students. Just like Teachers Ace and Ces, she uses pictures, personal illustrations, models and visual aids in textual form as forms of representation. Meanwhile, Teacher Des usually employs cooperative learning or small group discussion coupled with video presentation. She also prepares problem-solving activities for the students. Teacher Des has a happy face when she stays in front during discussions. She was very approachable and was easy to deal with.

General Pattern of PCK Among Teacher Cases Who Use the Inquiry Approach in Teaching Cell Division and Mendelian Genetics

Table 13a shows the emergent themes of PCK from interviews while Table 13b shows the emergent themes of PCK from classroom observations based on the Constant Comparative Analysis of the four teachers. It is in these tables where the common themes were obtained for

the discussion on the general pattern of the teachers' PCK in teaching cell division and Mendelian Genetics.

Table 13a. Emergent PCK Themes from Interviews Based on the Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – Teacher Ace, Teacher B, Teacher C and Teacher D).

K main	Theme	Extracted Code	Description	Sample Response/Entry
Content knowledge	Clear discussion of basic concepts of cell division and Mendelian genetics	Clear practical application of the role of cell division and Mendelian genetics	Discussing clearly with emphasis the role of mitosis and meiosis as well as basic concepts of genetics	<p>Of course..... they learn to understand why cells need to divide; for mitosis, body cells, need to divide for growth, survival and replenish old tissues. Somehow when students understand the basic concepts of genetics, they will at least be able to explain why this particular trait (for example, presence of dimples) runs in the family</p> <p>For sure, they learn to understand that cells need to divide for survival, growth and development and repair. Learning genetics is understanding heredity, passing of traits from parent to offspring, and variation</p> <p>For mitosis, students learn to understand that it is growth and repair. ..The students will be able to explain how traits are inherited from the parents to offspring.</p> <p>For mitosis students will be able to explain why we grow. ... Students will understand inheritance of traits upon learning genetics</p>
		Complete understanding of cell division and Mendelian genetics	Discussing clearly the basic concepts of cell division and Mendelian genetics	<p>Students will understand that the union of sex cells explains why we humans are not alike. Meiosis maintains reduced chromosome number that's why sex cells are haploid.</p> <p>Somehow when students understand the basic concepts of genetics, they will at least be able to explain why this particular trait (for example, presence of dimples) runs in the family.</p> <p>Of course the students will become knowledgeable about the concepts of cell division and Mendelian genetics</p> <p>As long as there are the sperm and egg cells from the male and female which unite during meiosis, we humans will be on earth. And students know how to explain how this trait is inherited through learning genetics.</p>

Table 13a. Emergent PCK Themes from Interviews Based on the Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – **Teacher Ace, **Teacher B**, **Teacher C** and **Teacher D**).**

Domain	Theme	Extracted Code	Description	Sample Response/Entry	
Instructional Strategies	Use cooperative learning	Cooperative learning is the best strategy	Employing group discussion to convey knowledge among the students	<p>... I also do the discussion through a group work/exercise</p> <p>... I think a group activity/exercise seems to work best in a specific group of learners especially for analyzing stages of mitosis and meiosis, and problem-solving activities in genetics.</p> <p>... I give them a group work as practice exercise.</p> <p>... in group work as an effective method to teach cell division and Mendelian genetics. ... I have been using group work</p>	
	Start a lesson with motivational activities	Motivational activities for starting a lesson	Using motivational activities to introduce a topic	<p>"I start the discussion by giving the students a motivational activity (sharing of personal activities).</p> <p>I start the discussion on cell division with a story-telling activity about cell organelles</p> <p>I start discussing cell division by showing them a short video clip about the DNA for the students to see that the nucleus is where we find the DNA and it is involved in cell division</p>	
	Use models and multimedia materials	Teaching using modelling, representations, media (as individual/group activity)	Using a variety of representations in teaching	<p>Ok. I discuss cell division using models, pictures/cut-outs and videos</p> <p>When I discuss cell division, I discuss the stages (PMAT) using models which are available in the school.</p> <p>For example, for the group activity, after I discuss about the basic differences between mitosis and meiosis, I divide the class into 4 or 5 groups... I give them cartolina or Manila paper and pentel pen, and the members discuss among themselves the stages of mitosis and meiosis</p> <p>I use models in discussing cell division. I always use the models provided by the school. At this point, I will have to use visuals (pictures) to discuss it</p> <p>In the previous school, I already used models. But I supplement my discussion with video clips and the other materials I mentioned. You know biology is very abstract so we, science teachers need to use a lot of representations. I use models, pictures, illustrations, visual aids based on the LM, film video clips</p>	
	Use of a variety of activities	Additional school requirements to enhance learning	Asking students to submit a small poster on the actual cut-outs of the stages of mitosis and family picture as instructional strategies to enhance learning	The day before I start the lesson, I ask my students to bring family pictures. On the day of the discussion, using the pictures they brought, I will ask them, how similar are you to your father? Mother? Can you explain what makes your characteristics similar to your parents	<p>For example, in the small group discussion, I may use posters</p>
		Use of additional activities	Using various activities as instructional strategies	For an additional activity which is a check-up activity, I use pneumonics, a hand activity about the stages of mitosis. I definitely do problem-solving activities on genetics either by group or as an individual activity	<p>Sometimes, I ask my students to do role playing on Gregor Mendel for appreciation of Mendel's work</p>
		Acquisition of additional reading materials	Giving the students a printed copy of a STORY about cell organelles as an instructional strategy to facilitate learning	Let me recall. I start the discussion on cell division with a story-telling activity about cell organelles.	

Table 13a. Emergent PCK Themes from Interviews Based on the Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – **Teacher Ace, **Teacher B**, **Teacher C** and **Teacher D**).**

main	Theme	Extracted Code	Description	Sample Response/Entry
nding nce	Develop or stimulate students' critical thinking by asking questions	Asking questions develop critical thinking	Students' understanding of science involves development of their critical thinking as they ask questions during the discussion	How? I encourage them to ask questions and do critical thinking I tell them to always ask questions I encourage them to ask questions based on their observations. I am a stimulator
		Asking questions stimulate student thinking		
		Use of media for student thinking	Students' understanding of science involves development of critical thinking as media is used	I use media (film clip, video,TV) to stimulate student thinking, you could see the eagerness of the students. I always use Smart TV because I observe using colored visuals, students are motivated to think. I use a lot of video clips, film clips and sometimes movies, I know the students are always excited to watch a film or a video. and they are stimulated to think
		Use of media, models, representations for student thinking	Students' understanding of science involves development of critical thinking as media, models and forms of representations are used	I always make use of pictures or cut-outs of pictures, personal drawing or illustration, from the textbook I summarize the content in a visual aid, I always use models. I use the internet to download film or videoclips and even movies, they get to understand better and appreciate the concepts I discuss cell division using models, pictures/cutouts and videos
	Use of multi-assessment tools	Knowing that students learn through a test or activities	Students' understanding of science involves student learning as the teacher uses a test or activity	It's simple... Through the test and activities done. If the scores are okay, I know they understand the lesson. Compared with the old curriculum where exercises are given before and after the lesson, in today's curriculum, it is performance-based so I know they understand if they can perform an experiment or they can solve problems during a test.
		Knowing that students learn through their reaction and activity	Students' understanding of science involves student learning as the teacher uses a test or activity	Let me see... first, it is based on the reaction of the students. Through an activity, I know they understand the lesson if their output is ok.
		Knowing that the students learn by active participation and through an activity	Students' understanding of science involves student learning through participation and activity	Through an assessment. if the activity is interactive they participate and while I talk they listen, I know they understand the lesson.
		Learning through experiment and problem-solving	Students' understanding of science involves student learning through an experiment	I am sure students learn to experiment on plant and animal cells. Students learn to solve problems in Mendelian genetics using the Punnett square.

Table 13a. Emergent PCK Themes from Interviews Based on the Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – **Teacher Ace, **Teacher B**, **Teacher C** and **Teacher D**).**

Domain	Theme	Extracted Code	Description	Sample Response/Entry	
Understanding science	Use of multi-assessment tools	Learning through knowledge on cell division and problem-solving	Students' learning measured through knowledge of basic concepts, representations and problem-solving	Students learn about cell division stages and solving problems in Mendelian genetics	
		Learning through representations and problem-solving	Students' understanding of science involves student learning through forms of representations and problem-solving	Students learn about cell division diagrams, at least for mitosis which is basic, any kind of related diagrams, illustrations or drawing on cell division Students learn about cell division representations like drawings or pictures. For Mendelian genetics, students learn to solve word problems	
		Assignments and more activities for slow learners	Students' learning measured through assignments and additional activities especially for slow learners	I also give assignments and a lot of activities For the remedial class, it is a different make-up. I check assignments and a lot of activities. I also give assignments, minimal quiz and many activities	
		Objective test and an activity	Students' understanding of science involves student learning as the teacher validates through exams and activities	When I give a test, it is a combination of simple recall and application. I give a test which is a combination of objective and practical questions I give them a test of recall and analysis. The test that I give is always a combination of objective and problem solving questions	
	Teach to develop conceptual understanding, critical or analytical thinking skills, and problem-solving skills	Use models and multimedia materials	Students' understanding of science involves student's development of conceptual understanding and critical thinking and other skills as teachers use models and multimedia materials	Students' understanding of science involves student's development of conceptual understanding and critical thinking and other skills as teachers use models and multimedia materials	Learning about cell division and Mendelian genetics will make students understand the concept of cytokinesis, crossing over, homologous chromosomes, Law of independent segregation, Law of independent assortment and all the other concepts (dominant/recessive trait, phenotype/genotype etc). I think students will have a very clear understanding of the concepts of cell division and Mendelian genetics. Of course the students will become knowledgeable about the concepts of cell division and Mendelian genetics. Learning about cell division and Mendelian genetics makes the students understand basic concepts of mitosis and meiosis (chromatid, cleavage furrow, cell plate, homologous chromosomes, synapsis, Law of Dominance, Law of Independent Segregation, Law of Independent Assortment, etc)
					Learning for development of skills
	Correct/Prevent misconceptions	Misconception prevented through a textbook or activity	Students' understanding of science involves correction/prevention of misconceptions	Students' understanding of science involves correction/prevention of misconceptions	Yes, I always make a summary of concepts based on the textbook everytime I make a discussion. I also prevent misconception through n activity. Sometimes I check the textbook for the summary of concept. Sometimes I forget. I also do an activity After the experiment, we use the textbook to determine the correct concepts involved in the activity. So I both do an activity and the textbook to prevent misconceptions. As new concepts are introduced, I make it a point to summarize based on the textbook and available resources

Table 13a. Emergent PCK Themes from Interviews Based on the Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – **Teacher A, **Teacher B**, **Teacher C** and **Teacher D**).**

Key Main	Theme	Extracted Code	Description	Sample Response/Entry
Assessment	Give extra work or remedial class to slow learners	Extra work for slow learners	Assessment involves teacher's giving of an extra work for slow learners	I know they understand the lesson if their output is ok. For those whose scores are low, I tell them that I will give an extra work.
		Patience to wait for output of slow learners	Assessment involves teacher's patience	Of course, I have to wait for the output of the slow learners
		Remedial class/Reteaching for slow learners	Assessment involves teacher's giving of a remedial class or reteaching for slow learners	For the remedial class, it is a different make-up, I give the students extra activities since we do not have a common schedule. For the slow learners, to make sure they understand before moving to another topic, I have to reteach the concepts. I also do remedial classes for the slow learners I also give assignments, minimal quiz and many activities

Table 13b. Emergent PCK Themes from Classroom Observations based on Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – **Teacher A, **Teacher B**, **Teacher C** and **Teacher D**).**

Key Main	Theme	Extracted Code	Description	Sample Response/Entry
Content edge	Clear discussion of basic concepts of cell division and Mendelian genetics	Instruction/Institution of content	Discussing clearly chromatid, centromere, euchromatin, heterochromatin, role of DNA, human sex chromosomes, prophase, homologous chromosomes, chromosome, etc.	Chromatid is one of the paired strands of the duplicated chromosome The chromosome is very important in cell division which is found in the nucleus of the cell
		Emphasis on more important topics	Discussing clearly with emphasis the role of mitosis and meiosis as well as basic concepts of genetics	Can anybody tell me the role of mitosis and meiosis?
		Emphasis on more important topics	Discussing clearly with emphasis the role of mitosis and meiosis as well as basic concepts of genetics	Can anybody tell me the role of mitosis and meiosis?
		Inheritance of traits due to genetics	Discussing clearly the concept behind inheritance of traits	We got the good traits from our parents
		Explanation of jargons Mitosis is for the increase in size and repair	Discussing clearly the basic genetics terms Discussing clearly the role of mitosis	Applying the genetics terms in an activity Mitosis is for growth and development Mitosis is for growth and repair.
		Synthesis of the lesson was given	Discussing clearly the differences between mitosis and meiosis as well as the cell organelles and functions of each organelle	After summarizing, she said "Goodbye class" She ended the discussion by summarizing the cell organelles and functions of each organelle using a Venn diagram

Table 13b. Emergent PCK Themes from Classroom Observations based on Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – Teacher A, Teacher B, Teacher C and Teacher D).

Main	Theme	Extracted Code	Description	Sample Response/Entry
Instructional strategies	Use cooperative learning	Cooperative learning is the best strategy	Employing group discussion to convey knowledge among the students	All did group work/exercise/discussion
	Start a lesson with motivational activities	Motivational activities for starting a lesson	Using a motivational activity to introduce a topic	<p>Started with a motivational activity (personal experience)</p> <p>Did not use a motivational activity, instead, lecture</p> <p>Started with a motivational activity (story-telling, role-playing)</p> <p>Started with a motivational activity (video, personal experience)</p>
		Motivational activity through review of previous lessons	Start the lesson by reviewing the previous/past lesson as a motivational activity	<p>She had a review about the previous lesson. She used the Smart TV for the review on the stages of mitosis.</p> <p>She had to make a review of the past lesson (story-telling activity) as she asked "What do you think is the function of the nucleus?"</p> <p>Review: The chromosome is of two types - XY for males and XX for females"</p>
		Motivational activity through visual materials	Start the lesson by using visual aids and video presentation as a motivational activity	<p>All used visual aids</p> <p>Teacher Ces played a video on mitosis</p> <p>Teacher Des used a video about DNA</p>
		Motivational activity through an activity	Start the lesson by asking for an ice-breaker or bringing a family tree as a motivational activity	<p>Everybody was happy and got energized after the presentation</p> <p>Which of your traits are similar to your father? Mother?"</p>
	Use models and multimedia materials	Utilization of visual materials/models for better teaching	Using illustrations/pictures, visual aids in textual form, video presentation as well as models for better teaching of cell division and Mendelian genetics	<p>All used models and forms of representations.</p> <p>The cell cycle (picture) is composed of G1, S, G2 and Mitosis.</p> <p>She then asked everybody to look at the Smart TV with picture</p> <p>Students match each picture with the specific stage</p> <p>Pointing to the model, she discussed the stages of mitosis as follows</p>

Table 13b. Emergent PCK Themes from Classroom Observations based on Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – Teacher A, Teacher B, Teacher C and Teacher D).

Main	Theme	Extracted Code	Description	Sample Response/Entry
Instructional strategies	Use of a variety of activities	Use of additional activities	Using various activities as instructional strategies	<p>I will teach you a hand activity on the stages of mitosis</p> <p>The teacher taught them the hand activity about the stages of mitosis.</p> <p>The teacher told them to stand and do the hand activity</p> <p>The teacher had to check on how the students were solving so she had to go from one student to another</p> <p>Now, I would like to introduce to you, our guest for today, Gregor Mendel (role playing)</p> <p>“to do the exercise for 10 minutes only” (Bikini Bottom genetics)</p>
		Additional school requirements to enhance learning	Asking students to submit a small poster on the actual cut-outs of the stages of mitosis and family picture as instructional strategies to enhance learning	<p>The project is a small poster on the actual cut-outs of the stages of mitosis which should be taken from previous studies</p> <p>Please bring a family picture</p>
		More students are willing to participate in activities	Asking of student-volunteers to answer in the activity as an instructional strategy to validate learning	<p>Do you follow what we are doing?</p> <p>Did you understand how to determine the phenotype? (asking volunteers to answer orally)</p>
		Utilization of hand-on activities	Giving students hands- on exercise as an instructional strategy to facilitate learning	<p>Posting of the exercise on the board</p> <p>Let us discuss the answers now</p>
		Acquisition of additional reading materials	Giving the students a printed copy of a STORY about cell organelles as an instructional strategy to facilitate learning	For you to reflect on how to answer question numbers 3 and 4, we will do an activity
		Use of trivia to encourage students to listen	Explaining the biological significance of cell division using a trivia as an instructional strategy to motivate learning	<p>If our body cells will not divide, it means we are not living anymore so we take care of our body. As our body cells divide, it means we are growing.”</p>
		Preliminary activities are more helpful before discussion	Using preliminary activity in the form of drills as an instructional strategy to facilitate learning	<p>Can anybody answer orally what is written on the board? (about identifying whether the given pairs is/are homozygous or heterozygous)</p>
		Additional meetings for slow learners	Using an additional meeting as an instructional strategy to facilitate learning of slow learners	<p>Look at the picture and identify each stage one by one, first, second, third... (After knowing that in previous quiz that most students got 1/5, the teacher had to review using metacards)</p>

Table 13b. Emergent PCK Themes from Classroom Observations based on Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – Teacher A, Teacher B, Teacher C and Teacher D).

Domain	Theme	Extracted Code	Description	Sample Response/Entry
Understanding science	Develop or stimulate students' critical thinking by asking questions	Critical thinking during discussion	Students' understanding of science involves development of their critical thinking as they ask questions during the discussion	<p>Among the cell parts that you know, which do you think is involved in mitosis?</p> <p>Can you describe the centromere? sister chromatids? heterochromatin? euchromatin?"</p> <p>How do the cells start dividing?</p> <p>I will give you 10 minutes to discuss among yourselves, then we will discuss later (Dividing the class into groups to discuss questions about stages of mitosis</p>
		Students learn through critical thinking	Students' understanding of science involves learning through critical thinking	Listen class, you will also express the dominant trait even if there is the recessive trait which is always hidden or not expressed
		Use of media, models, forms of representations to develop critical thinking	Students' understanding of science involves development of critical thinking as media, models and forms of representations are used	<p>Look for the picture of a chromosome as she asked, can anybody describe a chromosome?; What do you think is the importance of the chromosome? Used models of mitosis and meiosis, used visual aids in textual form, made personal illustration</p> <p>She made a recall first by showing a picture of the chromosome in the Smart TV and asked can you describe the centromere; used models of mitosis and meiosis; used visual aids in textual form</p> <p>Showed a picture of the chromosome as illustrated in the LM; As she was moving sideways in front, she asked, "how do the cells start dividing"? showed the picture of the cell cycle; used the model; visual aids in textual form, personal illustration</p> <p>discussed about the chromosomes by showing its picture, used models, visual aids in textual form, personal illustration</p>
	Use of multi-assessment tools	Validation from students' reactions	Students' understanding of science involves student learning as the teacher validates through students' reactions	<p>Yes as answered by the students</p> <p>Yes as answered by the students</p> <p>Yes as answered by the students</p> <p>Yes as answered by the students</p>
		Validation through exams and activities	Students' understanding of science involves student learning as the teacher validates through exams and activities	<p>She also reminded them about the first Summative/Long Test the next meeting</p> <p>She also announced the Summative Test the following meeting as she said "Goodbye class, this is all for today." "Always study the LM."</p> <p>The first Long Test will be on the 6th meeting while the second Long Test will be on the 10th meeting.</p> <p>On our sixth meeting, we will have our first long test and on our 10th meeting will be our second long test</p>

Table 13b. Emergent PCK Themes from Classroom Observations based on Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – Teacher A, Teacher B, Teacher C and Teacher D).

main	Theme	Extracted Code	Description	Sample Response/Entry
nding nce	Correct/Prevent misconceptions	Patience for teaching slow learners to prevent misconception	Students' understanding of science involves correction/prevention of misconceptions	Study more (After making a roll call and finding out that 5 students failed in the quiz) She spent so much time in explaining the procedure of the activity so she announced that "this activity will be an assignment". She still asked the students, "can you do it at home?, any questions?" (Spending much time in explaining the procedure of the activity)
		Misconception prevented through a textbook or activity	Students' understanding of science involves correction/prevention of misconceptions	one student mistakenly answered that the "chromosome is for the transfer of traits," confirmed the correction corrected to the class that "it is the ribosome not the nucleus that functions for protein synthesis" Using the textbook under the teacher's table, the teacher confirmed that "the sex cells are for meiosis while body cells are for mitosis" after summarizing the correct concepts on the reasons why garden peas were used by Mendel in his experiment, she elaborated it by giving the students an activity
	Students are assisted in answering	Students are assisted in answering	Students' understanding of science involves assistance to students when doing/answering an exercise/activity	While the students were answering, the teacher went from one student to another to assist. Teacher Ces went from one group to another to check on what the students were doing. As the groups were answering, she went back and forth to check on what the students were doing
		Commending students who participated in the discussion	Students' understanding of science involves student learning as the teacher commends them for active participation during the discussion	After the presentation, Teacher Ace said, "very good, all of you have an idea about the stages of mitosis, let us give everybody a round of applause" One student shared that based on the picture, "it is G1." The teacher said, "yes very good" One student raised her hand and said, "in prophase, the cell membrane is still intact." Then the teacher said, "very good" One student raised his hand and confidently said, "it is in the nucleus." The teacher acknowledged his answer by saying "Very Good!"
ent	Give extra work or remedial class to slow learners	Encouragement to study harder for slow learners	Assessment involves teacher's giving of an extra work for slow learners	After making a roll call and finding out that 5 students failed in the quiz; For those who failed, Teacher Ace told them, "to study more" When she checked on the scores, half of the class passed while the rest failed. Nevertheless, she reminded those who failed to catch up by reading the module and the notes. (Encouraging students who failed in the quiz)
		Remedial class/Reteaching for slow learners	Assessment involves teacher's giving of a remedial class or reteaching for slow learners	Teacher Ace's remedial class – Dropping the genes Teacher Bes' remedial class- Human Heredity She further said, "anyway for those who still do not understand, attend the remedial class on Friday, 11:30-12:30." (Modelling Meiosis) Teacher Des' remedial class – Modelling Meiosis

The general PCK pattern of the teachers is reported in Figure 7. For the three (3) teachers (Ace, Ces and Des), the observed pattern was that before the lesson, they usually start with a motivational activity (Knowledge of Instructional Strategy). Although Teacher Bes does not use a motivational activity before the lesson, she, instead, uses a different approach (lecture style method) to discuss background information. The teachers proceed to the lesson (during the lesson) where they teach content (Knowledge of Content /KC), which is supported by both or either by the use of models and multimedia materials, cooperative learning or a variety of activities (Knowledge of Instructional Strategies/KIS). Teaching of content also facilitates student learning (Knowledge of Students' Understanding of Science/KSUS). After the lesson, all the teachers assess student learning (Knowledge of Assessment) as they give extra work or remedial class to slow learners.

There is interconnectedness between KC and KIS, KC and KSUS and KIS and KSUS, which means that they are integrated. The numbers illustrate the frequency with which the PCK components were used and integrated during the 10-day observation period. One similarity among the four case teachers is that none of them depended solely on a single PCK component during their teaching, and were likely to use two. Of all the combinations, the highest frequency of integration was for the two components, "knowledge of instructional strategies" and "knowledge of students' understanding of science", which occurred 16, 10, 13 and 21 times for Teachers A, B, C and D respectively. While previous studies have focused on one specific PCK component in guiding teaching practice (Wu & Badger, 2009), this study illustrates the integration of some of the PCK components and reveals the dynamic and complex nature of their functions in this inquiry-based teaching context.

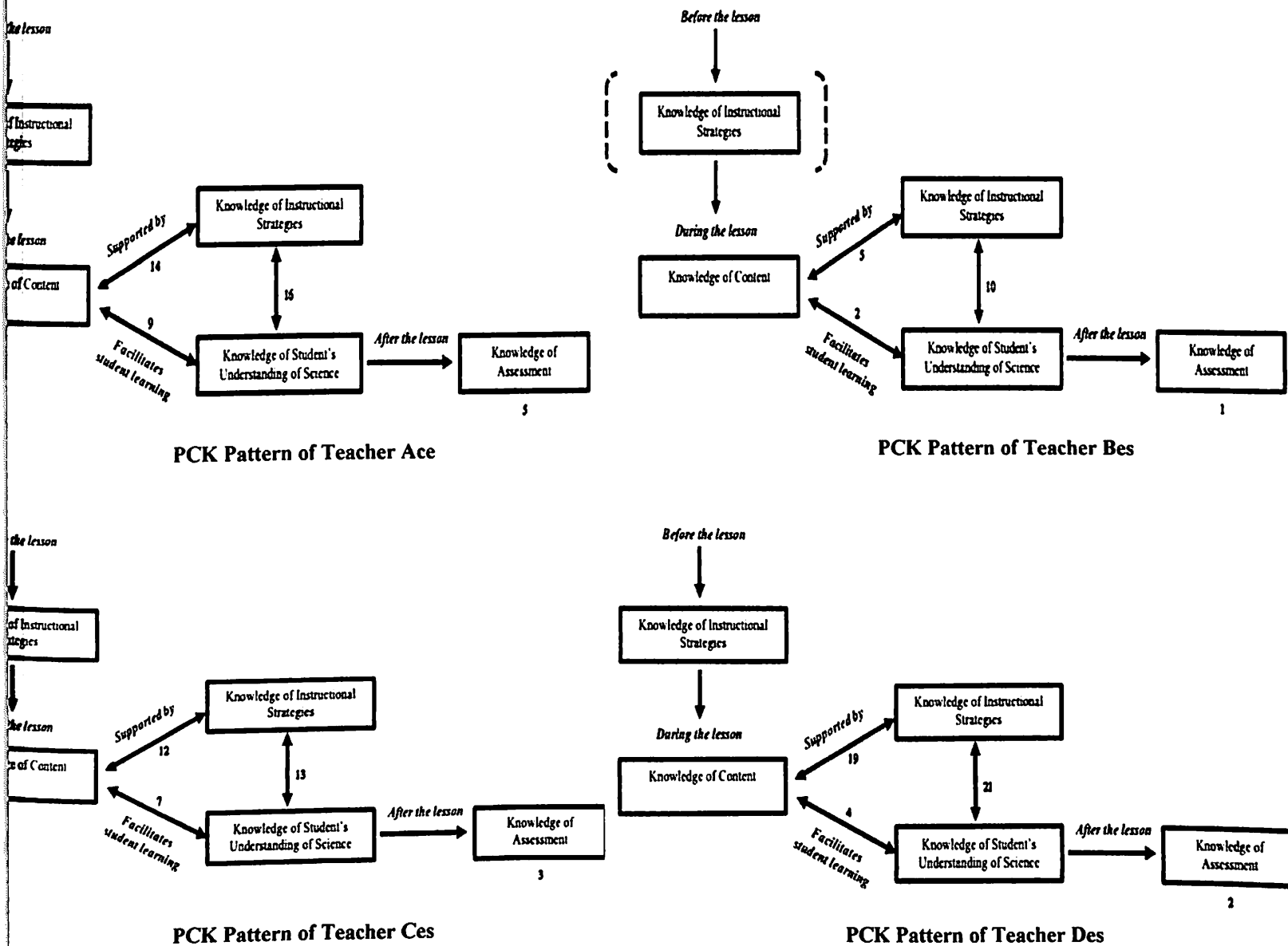


Figure 7. General PCK Pattern of the Four Teachers (T. Ace, Ces and Des start the lesson with a motivational activity while T. Bes (with broken lines) starts with a different approach)

On the other hand, the lowest frequency of integration was for the two components, “knowledge of content” and “knowledge of students’ understanding of science”, which occurred 9, 2, 7 and 4 times only for teachers A, B, C and D respectively. It seems that it is not enough to teach the students the content to develop students’ understanding; what is more important is the teacher’s appropriate instructional strategies in teaching. According to Persaud (2018), instructional strategies serve as backbone for teaching, and, when applied correctly, can help students gain

deeper understanding and can encourage critical thinking beyond basic retention and surface understanding. Knowledge of Assessment did not play an active role in classroom teaching, and showed no integration with other PCK components.

The themes involved in the PCK pattern of the teachers were the following:

a. Before the Lesson

Start a lesson with motivational activities

Teachers Ace, Ces and Des reported that before the lesson, they start with motivational activities that serve as the starting point in the discussion of specific topics. The teachers' use of motivational activities has been reflected in their interviews, to wit:

I start the discussion by giving the students a motivational activity (sharing of personal activities). Before I discuss, I ask them, "After taking your breakfast, what do you do as you prepare to go to the school"? Most of the students will answer, "I take a bath". And then I will ask them to think critically why taking a bath is important. The students will give a variety of answers. Then I tell them that taking a bath is a way of removing dead cells/dirt from our body. From this motivation, I introduce cell division but I start with the cell cycle. [Teacher Ace]

Also as a motivation and it is here where I will mention about cell division. I will ask them, "How did you grow? Is your height today the same as before? What about when you take a bath? What is it that you take off from your body when you use a scrubbing pad?" Most of them will laugh. Then during the discussion proper, I will ask volunteers to show their pictures in front. Then I will ask, "What physical features did you get from your mother/father?" Then I will also ask, "What about features which are not physical, but you got from your mother/father?" They answer actively. And from these questions, I will arrive at the principle of Genetics.. The day before the discussion of this topic, I will give them an assignment, "bring picture of your parents. I assume that their answers will lead to the science of Genetics, and it is here when I start the lesson. [Teacher Ces]

The day before I start the lesson, I ask my students to bring family pictures. On the day of the discussion, using the pictures they brought, I ask them, "How similar are you to your father? Mother? Can you explain what makes your characteristics similar to your parents?" [Teacher Des]

As indicated in their responses, the teachers reported that they start the discussion on cell division and Mendelian genetics using practical examples. For instance, Teacher Ace reported

that, *“I start the discussion by giving the students a motivational activity (sharing of personal activities) while Teacher Ces (also referring to the taking a bath sharing) similarly said, “Also as a motivation... and it is here where I will mention about cell division.”* Meanwhile, Teachers Ces and Des reported a similar motivational activity in introducing genetics, where the activity involves all the students to *“bring picture of your parents/family picture.”* The teachers believe that in doing this motivational activity, the students will increase their engagement because there will be an active classroom atmosphere. This is consistent with what Alstad (2019) had reported that incorporating a real-life connection into lessons will dramatically reduce classroom management challenges because engagement will increase.

Interestingly, Teacher Ces seemed to be very innovative, as she shared other motivational activities such as the story-telling activity and role playing activity. The teacher claimed that, *“it is in my list which for the past years I have been keeping so that if needed and time permits, I have it ready to implement.”* Being knowledgeable on the story-telling activity and role playing, the teacher narrated:

Let me recall. I start the discussion on cell division with a story-telling activity about cell organelles. It is an activity about the functions of the parts of the cell as if the organelles are quarrelling because while some parts are busy with their work, a few do not work at all. This is how I start the activity. I divide the class into five groups, give them a printed copy of the “cell functions” story and a list of guide questions. It is a group activity wherein the members do a discussion on cell functions. I follow a general rubric for evaluating the group’s work. After about 15 minutes, I ask a group representative to report their work. Then I summarize and discuss about the most important cell part in cell division. I tell them it is the nucleus which contains the chromosomes. I tell them that the nucleus is not always found at the center. I emphasize that it is the nucleus that is involved in cell division. It is here where I start the discussion about cell division.

Sometimes, I ask my students to do role playing on Gregor Mendel for appreciation of Mendel’s work. It is funny because one student becomes Mendel for one day only. Sorry my answer is too long. Is it ok?

It is in my list which for the past years I have been keeping so that if needed and time permits, I have it ready to implement. I want the students practice critical thinking skills, especially good decision-making skills here but of, course, it is for transferring knowledge

and information at it is my springboard for discussing cell division. For the role playing, I can arouse the interest of the students and we enjoy this a lot; it's a good learning experience.

As indicated in her responses, the story-telling activity is “*a group activity wherein the members do a discussion on cell functions.*” Teacher Ces wanted to have this activity done in the class for reflective discussion because “*I want the students to practice critical thinking skills, especially good decision-making skills here but of, course, it is for transferring knowledge and information at it is my springboard for discussing cell division.*” This is consistent with what McKillop (2005) had reported, that storytelling enables the students to make their own decisions, which can be used as an effective tool for reflective discussion that calls for use of important critical thinking skills. Cerdan (2017) supports that motivational activities allow students to be competent and promote skills like explaining, synthesizing, and making connections to other materials. The teacher describes the activity as a group discussion with guide questions, after which, a group representative reports. She added that she makes a summary focusing on the nucleus, as it is involved in cell division. For the role playing activity, Teacher Ces wanted to implement this so that “*I can arouse the interest of the students and we enjoy this a lot; it's a good learning experience*”. This is supported by Simpson (2017), who considered that role-play is an effective technique to animate the teaching and learning atmosphere and arouse the interests of learners. The author also said that role play is really a worthwhile learning experience for both the students and the teacher. In addition, Omrod (2008) said that a motivation (such as a role play) is something that energizes, directs, and sustains behavior; it gets students moving, points them in a particular direction, and keeps them going.

Teachers Ace's and Des' motivational activities were consistently observed as their actual teaching activity. However, in the case of Teacher Ces, only the story-telling and role playing activities, as well as another short role-playing activity were implemented. Teacher Ces

prepared this short role-playing activity to visualize what happens in a cross of traits involving family members, who made use of colored visors (pre-made by T. Ces) placed on their head to show what will happen in a given cross. The activity clarified how the genotypes and phenotypes are obtained, as explained by Teacher Ace. Regarding the story-telling activity, Teacher Ces explained that the students paid attention to the story, as they made their decision when they answered the guide questions. According to Barker and Gower (2010), storytelling does not just allow the students to pay more attention but it also gives them the ability to make a better informed decision. NetlKX (2016) added that “stories are used to transfer knowledge and information, help make decisions about how to act, make decisions about what to believe in and make sense of complex situations for better decision making.” In addition, as a motivational activity to start the next lesson in the next meeting, Teacher Ces had to make a review of the past lesson (story-telling activity) as she asked “*What do you think is the function of the nucleus?*” Further, as a motivational activity before the introduction of the next lesson, Teacher Ces asked for an ice-breaker (a presentation about “Sponge Bob” from Group 2), where everybody got energized. Similarly, Teacher Des had a review of the past lesson as she emphasized that “*the chromosome is of two types - XY for males and XX for females.*” In addition, as a motivational activity, Teacher Des used a visual material in the form of a short video clip about the DNA. Specifically, Teacher Des reported that she blended her discussion of DNA with a video as she narrated:

Yes. I start discussing cell division by showing them a short video clip about the DNA for the students to see that the nucleus is where we find the DNA and it is involved in cell division. It is also through the video clip that I review about other important cell organelles.

Further, as indicated in Teacher Des’ responses, she is so fond of using video animations as “*I start discussing cell division by showing them a short video clip about the DNA for the*

students to see that the nucleus is where we find the DNA and it is involved in cell division.” The teacher explained that her use of video is not only to facilitate her discussion of content but also to arouse students’ interest to learn. This is consistent with what Kosterelioglu (2016) had reported - the use of videos in the classroom environment will have potential effects such as: arousing student interest, facilitating student concentration, developing imagination, supporting creativity and increasing comprehension. Mayer (2001) had also indicated that videos used in learning environments contribute to increase student interest and motivation. Moreover, the teacher pointed out that video effects help her interact with the students, as well as motivate her to recall and transfer knowledge to the students because *“It is also through the video clip that I review about other important cell organelles.”* According to Greenberg and Zanetis (2012), videos have also educational effects such as providing interaction with the content, allowing transfer of knowledge in the mind and facilitating recall.

The teachers’ use of motivational activities was patterned from the Experiential Learning Cycle, which is a method of educating through first-hand experience in which skills, knowledge, and experience are acquired outside of the traditional academic classroom setting (Firestone, 2017). The concept of experiential learning was first explored by John Dewey and Jean Piaget, among others. It was made popular by education theorist David A. Kolb, (1984) who, along with Ron Fry, developed the theory, which is based on the idea that learning is a process whereby knowledge is created through transformation of experience. The sharing/reflective observation stage (S) involves the students’ sharing of the experience or reflecting on the activity (taking a bath, story-telling, bringing a family picture, video clip on DNA); the processing stage (P) involves the teacher’s discussion about the activity or experience (significance of taking a bath, cell parts working together, inheritance of traits, DNA as the genetic material); the

conceptualizing stage (C) involves the formation of new skills or knowledge based on the experience or activity (realization that taking a bath is related to cell division, cell parts must do their functions well, traits are inherited from parents, DNA is involved in cell division); and, the applying stage (A), in which the new learning (skills or knowledge) is implemented (observation of cell division in an experiment, applying inheritance through problem-solving exercises). An experience is a direct observation or a particular activity as a basis of knowledge.

On the other hand, Teacher Bes reported that she starts a lesson with the lecture style method as she emphasized:

Ok. I start the discussion on cell division by giving a lecture on the chromosome. I tell them about the parts and function of each part. Then I discuss now cell division. Ahh... I start discussing Mendelian genetics through Mendel's experiment.

Teacher Bes seemed to be very comfortable with lecture style method as “*I start the discussion on cell division by giving a lecture on the chromosome.*” Thinking that the lecture method is a good teaching strategy, the teacher claimed that in most of her discussions, she uses the lecture method more often than other teaching strategies, which is consistent with what was observed in her actual teaching. According to the teacher, the lecture method is easier to employ and this is supported by Kaur (2011) who had indicated that the use of the lecture style method as a popular teaching method is easier to learn than most other instructional strategies. The teacher also shared that when the lecture method is used in her discussion, she believed that she is able to impart important knowledge as, “*I tell them about the parts and function of each part (of the chromosome).*” Realizing that the lecture method is an effective method, Teacher Bes used this when “*I discuss cell division*” and “*I start discussing Mendelian genetics through Mendel's experiment.*” For instance, when she had an actual lecture on cell organelles, she was able to impart the knowledge on the DNA as the genetic material. According to Ibrahim et al.

(2018), the lecture method, although teacher-centered, can be used in constructing a teacher's PCK since the lecture method imparts information and knowledge. While it might be argued that such method creates a passive environment, it is employed to maximize the time and explain the points that are too technical for the students to understand on their own. In addition, as a motivational activity during her actual teaching, before starting a new lesson, Teacher Bes had to review the previous lesson (mitosis stages) using the Smart TV and a visual aid.

b. During the Lesson

During the lesson, the teachers taught the content (Knowledge of Content) using models and multimedia materials, cooperative learning and a variety of activities (Knowledge of Instructional Strategies). A combination of strategies were used (i.e. cooperative learning and model; model and video, an activity and video, etc.) As the teachers used these strategies, they were able to discuss clearly the basic concepts of cell division and Mendelian genetics (Knowledge of Content). The teachers' discussion of content also indicated students' understanding of basic concepts (Knowledge of Students' Understanding of Science).

Use of models and multimedia materials

Models. The teachers used models in the teaching of cell division and Mendelian genetics. This means teaching content using modelling. The teachers' use of models has been reflected in their interviews, to wit:

[Teacher Ace]: *I always use models which are available in the school. The models are very useful because I can ask a variety of questions, from simple to complex questions so that they will be able to think critically.*

[Teacher Bes]: *... use models (provided by school) ...*

[Teacher Ces]: *I use models in discussing cell division. I always use the models provided by the school.*

[Teacher Des]: *In the previous school, I already used models. I show them ... models.*

As indicated in their responses, all the teachers use models of mitosis and meiosis provided by DepEd. Teacher Ace expressed the usefulness of models as she said, “*I always use models which are available in the school. The models are very useful because I can ask a variety of questions, from simple to complex questions so that they will be able to think critically.*” This is consistent with the finding of Baranowska-Piasek (2002). According to the author, models are a useful resource for teaching that enable the development of a wide range of thinking skills (i.e. describing skill, enumerating skill, analyzing skill, critical thinking skill, reflective thinking skill and creative thinking skill) because teachers are motivated to ask questions about what the students think on the representation they are viewing. Gilbert (2004) supports that working with models can also improve content knowledge and facilitate student’s learning and understanding of concepts. For instance, along with the information in the textbook, the models of mitosis and meiosis were useful as supplementary materials in Teacher Ces’ actual discussion. Moreover, after the video presentation, Teacher Des’ discussion was further supported by the models. When Teacher Bes used the models, the students were observed to have a deeper understanding as they listened very carefully to the teacher’s discussion.

For all the cases cited, their use of the models had helped them teach the content more efficiently, making complex concepts easier to understand. This is consistent with what Gilbert (2004) had indicated, that the use of models in teaching content includes providing descriptions and/or simplifications of complex phenomena (mitosis and meiosis). In addition, Harrison and Treagust (2000) opined that after students’ viewing of a model, they create a picturistic view in their mind and hence can explore it better. The

authors added that “it's scientific that one can understand the concept only after he/she gets the chance to observe it and that chance is provided by models.”

The usefulness of models was also explored by Eilam and Gilbert (2014), who made key findings, namely, (1) visual representations are important in teaching and learning science content; (2) a diverse range of visual representations are important within the STEM education; (3) much learning with visual representations involves multiple representations; (4) some visual representations are seen as more central in STEM education than others; (5) visual representations can shape engagement and motivation, and (6) certain questions are more often associated with particular forms of representations.

Forms of representations. The teachers reported that they use different forms of representations when they teach content. Gilbert (2004) supports that representations are important tools in science investigations. They are valuable means of expressing and understanding a process and constructing knowledge. Specifically, the teachers use pictures, visual aids in textual form and personal illustrations, which have been reflected in their interviews, to wit:

For the representations I use, I always make use of pictures or cut-outs of pictures, personal drawing or illustration. [Teacher Ace]

Ok. I discuss cell division using models, pictures/cut-outs and videos. For example, for the group activity, after I discuss about the basic differences between mitosis and meiosis, I divide the class into 4 or 5 groups... I give them cartolina or Manila paper and pentel pen, and the members discuss among themselves the stages of mitosis and meiosis. [Teacher Bes]

I use models in discussing cell division. I always use the models provided by the school. At this point, I will have to use visuals (pictures) to discuss it. [Teacher Ces]

You know biology is very abstract so we, science teachers need to use a lot of representations. I use models, pictures, illustrations, visual aids based on the LM, film/video clips. [Teacher Des]

As indicated in their responses, all the teachers reported that they use different forms of representation. This was consistent in their actual teaching in order to facilitate the students' learning of content. The teachers were so innovative in coming up with very clear presentations of visual materials. They knew very well that it was difficult for the students to understand some concepts so they had to prepare forms of representation to support their discussion. When pictures, visual aids in textual form and personal illustrations were used, the discussion was interactive so that skills are developed in evaluating facts and evidences which are presented in the visual tools. Moreover, working with visual tools allowed for the students' increasing clarity in observations and interpretations of what they see in the classroom. A past study suggests that giving students pertinent visual information, such as diagrams, will lead to better understanding of that lesson. The study, by Mark A. McDaniel, a professor of psychology at Washington University in St. Louis, found that college students who had visual aids given to them before a science lecture were better able to understand and remember the lecture. Students given illustrative diagrams likely engage in deeper levels of processing while listening to the lecture (Brenneman, 2015). Specifically, the following forms of representation were used by the teachers in their actual teaching.

1. Picture. The pictures used by the teachers were either taken from the textbook or from another source. There were also instances that the use of pictures was combined with other forms of representation or sometimes with a specific

teaching strategy. For example, three (3) teachers (Ace, Bes and Ces) used a picture of the chromosome based on the textbook, while Teacher Des used a chromosome picture based on the textbook and on another source combined with visual aids in textual form. Through this representation, the teachers were able to provide information about the characteristics of the chromosome. In another instance, as picture of the cell cycle was used, Teacher Ace combined it with visual aids in textual form while Teacher Bes had it shown in the Smart TV. Moreover, Teacher Ces used a picture of the cell cycle after the video presentation after which, in small group discussion, she asked the students to draw the stages of mitosis. Further, Teacher Des was very resourceful, as she printed a picture of the cell cycle from another source since the cell cycle in the LM was blurred and the students would not appreciate it. Meanwhile, two teachers (Bes and Ces) used a picture of mitosis stages. While Teacher Bes asked the students to describe the stages in small group discussion, Teacher Ces asked the students to match each picture with a specific stage of mitosis. In terms of understanding the concept of homologous chromosomes, both Teachers Ace and Des used a picture based on the textbook. To explain the pairing of homologous chromosomes, which is difficult to comprehend, showing a picture of the process made it easier for most students to remember. In addition, Teacher Des used a picture of gamete formation which was also based on the textbook.

This usefulness of pictures in teaching the basic concepts of cell division and Mendelian genetics is consistent with what Lynch (2006) had indicated, that teachers can observe a science phenomenon (i.e. cell division) and represent it

visually using a picture. A picture is a description so vivid or graphic and is used to give an accurate idea of something (e.g. cell division stages and chromosome parts). Pictures also bring images familiar to students into the classroom to make the instruction more realistic. As it has been shown, they give a detailed picture of what is happening (stages of mitosis) as well as help create a clearer picture of what is to be understood (Caron, 2014). The author added that pictures or photographs are considered "proof." Likewise, Chitman-Booker & Koop (2013) said that an effective strategy to help students internalize information leading to true understanding is by using a picture in an inquiry-based science environment.

2. Visual aids in textual form. All the teachers used this material in their discussion as the only visual material or in combination with other visual forms or with a specific strategy. For example, in Teacher Ace's discussion of the cell cycle, she prepared this material to facilitate her discussion as well as to ask her students some questions. Similarly, in Teacher Des' discussion, using the information from this material, along with a picture taken from another source, the students were made to understand the concept of the cell cycle. Moreover, in discussing the complex stages of meiosis, the same teachers found the material very helpful. Specifically, in a small group discussion, Teacher Ace prepared the material to discuss the characteristics of the stages of meiosis. Meiosis is more difficult to discuss than mitosis but the visual material made the teacher's discussion very comprehensive, as Teacher Ace was able to ask questions. Likewise, when Teacher Des introduced the lesson on meiosis, she posted this material to emphasize distinct characteristics of each stage. Meanwhile, in

discussing Mendel's experiments, most of the teachers used this material to make the discussion much easier to understand. For instance, Teacher Ace used it to facilitate her discussion on the experiment's procedure, results and conclusions. True enough, the visual material was effective in Teacher Ace's explanation of the experiment, leading to the understanding of the basic genetics concepts. Moreover, the use of the visual material facilitated Teacher Ace's asking of questions, such as the question on why the garden pea was used by Mendel. Similarly, for the lecture on Mendel's experiment, Teacher Bes prepared this material for the students to understand its details including the reasons why pea plant was used by Mendel to explain the inheritance of traits (just like T. Ace). Specifically, one material (with blank information on a Manila paper) used by the two (2) teachers was about Mendel's first and second experiments, which served as an exercise about the seven (7) characteristics used by Mendel in his experiments. In this material, the students were asked to provide the correct symbols for the genotype and phenotype of the given traits, as well as determine whether the traits were dominant or recessive. Teacher Des found the material very useful in defining genetics terms. Teacher Ces used a variety of the material to discuss the Law of Segregation, Law of Dominance and Law of Independent Assortment. Moreover, both teachers (Ace and Bes) prepared this visual material when they asked the students to solve some genetics problems.

Inglis (2007) supports that visual aids in textual form help clarify an idea (e.g. cell division series of events and genetics terms) and reinforce a concept as well as help students understand concepts more easily because the content is

presented in a summarized format (Ryan, 2017). As observed, this visual material is made to display complex information on cell division and Mendelian genetics clearly and help students make sense of difficult concepts.

3. *Personal illustration.* Three (3) teachers (Ace, Ces and Des) made personal illustrations in their actual teaching. For example, Teacher Ace provided a personal illustration of cytokinesis, which made the students understand the differences between animal cytokinesis and plant cytokinesis very clearly. As Teacher Ace drew cytokinesis personally, she was also able to ask inquiry-based questions. Similarly, as Teacher Des noted that cytokinesis is not illustrated in the LM, she had to emphasize this concept clearly by illustrating it on the board. Such importance of this material is consistent with what Ramirez-Garcia (2013) had claimed that personal illustrations help students understand and remember concepts more easily, clearly and smoothly. Illustrations also help teachers explain the meaning behind various vocabularies and structures without explanation, as in the case of cytokinesis. The author added that teachers can ask prompting questions about this form of representation to boost student thinking skills. Likewise, resourcefulness was observed when Teacher Des made her personal illustration of Mendel's experiment, which was based on another reference. Just like Teacher Ace, she found the presentation of Mendel's experiment in the LM incomplete, so she made a modified illustration of this. The students were very eager to listen to her and as observed, this presentation was easy to understand. Further, Teacher Des illustrated personally the Punnett Square in order to show the probabilities of outcomes for a given cross.

Meanwhile, a quiz was given in the form of a personal illustration of the stages of mitosis where Teacher Ces asked the students to analyze what happens in each stage by writing two characteristics of each stage. Moreover, as Teacher Ces asked for the similarities and differences of mitosis and meiosis, the use of an illustration in the form of a Venn diagram was used in her discussion to facilitate teaching and student learning. Mannan (2005) supports that this form of representation ‘helps the teacher to clarify, establish, correlate and coordinate accurate concepts, interpretations and appreciations, and enable the teacher to make learning more concrete, effective, interesting, inspirational, meaningful and vivid’ (p.108).

This usefulness of personal illustration is also supported by Leung (2017), who used personal illustrations or drawings to teach abstract ideas or concepts. As a personal illustration was done, the author was able to arouse the students’ interest, as well as promote thinking. Moreover, with the personal illustration, the students were able to find it easier to reflect and think “out of the picture/box”. Further, the hand-drawn illustration also aroused students’ imagination. According to the author, a teacher does not have to be a talented illustrator to utilize illustrations/drawings in the classroom; the key success factor is to get students involved and engaged with the drawings, to encourage them to imagine and visualize what is in the drawing and, most importantly, what is not.

Multimedia Materials. The teachers’ use of multimedia as they reported is in the form of video presentation and powerpoint presentation. While most of the teachers use the LCD projector, Teacher Bes prefers to use the Smart TV. Moreover, the teachers supplement

the video presentation with either a powerpoint presentation or other forms of representations. Such use of multimedia has been reflected in the teachers' interview responses, to wit:

I have to make some supplementary materials, If the Smart TV is not available, I make my own illustrations, which I pattern from the net. I make use of multimedia presentation but it is not just showing about the slides, but in specific slides, I will ask them some questions. Students do small group discussion or group exercise. But I do not always do this because some students become dependent on others so what I do is I require them to perform an individual activity. [Teacher Bes]

...supplement my discussion with video clips and the other materials (representations) I mentioned. After showing videos on the stages, I supplement this with multimedia presentation. In film showing, I pause then ask inquiry-based questions. I download supplementary video clips from the net. [Teacher Des]

I use video film clips. I make it a point I pause the video and ask the students about important points. Some questions I ask are how do you describe the chromosomes in the stages of mitosis and meiosis? and how is mitosis different from meiosis? If I do not use video film clips, it will be difficult to explain about cell division. The students will find it very difficult to understand. [Teacher Ces]

Teacher Bes seemed to know what adjustment to make when she faces problems in the classroom like, *“If the Smart TV is not available I have to make some supplementary materials, I make my own illustrations which I pattern from the net.”* The teacher added an additional adjustment as *“I make use of multimedia presentation”* but she wanted to make the discussion more meaningful as she explained that *“it is not just showing about the slides, but in specific slides, I will ask them some questions.”*

Consistent in her actual teaching in using the TV for her PowerPoint presentation, Teacher Bes was able to ask questions about the cell cycle although her questions were just simple. According to Jones (2003), aside from the fact that PowerPoint presentation can enhance the teaching and learning experience, it may be useful for simple question and answer sessions. This is consistent with the finding of Luf who Bang (2013), who

claimed that the use of PowerPoint in science classrooms involves “redefining,” as a lot of questions are asked during its presentation. Similarly, Teachers Ces and Des reported that they are also able to ask questions when they present video clips. The latter pointed out as an evidence that *“I download supplementary video clips from the net. As indicated in their responses, both cases use the same process in asking questions. While the video is played, both teachers reported that they pause, discuss and ask questions promoting an active interaction between them and the students. For instance, Teacher Des considered that “In film showing, I pause then ask inquiry-based questions.”* In her actual teaching, Teacher Des’ video presentation was supplemented with a PowerPoint presentation, which she redefined by asking questions such as, *“Which do you think is involved in cell division?”* or *“Based on the short video clip, where do you find the DNA; what about the chromosome and the genes?”* On the other hand, Teacher Ces reported that *“I make it a point I pause the video and ask the students about important points. Some questions I ask are “How do you describe the chromosomes in the stages of mitosis and meiosis?” and “How is mitosis different from meiosis?”* Asking many questions is consistent in her actual teaching when the teacher showed video clips of the cell cycle, mitosis and meiosis. According to Koc (2005), video showing promotes higher-order thinking skills for the students, as questions are asked. The similar questioning process done by the two (2) teachers follows the APC (Ask, Pause and Call) pattern by Clark (2006), where the teacher asks a question, then pauses to allow the students to think and calls on someone to answer the question. This process is supported by Jenkins and Johnson (2010) who confirmed that when showing the video, teachers should pause and ask questions about what students see or how the students might be thinking about what they see in the video.

Teacher Ces further pointed out the importance of showing videos because, *"If I do not use video film clips, it will be difficult to explain cell division. The students will find it very difficult to understand."* According to Koc (2005), video showing is also used as a tool for academic learning.

While most of the teachers reported using models and multimedia materials in the teaching of cell division and Mendelian genetics in small group discussions, Teacher Bes commented that, *"I do not always do this because some students become dependent on others so what I do is I require them to do an individual activity."* True enough, as observed in her actual teaching, she opted to ask the students to work on Activity 4 and a genetics exercise as an individual activity. She wanted some activities done individually for quick completion. This is consistent with what Reddy (2020) had indicated that in working individually, *"you become very efficient, things get completed quickly and you become independent."* But Teacher Bes also considered that at times, *"Students do small group discussion or group exercise."*

Use cooperative learning

The teachers use cooperative learning or small group discussion (SGD) and consider it as the best strategy in discussing the stages of mitosis and meiosis and in doing problem-solving activities in genetics. Such use of cooperative learning in teaching has been reflected in the teachers' interview responses, to wit:

... I also do the discussion through a group work/exercise. The method which seems to work best in a specific group of learners is cooperative learning especially for problem-solving activities. I think, group work is the best method. In cooperative learning, the members of the group help one another in learning the concept. In cooperative learning there is exchange of ideas among the students and they can always make good decisions.
[Teacher Ace]

... I think a group activity/exercise seems to work best in a specific group of learners especially for analyzing stages of mitosis and meiosis, and problem-solving activities in genetics. [Teacher Bes]

... I give them a group work as practice exercise. The best method is cooperative learning. I can always ask my students to discuss about science concepts and they like to be working in groups... where the students sort of do a small group discussion about cell division and Mendelian genetics involving-problem solving activities. [Teacher Ces]

... in group work as an effective method to teach cell division and Mendelian genetics, ... I have been using group work. ... I think the strategy that seems to work best in a specific group of learners is a group activity or exercise on cell division and Mendelian genetics... Because in a group activity the grouping is heterogeneous so everybody is encouraged to participate in the discussion." [Teacher Des]

As indicated in their responses, all the teachers reported that they always employ

cooperative learning, which they regarded as a "groupwork/exercise or group activity." They also thought of considering it as the best method. For Teacher Ace, "The method which seems to work best in a specific group of learners is cooperative learning especially for problem-solving activities." Teacher Ace explained further that "In cooperative learning, the members of the group help one another in learning the concept" and "In cooperative learning there is exchange of ideas among the students and they can always make good decisions." Such exchange of student ideas and making good decisions where the students help one another in learning concepts was observed in her actual teaching, as she asked the students to discuss the events that take place in each stage of mitosis. Sitting on the floor, the students in each group exchanged ideas about mitosis, while the teacher acted as the facilitator as she went back and forth to check on each group. The students' discussion helped the group to make a decision on what they would submit as an output. Helping one another, the students came up with a good output based on the concepts they learned from the group discussion. This is consistent with what Hamann et al. (2010) had reported, that students in a group can go on to learn new things from others. Sravani

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As indicated in their responses, all the teachers reported that they always employ cooperative learning, which they regarded as a “groupwork/exercise or group activity.” They also thought of considering it as the best method. For Teacher Ace, “The method which seems to work best in a specific group of learners is cooperative learning especially for problem-solving activities.” Teacher Ace explained further that “In cooperative learning, the members of the group help one another in learning the concept” and “In cooperative learning there is exchange of ideas among the students and they can always make good decisions.” Such exchange of student ideas and making good decisions where the students help one another in learning concepts was observed in her actual teaching, as she asked the students to discuss the events that take place in each stage of mitosis. Sitting on the floor, the students in each group exchanged ideas about mitosis, while the teacher acted as the facilitator as she went back and forth to check on each group. The students’ discussion helped the group to make a decision on what they would submit as an output. Helping one another, the students came up with a good output based on the concepts they learned from the group discussion. This is consistent with what Hamann et al. (2010) had reported, that students in a group can go on to learn new things from others. Sravani

(2017) supports that working in a group helps the students become more productive, being able to raise a complete output. If working in a group, everyone works together making use of the best of his/her skills to make sure of quality output. Moreover, when working in a group, each member gets the opportunity to come out with own ideas and suggestions, thus paving way for new methods on how to complete the task properly (Jaques, 2003).

Teacher Des seemed to be familiar with the use of cooperative learning - "*I have been using group work*" and this must be the reason why she also thinks that "*in group work, as an effective method to teach cell division and Mendelian genetics, I think the strategy that seems to work best in a specific group of learners is a group activity or exercise on cell division and Mendelian genetics.*" With her continuous practice of cooperative learning, she has mastered dealing with the students as she believed that "*Because in a group activity the grouping is heterogeneous so everybody is encouraged to participate in the discussion.*" This is illustrated with what Teacher Des had experienced in her actual teaching, where student participation was observed when a questionnaire on genetics was given to the students as a group activity. As they worked as a group, the students participated actively in the discussion and talked freely about their ideas. According to Webb (2009), groups can be heterogeneous and mixing students can encourage participation as students become exposed to varied perspectives and work with people different from themselves.

Teacher Bes considered, too, a group activity "*for problem-solving activities*" in genetics as well as "*for analyzing stages of mitosis and meiosis*" as she reasoned that, "*a group activity/exercise seems to work best in a specific group of learners.*" As for Teacher Ces, she also considered cooperative learning as the method where "*I can always ask my students to discuss science concepts and they like to be working in group*" as well as "*where the students*

sort of do a small group discussion about cell division and Mendelian genetics involving-problem solving activities. This teaching strategy was spontaneously employed by the two (2) cases in their actual teaching. For instance, Teacher Bes employed it in the students' description and analysis of the stages of mitosis using cut-outs. As the facilitator, the students were able to finish answering the guide questions. According to Bakhtiyar et al. (2003), in cooperative learning, which is supervised by the teacher as the facilitator, the students discuss and analyze concepts. The authors opined that the students get actively involved in the learning process and take responsibility for their own learning. In another instance, Teacher Ces prepared a number of activities for the students to work in small discussion groups. Some of these activities were a story-telling activity, drawing of the stages of mitosis based on the video clip, conduct of Activities 1, 2, 4 and 5 and solving Bikini Bottom Genetics. It seemed that the teacher was highly encouraged to use cooperative learning in her classes, as she is supported by Millis (2002) who said, "I am encouraged to take this approach because cooperative learning is a highly structured form of group work that focuses on problem-solving that when directed by a good teacher can deepen students' learning."

Cooperative learning is a suitable student-oriented teaching method, as well as an avenue for asking inquiry-based questions. It is student-centered, which can help motivate students and help them realize their potential. In this classroom technique, students discuss issues, as supervised by the teacher; thus, the teacher plays the role of facilitator (Bakhtiyar et al., 2003). This was observed in all the teachers when they assisted the students in describing the stages of mitosis and they got actively involved in the learning process and took responsibility for their own learning. Sravani (2017) supports that working in a group helps the students become more productive by being able to raise a complete output. When working in a group, everyone works

together, making use of the best of his/her skills, to make sure of quality output. When working in a group, each member gets the opportunity to come up with his own ideas and suggestions, thus paving way for new methods on how to complete the task properly (Jaques, 2003). This is illustrated in all the classes of the teachers, where the students came up with outputs that they presented based on their discussion as a group.

Cooperative learning also improves the ability to apply knowledge, solve problems, develop critical thinking, and positive attitudes (McKeachie & Kulik, 1975). Specifically, students' conduct of the experiment, which was supervised by Teacher Ces, involved application of knowledge of cell division and development of critical thinking, as the groups made an investigation on the behavior of the chromosomes in the stages of mitosis as seen in the microscope. Hamann et al. (2010) support that students in a group can go on to learn new things from the others as they get the option to learn from each other. Moreover, all the students, while working in groups, have their own ideas, from which another student can learn so many things. For instance, as the students were asked to sit on the floor to discuss mitosis/meiosis (by all the teachers) and cell organelle functions (by Teacher Ces), it was observed that there were interactions as the students listened and learned from one another.

Moreover, cooperative learning also includes better communication skills and intellectual development (Brown & Atkins, 1988). Grantham (2008) opined that while working in a group, everyone gets the opportunity to communicate well with others within the group. Each idea or suggestion is considered and thoroughly discussed before the group arrives at a conclusion. Hence, the flow of conversation or communication is smooth and effortless within the members of the group, as well, a correct exchange of information occurs. This contributes a lot to the success of the task given. For example, the whole period (though it was planned to be for 20

minutes only) was maximized for the story-telling group activity supervised by Teacher Ces. The activity started with the reading of the printed material per group, after which, the guide questions were given. Discussion in each group started, where each member was encouraged to talk and communicate with one another as one member acted as the leader. With the leader, there was a smooth discussion until they came up with their output.

Use of a Variety of Activities

As indicated in their responses, the teachers reported that they use a variety of activities such as an additional school requirement, use of additional activities and acquisition of additional reading materials in order to enhance learning

The additional school requirement is in the form of a small poster with the actual cut-outs of the stages of mitosis, as well as a family picture. In the interview, Teachers Ace and Des narrated:

For example, in the small group discussion, I may use posters. [Teacher Ace]

The day before I start the lesson, I ask my students to bring family pictures. On the day of the discussion, using the pictures they brought, I will ask them, how similar are you to your father? Mother? Can you explain what makes your characteristics similar to your parents [Teacher Des]

As indicated in her response, Teacher Ace appeared to be very sure of an activity to do as she shared “*For example, in the small group discussion, I may use posters.*” In her actual teaching, Teacher Ace assigned a project of the actual pictures of dividing cells posted in an illustration board where the stages of mitosis are properly labeled. Submitted as a group work, Teacher Ace used this tool for her review on the characteristics of the stages of mitosis. As the project work was used, there was more meaningful understanding of the concept of mitosis; it enhanced students’ academic performance (a quiz was given afterwards with fair scores) and it helped Teacher Ace improve content knowledge (Kanter & Konstantopoulos, 2009). On the

other hand, Teacher Des said, *“The day before I start the lesson, I ask my students to bring family pictures”* as she would eagerly ask, *“Can you explain what makes your characteristics similar to your parents?”* As Teacher Des asked the students to *“bring a family picture”* in her actual teaching, the students were very active to participate which is consistent with what Alstad (2019) had indicated that this practical activity will increase engagement.

Consistent both in the interview and actual teaching, the teachers reported that they use additional activities (i.e. pneumonics , role playing) as another form of instructional strategy. For example, Teacher Ace expressed the importance of learning the concept while enjoying an activity as she shared, *“For an additional activity which is a check-up activity, I use pneumonics, a hand activity about the stages of mitosis.”* The teacher added, *“I definitely do problem-solving activities on genetics either by group or as an individual activity.”* Meanwhile, Teacher Ces was excited to share that *“Sometimes, I ask my students to do role-playing on Gregor Mendel for appreciation of Mendel’s work.”* According to Perry et al. (2009), simulation using role play is a form of experiential learning; it is an instructional scenario where the learner is placed in a world (Mendel’s world) made by the teacher to facilitate learning. As also indicated in her response, Teacher Ces was very proud to say, *“I start the discussion on cell division with a story-telling activity about cell organelles,”* which is a reading material about cell organelles.” Teacher Ces acquired this as an additional reading material as she told them, *“For you to reflect on how to answer question numbers 3 and 4, we will do an activity.”* Although not mentioned in the interview, Teachers Ces and Des did the hand activity/pneumonics;, they said that, sometimes, additional activities like these are needed *“to make the students alive and become motivated to listen.”* Further, Teacher Bes did not mention any additional activity in the interview though she was observed in her actual teaching that she prepared a problem-solving activity in genetics.

Although not mentioned in the interview, the teachers prepared other activities to enhance and facilitate learning in their actual teaching. An example was a genetics exercise where students were observed to participate and willingly answer as Teacher Ace asked, “*Did you understand how to determine the phenotype?*” Moreover, Teacher Ace prepared a hands-on activity or exercise that she posted on the board. An additional activity prepared by Teacher Ces was an additional meeting for slow learners, where the teacher had to review the previous lesson using metacards before a quiz. According to the teacher, providing more time to review the slow learners was very useful to facilitate learning. Teacher Des prepared a trivia to encourage the students to listen as she explained the biological significance of cell division – “*If our body cells will not divide, it means we are not living anymore so we take care of our body. As our body cells divide, it means we are growing.*” Likewise, Teacher Des prepared a preliminary activity in the form of a drill as she asked, “*Can anybody answer orally what is written on the board?*” (about identifying whether the given pair/s is/are homozygous or heterozygous). Additional activities like these are very helpful to increase student engagement as supported by Naik (2018) who claimed that such activities also improve academic performance.

Clear Discussion of the Basic Concepts of Cell Division and Mendelian Genetics

Because the teachers use models and multimedia materials, cooperative learning and a variety of activities to teach content, they present a clear discussion of cell division and Mendelian genetics as they relate the concepts to practical situations. As the teachers relate to practical situations, they are able to discuss the important role of mitosis, meiosis and genetics. On the role of mitosis, the following teachers narrated:

[Teacher Ace]: *My opinion? Ahh... After learning about mitosis, students will understand why we increase in size and why a small cut in our body (if not diabetic) heals. Of course..... they learn to understand why cells need to divide; for mitosis, body cells, need*

to divide for growth, survival and replenish old tissues. This is important to know so that we take care of our body.

[Teacher Des]: *For sure, they learn to understand that cells need to divide for survival, growth and development and repair. If our body cells will not divide, it means we are not living anymore so we take care of our body; we continuously grow. Oh yes... ok. For mitosis, once students learn about it, they understand why from infancy there is a need to grow; like now, everybody has grown and this is because of mitosis. We also get to develop body parts because of mitosis..*

[Teacher Ces]: *For mitosis, students learn to understand that it is for growth and repair.*

[Teacher Bes]: *For mitosis, students will be able to explain why we grow.*

As indicated in their responses, the teachers described the role of mitosis by relating it to practical situations. For instance, Teacher Ace believed that mitosis involves growth and wound healing as she explained that, *“After learning about mitosis, students will understand why we increase in size and why a small cut in our body (if not diabetic) heals.”* Although wound healing was not mentioned in her actual teaching, Teacher Ace related the concept of growth to the practical activity of “taking a bath.” When she introduced cell division by asking the students to share their experiences on taking a bath, the students realized that scrubbing the body during their bath means removal of dead cells, indicating that the cells grow through cell division, and not death of cells. In another instance, Teacher Des revealed a clearer explanation on the role of mitosis, which she also discussed in her actual teaching. Because she was knowledgeable on mitosis, she confidently reported in the interview that cells divide to make us alive and *“If our body cells will not divide, it means we are not living anymore so we take care of our body.”* Further, she reasoned out that *“For mitosis, once students learn about it, they understand why from infancy there is a need to grow.”* The teacher also described that *“like now, everybody has grown and this is because of mitosis”* as she added *“ We also get to develop body parts because of mitosis.”* Through the students’ sharing of personal experience as cited by the cases

mentioned, there was a deeper understanding of concepts, as the teachers established a common concept on the role of mitosis, which is “*for survival, growth, development and repair/replenishment of tissue.*” Meanwhile, with very short answers, both Teachers Ces and Bes described the role of mitosis - for growth and repair.

Likewise, the teachers identified the role of genetics by relating it to practical situations, specifically, on sharing of traits inherited in the family or why a trait runs in the family, and explaining why there is resemblance with parents. The teachers narrated:

[Teacher Ace]: *Somehow when students understand the basic concepts of genetics, they will at least be able to explain why this particular trait (for example, presence of dimples) runs in the family. Students learn how traits are inherited so that they can explain why they resemble their parents.*

[Teacher Bes]: *Students will understand inheritance of traits upon learning genetics. I think students will have a very clear understanding of the concepts of Mendelian genetics.*

[Teacher Ces]: *Of course the students will become knowledgeable about the concepts of cell division and Mendelian genetics. The students will be able to explain how traits are inherited from the parents to offspring.*

[Teacher Des]: *Learning genetics is understanding heredity, passing of traits from parent to offspring, and variation. At least students may somehow explain the inheritance of a specific trait in the family. And students know how to explain how this trait is inherited through learning genetics*

As indicated in their responses, the teachers shared the common belief that learning or understanding genetics allows the students to explain the inheritance of traits. Teacher Des emphasized the concepts involved as, “*Learning genetics is understanding heredity and variation.* For genetics to be understood better by relating it to practical examples, Teacher Ace had to give specific examples as she commented that, “*They will at least be able to explain why this particular trait (for example, presence of dimples) runs in the family.* The teacher further explained that “*Students learn how traits are inherited so that they can explain why they*

resemble their parents.” This is illustrated with what the teachers have experienced in their actual teaching. For instance, Teacher Ace asked her students to look at each other and look for the “*good traits they see*” and later answer a set of questions the teacher prepared. In another instance, Teacher Des asked for three (3) volunteers to go to the front and share their answer to the question, “*Which of your traits are similar to your father? mother?*” Meanwhile, with no practical example, Teacher Bes assumed that “*students will have a very clear understanding of the concepts of Mendelian genetics*” which she further explained that “*Students will understand inheritance of traits upon learning genetics.*” Likewise, Teacher Ces just mentioned that “*The students will be able to explain how traits are inherited from the parents to offspring*” even though she did not mention it in her actual teaching.

According to Liu and Lin (2006), teachers often lead students to a deeper understanding of concepts through the act of personal experience or practical situations. These practical situations are important for the teachers’ effective teaching, as they are used to understand concepts. Effective science teaching is characterized by the teachers’ ability to create learning environments (an environment of personal sharing) that challenge learners to develop a deep understanding of science concepts (Alshehry, 2014; Cone, 2012; Harrell & Subramaniam, 2015; Oh & Kim, 2013) specifically, cell division and Mendelian genetics. Likewise, effective science teaching requires that science lessons be contextualized to appeal to students’ interests and prior experience (Fitzgerald et al., 2013; Fuentes, Blooms & Peace, 2014).

As for the role of meiosis, the two (2) teachers (Ace and Des) were also able to identify it, which they discussed very clearly and completely, both in the interview and in their actual teaching. The discussion on meiosis automatically took place right after the discussion on

mitosis. The two teachers showed complete knowledge on the role of meiosis, while Teachers Bes and Ces showed limited knowledge. The responses of the teachers were as follows:

[Teacher Ace]: *Students will understand that the union of sex cells explains why we humans are not alike. Meiosis maintains reduced chromosome number that's why sex cells are haploid. For meiosis, as long as there is the union of the sex cells, there is always variation. Students will understand that meiosis will lead to genetic diseases if it does not function normally. So they will know about genetic diseases. For meiosis, students will understand why there should always be a male and female species so that the human species does not become extinct as long as there is the union of sex cells; and this happens only in meiosis.*

[Teacher Des]: *If they learn about the role of meiosis, students will understand that meiosis avoids occurrence of genetic disorders because the chromosome number is maintained as half of the chromosome comes from the father and the other half comes from the mother. . For meiosis, students understand why the human species is still living. As long as there are the sperm and egg cells from the male and female which unite during meiosis, we humans will be on earth. This is another role of meiosis; chromosome number (sex cells) is always reduced. But of course, meiosis makes all of us different from one another.*

[Teacher Bes]: *For meiosis, students learn to understand sexual reproduction through union of reproductive cells.*

[Teacher Ces]: *It is for sex cell reproduction*

Knowledge regarding pedagogical content of the subject based on Shulman's (1986)

Subject Matter Knowledge, addresses knowledge of the broad content relating to the pedagogical aspect of the subject. This aspect is aligned to the teachers' ability to sequence, arrange, organize and explain the subject matter to students in an effective and appropriate manner (Anderson & Clark, 2012; Kleickmann et al., 2013; Shulman, 1986). As indicated in the responses of Teachers Ace and Des , they seemed to know the role of meiosis very well. For instance, Teacher Ace showed the ability to organize her thoughts and explain that the role of meiosis is associated with "variation (that is why humans are not alike)," "development of genetic diseases" for abnormal meiosis, "no extinction because of union of sex cells," and "reduced chromosome number."

Similarly, Teacher Des explained meiosis as associated with "avoidance of occurrence of genetic

disorders,” “chromosome number that is maintained or reduced chromosome number” and “non-extinction of species.” On the other hand, Teachers Bes and Ces seemed to have not been able to organize their thoughts because they failed to explain the role of meiosis completely. Very simply, Teacher Bes just mentioned, “*For meiosis, students learn to understand sexual reproduction through union of reproductive cells*” and even mentioned meiosis I and II but did not tell something about these processes. Likewise, Teacher Ces had an incomplete understanding on meiosis having said that “*It is for sex cell reproduction*” only. Science teachers should have pedagogical knowledge of the subject and have comprehensive knowledge of the subject content. They should exude self-confidence in the teaching and learning environment (Anderson & Clark, 2012; Cone, 2012; Fitzgerald et al., 2013; Lumpe, Czerniak, Haney & Belyukova, 2012). For teachers to be able to communicate adequate understanding of scientific knowledge, they need to conceptualize the content knowledge from multiple perspectives and at levels deeper than what needs to be presented to students (Ghazi, Shahzada, Shah & Shauib, 2013; Johnson et al., 2012). When teachers lack this depth, they might fail to challenge students’ understanding or misunderstanding of science content, which could result in superficial learning (Alshehry, 2014; Anderson & Clark, 2012; Cone, 2012). Lack of science content knowledge often limits teachers’ ability to plan effectively and deliver meaningful science lessons (Nowicki et al., 2013; Oh & Kim, 2013). When science teachers possess superficial content knowledge, they may deliver erroneous content, which can lead to some students developing misconceptions (Ghazi et al., 2013). True enough, the two cases had shown some instances of misconceptions or missed discussion of concepts in their actual teaching which might be due to limited content knowledge.

Further, in the teachers' actual teaching, as they used models and multimedia materials, employed cooperative learning and used a variety of activities to teach content, they were able to discuss clearly the basic concepts of cell division, namely, chromatid, centromere, euchromatin, etc. On Mendelian genetics, they were able to understand the basic genetics terms such as phenotype, genotype, dominant trait, etc. For example, Teacher Ace defined the chromatid very clearly while Teacher Bes described the chromosome's location in the cell. Teacher Ces was able to synthesize clearly the cell organelles and their functions while Teacher Ace was able to differentiate between mitosis and meiosis.

Meanwhile, Teacher Bes was not able to relate mitosis to practical situations. Based on the software used for data analysis, she is considered to have incomplete coding concepts since what she shared on the role of mitosis is incomplete and she was not even sure, by saying "*I think students will have a very clear understanding of the concepts of cell division.*" Deeming it to be incomplete, the teacher still stated the idea that, "*For mitosis, students will be able to explain why we grow.*" Moreover, although she mentioned that growth is associated with cell division, Teacher Bes seemed to be confused with the process of mitosis when she said incompletely that, "*Students will also learn the basic concepts of mitosis like the chromatids overlap*" which appeared to have no meaning at all. Teacher Bes also showed an incomplete understanding on cell division in her actual teaching when she mentioned only about body cells that are involved in mitosis. Likewise, Teacher Ces, did not relate mitosis to practical situations when she was interviewed as she simply said, "*For mitosis, students learn to understand that it is growth and repair*" though she implemented a practical activity about it in her actual teaching.

Develop or stimulate students' critical thinking by asking questions

Asking questions to develop critical thinking. As the teachers teach content, they facilitate students' understanding of science. By doing so, teachers develop or stimulate students' critical thinking, by asking questions that are an integral part of meaningful learning and scientific inquiry. The teachers narrated:

[Teacher Ace]: *How? I encourage them to ask questions and do critical thinking. I encourage them to react by asking questions during presentations of output. I tell them they can ask any question that will require them to think critically. From the visual aids, I ask questions that will require them to think critically and creatively. I use media (film clip, video, TV) to stimulate student thinking, you could see the eagerness of the students. I always make use of pictures or cut-out of pictures, personal drawing or illustration, from the textbook, I summarize the content in a visual aid; I always use models.*

[Teacher Bes]: *I remember... I tell them to always ask questions. I tell them, there is no harm in asking because asking questions makes one to be a critical thinker. I always use Smart TV I observe using colored visuals, students are modified to think, I discuss cell division using models, pictures/cutouts and videos*

[Teacher Ces]: *I use a lot of videoclips, film clips and sometimes movies. I know the students are always excited to watch a film or a video and they are stimulated to think. I encourage them to ask questions based on their observations. A simple to complex question is okay.*

[Teacher Des: *I use the Internet to download film or videoclips and even movies; they got to understand better and appreciate the concepts. I am a stimulator. I stimulate their minds to ask any kind of question. Why is it like that? What happens next? What happens if we do like this? And so on. Using pictures and models, I tell them to ask questions.*

As indicated in their responses, the teachers reported that they encourage their students to ask questions because they believed that asking questions develop thinking skills. For instance, Teacher Ace associated asking questions to thinking skills and felt she has to maintain it as she shared, "*I encourage them to ask questions and do critical thinking.*" With her goal of maintaining an inquiry atmosphere in the classroom, she

added, *“I encourage them to react by asking questions during presentations of output”* as well as *“I tell them they can ask any question that will require them to think critically.”*

According to Graesser and Olde (2003), asking questions has the potential to facilitate productive thinking in students, enhance creativity and higher order thinking. In many instances during her actual teaching, when Teacher Ace discussed the DNA, XX and XY chromosomes of humans, Law of Independent Assortment, substages of the cell cycle and Mendel’s experiment, the students had to think critically as they were encouraged to ask a question about the concept/lesson presented. For example, when Teacher Ace asked, *“Among the cell parts that you know, which do you think is involved in mitosis?”*, the students were made to think critically. Similarly, her mention of the human chromosomes made one student think curiously as she asked, *“Does it mean Ma’am, our chromosomes can’t be beyond 46?”* This is a thinking skill of elaborating so that the concept is better understood. As Cuccio-Schirripa and Steiner (2000) had reported, asking questions helps students to elaborate on their knowledge. Likewise, Chin and Osborne (2008) had indicated that the act of ‘composing questions’ focuses the attention of students on content, main ideas, and checking if content is understood.

Moreover, after discussing Mendel’s experiment, another student was encouraged to ask, *“Ma’am, based on advanced reading, I came across homozygous and heterozygous; what are these Ma’am?”* which was a question involving clarifying skill. Teacher Ace also considered using “visual aids” where *“I ask questions that will require them to think critically and creatively.”* According to Cuccio-Schirripa and Steiner (2000), questioning is one of the thinking processing skills that is structurally embedded in the thinking operation, not only of critical thinking but also creative thinking, and problem solving.

Another instance of students' learning through critical thinking in her actual teaching involved Teacher Ace's instruction as she said, "*Listen class, you will also express the dominant trait even if there is the recessive trait which is always hidden or not expressed.*"

Similarly, Teacher Bes wanted the students to be confident in asking questions as she emphasized, "*I tell them to always ask questions.*" She reported that she always tries to encourage them to ask questions because "*there is no harm in asking, asking questions makes one become a critical thinker.*" As Stasiulionyte (2016) had indicated, "Asking any question is helpful in discovering a person's individual way of thinking;" it is but right that any student's question is entertained, to move their minds to think more. In her actual teaching, when Teacher Bes was about to introduce the concept of meiosis, one student was encouraged to ask, "*Is meiosis very much different from mitosis?*" This is a skill of differentiating concepts, which is an important way of thinking. In another instance, when the students had a hard time in understanding the concept of determining the ratios of the genotype and phenotype, one student was encouraged to ask, "*Ma'am how did you arrive at the ratios?*" It seemed that the student's question was procedure-based and needed recall but the question made the student to think more as she asked another question, "*Ma'am, what about the traits that we have, but our parents do not have, how is it possible?*" Another question Teacher Bes asked was "*Can you describe the centromere? Sister chromatids? Heterochromatin? Euchromatin?*," which required the students to think critically. An instance when a simple question was asked involved Teacher Bes' short lecture on cell organelles where one student was encouraged to ask, "*Ma'am what is the genetic material?*" Although it was a question of recall, this seemed

to be important, as it led to the discussion of the cell cycle where the students might have asked more questions.

Teacher Ces preferred actual observations as the basis for the students' asking of questions as she said, *"I encourage them to ask questions based on their observations."* According to the teacher, the actual observation happens during her discussion and it is here where *"A simple to complex question is okay."* As Vale and Kozminski (2013) have reported, "The goal of asking and answering a question is not necessarily to probe a completely untouched area of science rather, it should be a personal quest to resolve a curiosity." In her actual teaching, the simple questions asked by the students were questions of recall such as *"Ma'am, is PMAT the correct order?"* and *"Ma'am, where are homologous chromosomes found?"* Although simple, the students were encouraged to express what was in their minds when Teacher Ces discussed about mitosis. Other simple questions asked by the students involved describing hemophilia and Cri-du-chat and giving the meaning of random. According to House (2017),

"Practice at retrieving new knowledge or skill from memory is a potent tool for learning and durable retention." The author further said that retrieval of knowledge is an important aspect of embedding knowledge. As a result, lower cognitive questions play an important role in developing and embedding the core knowledge that students need to be able to successfully engage with higher cognitive questions."

This implies that the simple question of recall is important because it supports students to progress toward their thinking goals and to develop inquiring minds. On the other hand, there were also complex questions asked by the students during Teacher Ces' actual teaching. One question involved differentiating mitosis from meiosis when Activity 2 was done. Other questions involved the use of "why" and "how" when the students wanted to know the relationship between the nucleus and DNA and the reason

for the color in the chromosomes. A specific question asked by Teacher Ces that required the students to think critically was *“How do the cells start dividing?”* Meanwhile, a complex question asked by one student involved evaluation of possibilities as he asked, *“Ma’am, what about if there are two (2) kinds of characteristics crossed?”* According to Chin and Osborne (2008), the ability to ask thinking questions is an important component of scientific literacy, as it allows them to articulate their current understanding of a topic (differentiating concepts).

Finally, Teacher Des reported that, *“I tell them to ask questions”* by *“Using pictures and models”* as she humbly confessed, *“I am a stimulator. I stimulate their (students’) minds to ask any kind of question.”* Akers (2010) reported that visual aids are important in keeping students motivated and actively engaged in their classes. By using visual stimuli, teachers are more likely to maintain student attention and encourage active participation by asking any question.” For instance, in an actual teaching activity, as Teacher Des was about to discuss the basic genetics terms using visual aids, one student was stimulated to ask *“will you teach us how to solve genetics problems?”* This is a “how” question which was important to consider in relation to understanding word problems in genetics. Also, in Teacher Des’ use of models in the discussion on the differences between mitosis and meiosis, the mention of unfamiliar term/s stimulated one student to ask *“Ma’am what is homologous pairing?”* Although it was a simple question, the students’ minds were stimulated to think more as visuals were used. Moreover, Teacher Des stimulated students’ critical thinking as she instructed them, on the topic of the stages of mitosis, *“I will give you 10 minutes to discuss among yourselves, then we will discuss later”*.

Use of media, models, representations for student thinking. Teachers use a variety of learning materials such as media, models, and forms of representations for student thinking. Their use of such learning materials/resources for student thinking has been reflected in the teachers' responses, to wit:

I use media (film clip, video, TV) to stimulate student thinking, you could see the eagerness of the students as their eyes are focused on understanding the concepts presented in relation to meiosis. I always make use of pictures or cut-outs of pictures, personal drawing or illustration, from the textbook I summarize the content in a visual aid, I always use models. I always make use of pictures or cut-outs of pictures. All these representations are very useful for explaining content. In addition, I need to make visuals so that the students will understand the lesson more easily. It takes time for me to do the visual aids but it is all right as long as the students learn the topic very well. I summarize the content in a visual aid. For the representations I use, ... personal drawing or illustration personal drawing or illustration, from the textbook. [Teacher Ace]

I always use Smart TV because I observe using colored visuals, students are motivated to think. Ok. I discuss cell division using models, pictures/cut-outs and videos. Ok. I discuss cell division using models... There are available models of mitosis and meiosis provided by the school. I use these models. I follow the module but sometimes the illustrations are blurred that's why I make some cut-outs of pictures so that the students will understand better. [Teacher Bes]

I use a lot of video clips, film clips and sometimes movies, I know the students are always excited to watch a film or a video. and they are stimulated to think. Then I introduce Mendel's experiment. At this point, I will have to use visuals (pictures) to discuss it; I use models in discussing cell division; I always prepare visual aids in Manila paper. I use models in discussing cell division. I always use the models provided by the school. At this point, I will have to use visuals (pictures) to discuss it (cell division). When I see colored pictures, I print them and paste in a bond paper or cartolina and let be seen by the students. These will be passed around from one student to another. I always prepare visual aids in Manila paper based on the content in the textbook. I ask somebody to draw or illustrate some pictures in the textbook to make it larger and be appreciated by the students. [Teacher Ces]

I use the internet to download film or videoclips and even movies. Watching this stuff pacifies the noise of the students. But more than that they get to understand better and appreciate the concepts. I show them pictures and models; I supplement my discussion with video clips I use models, pictures, illustrations, visual aids based on the LM, film/video clips. I show them ... models. I show them pictures, cut-outs of pictures. I show them my own illustrations in discussing about cell division. [Teacher Des]

As indicated in their responses, the teachers reported that they use media, model and representations for student thinking. Media can be used as an effective means to promote a critical thinking attitude, while models and forms of representations such as pictures, personal illustration, models, visual aids in textual form help develop student thinking. For instance, Teacher Ace wanted her students to participate always in class discussions by using forms of media as she said, "*I use media (film clip, video, TV) to stimulate student thinking.*" The teacher added that she feels very happy about it as "*you could see the eagerness of the students as their eyes are focused on understanding the concepts presented in relation to meiosis.*" According to the teacher, the use of media offers immediate attractions. This is consistent with what Shenton (2014) had indicated that material of this kind is highly visual, which helps gain attention and maintain student interest in the theories and concepts under discussion. In her actual teaching, Teacher Ace did not show a video due to time constraint. Nevertheless, a videoclip on fertilization was shown outside her regular class. Teacher Ace recalled that after her video presentation, the students were stimulated to think as they raised their hands to clarify their thoughts. According to Wright et al. (2015), "learners become critical thinkers when they master certain skills such as the ability to clarify." Moreover, a representation in the form of a picture was also used by Teacher Ace as she instructed the students to look for the picture of a chromosome and asked "*Can anybody describe a chromosome?*" and "*what do you think is the importance of the chromosome?*" which stimulated the students to think deeply as one student tried to answer.

Teachers Bes and Ces reported that they show video clips on the cell cycle, mitosis and meiosis. Both cases showed satisfaction when they presented video clips in

their actual classes. Teacher Bes felt comfortable to say that *“I always use Smart TV because I observe that in using colored visuals, students are motivated to think. I discuss using videos.”* For example, when the stages of mitosis were shown in the Smart TV, the students sat together in one area, watched the video and analyzed each of the events of mitosis. As instructions were made by the teacher, a small group discussion was formed, for the students to discuss, reflect, analyze and evaluate the video shown. The students were observed to be thinking hard as their heads went up and down until they prepared their output. On the other hand, Teacher Ces felt happy to share that, *“I use a lot of video clips, film clips and sometimes movies”* because *“I know the students are always excited to watch a film or a video and they are stimulated to think.”* For instance, in her actual teaching, when the video animation of mitosis was shown, the students became engaged as they were very excited and became a little noisy as they shouted *“wow, excellent, amazing”* with eyes wide open. They were attracted to the colors and movement of the chromosomes as they nodded their heads in deep thinking. The visual nature of the video appealed to the students, allowing them to process information. Student thinking continued to get activated as the students were asked to work by group wherein they discussed, reflected and analyzed the stages of mitosis. Using critical thinking and reflective thinking, the students came up with an output in the form of an illustration of the stages of mitosis based on their understanding of the video. According to Buckingham (2009), media create excellent opportunities for students to think as they discuss, reflect, analyze, evaluate different perspectives and construct their own meanings through the discussion with groupmates in a small discussion group. Very importantly, students can hone their thinking skills by analyzing media using the theories and concepts

they are studying (Lauri et al., 2015). This is consistent with what Kaltura (2015) had indicated, that the use of video clips allows for more efficient processing and increases student thinking. Brame (2016) also reported that videos have particular value to the students because they find it more engaging and it can be well-suited to illuminating the abstract or hard-to-visualize phenomena (e.g. cell division).

Meanwhile, Teacher Des must be always prepared and ready to navigate the internet for the students as she shared, *“I use the internet to download film or videoclips and even movies.”* She knew the positive effect of videos on the students as she commented, *“ Watching this stuff pacifies the noise of the students. But more than that they get to understand better and appreciate the concepts.”* For example, in one classroom activity, the students were observed to be very silent at first but when the teacher announced that a short videoclip on the DNA would be shown, the students started to think aloud and talk with their seatmates. Although short, the video created a more engaging sensory experience as the students saw the colored animation of the DNA that made them understand the concepts more easily. In another instance, when Teacher Des discussed the nucleus based on the video presentation, student thinking was also activated. As observed, the students became very eager to view the video and went to the front to discuss what they know about what was to be shown until one student asked, *“Ma’am, how important are the chromosomes?”* They continued talking with their seatmates as the video was being played with the students’ head nodding repeatedly implying that they were thinking very hard about what they see. Furthermore, the students were observed thinking deeply and uttering words silently about the video. Then, they participated actively in the discussion that followed after the short video presentation, where the

teacher asked questions to check their understanding of the concepts presented in the video. According to System Admin (2017), animated video can make virtually any concept come to life and is great for portraying abstract ideas. As observed, the short video was useful for discussing the next lesson on cell division, which was consistent with what Lynch (2019) had indicated, that video clips which may be often short and immersive, help students quickly grasp an abstract concept so everyone can move on to the next lesson.

Aside from the use of videos, all the teachers reported that they use models in teaching cell division. For example, Teacher Ace candidly said, *“I always use models”* when she discussed the stages of mitosis and meiosis in the classroom. As observed in her class, student thinking was activated when a student raised her hand and sought for a reason to her questions, *“Why does meiosis have to be very long?; Why does it have many stages?”* Like Teacher Ace, Teacher Bes had to explain why she had to use the models - *“I discuss cell division using models... There are available models of mitosis and meiosis provided by the school. I use these models.”* In the classroom, when she used the model of mitosis, the students were very eager to listen as they focused their eyes on the models. Thinking silently, the students were observed to nod while others showed a “thumbs up” after understanding the concepts. Likewise, Teacher Ces reiterated that, *“I use models in discussing cell division. I always use the models provided by the school.”* In her actual teaching, when the teacher showed the model of meiosis, student thinking was activated as some students leaned forward, focused on viewing the video and closed their eyes while thinking while one student asked, *“Are these really happening in cells?”* Very simply, Teacher Des reported, *“I show them ... models.”* When she used a model to discuss the

stages of meiosis in her class, the students were stimulated to think - they became silent, closed and opened their eyes very fast while nodding until one student asked, "*Ma'am, why are there 4 haploid cells in meiosis?*" and "*Ma'am, what is crossing-over?*"

According to Gilbert (2004), working with representations such as models can promote thinking skills such as critical thinking and other thinking skills, improve content knowledge and facilitate student's learning and understanding of concepts. This is because students are motivated to ask questions about what they think about the representations they are viewing. The author emphasized that the use of models provides an environment for interactive student engagement and enhances thinking abilities/skills. This is also consistent with what Wright et al. (2015) had reported that "learners become critical when they seek reasons and evidence, infer wisely and analyze information."

All the teachers also reported that they use cut-outs/pictures in their teaching of cell division and Mendelian genetics. Teachers Ace and Bes expressed their reasons why they opted to use pictures in their discussion. Being a resourceful teacher, Teacher Ace shared, "*I always make use of pictures or cut-outs of pictures, personal drawing or illustration, from the textbook I summarize the content in a visual aid*" and she had to emphasize that, "*All these representations are very useful for explaining content.*" As observed consistently in her actual teaching, for example, Teacher Ace used pictures of the cell cycle and chromosome to clarify concepts and stimulate student thinking. As she showed the picture of the chromosome, the students got excited and overwhelmed with the many concepts she explained as they listened carefully. Thinking deeply about what they heard stimulated a student's thinking as she asked about the meaning when the chromosomes cannot be more than 46. In another instance, Teacher Ace used a diagram

(as picture) when she discussed the law of segregation. Student thinking was activated as one student immediately asked about the meaning of the dominant trait preventing the expression of the recessive trait. On the other hand, Teacher Bes pointed out a problem in the module as she remarked, *“I follow the module but sometimes the illustrations are blurred that’s why I make some cut-outs of pictures so that the students will understand better.”* To elaborate the concepts discussed in the classroom, Teacher Bes used pictures of the cell cycle and stages of mitosis shown in the Smart TV. The teacher’s use of the pictures stimulated student thinking as a student immediately raised his hand and inquired about the longest phase of the cell cycle.

With no mention of the reasons why the two cases use pictures and resourcefulness to provide for the students, they narrated:

[Teacher Ces]: At this point, I will have to use visuals (pictures) to discuss it (cell division). When I see colored pictures, I print them and paste in a bond paper or cartolina and let be seen by the students. These will be passed around from one student to another.

[Teacher Des]: I show them pictures, cut-outs of pictures.

In her actual teaching, Teacher Ces did not do what she described in the interview. She instead used pictures or colored metacards of the stages of mitosis along with pictures of the chromosome to facilitate the discussion as well as to stimulate student thinking. In addition, Teacher Ces used a picture of the cell cycle to discuss its substages. Student thinking was stimulated when many students shouted “Ma’am” while raising their hands until one student asked about the shortest stage in the cell cycle. When she compared mitosis with meiosis, she posted a Venn diagram, which stimulated student thinking as the students looked up, thinking about something until one student

immediately asked, “*Can you explore the similarities?*” On the other hand, Teacher Des just simply said, “*I showed them pictures, cut-outs of pictures.*” As observed in the classroom, she also used pictures of a chromosome, cell cycle and homologous chromosome, which she found useful for understanding the concepts because they are attractive and colorful. When shown, the students were very eager and excited. Student thinking was activated as many students discussed noisily with one another and analyzed the information presented about the chromosome. Immediately, one student raised his hand and asked “*Ma'am, does it mean it can never be XXY or XYY?*” In another instance, as Teacher Des used a picture to discuss the cell cycle, student thinking was stimulated as one student was so eager to know something about the picture, raised her hand first and asked about the longest and shortest stages of the cell cycle. Mannan (2005) supports that forms of representation such as pictures help clarify (Which is the longest stage in the cell cycle), establish (Is mitosis very much different from meiosis?) and correlate and coordinate accurate concepts (Does it mean that it can never be XXY or XYY?). According to Evagorou et al. (2015), the use of photographs or pictures makes it possible for teachers to interact with and represent complex phenomena (complex stages of cell division). This has been illustrated in the cited cases. This is consistent with what Sadiq (2020) had reported, that pictures make it possible for students to absorb large amounts of data quickly and using photographs for explaining complex phenomena is one of the teaching aids of modern education system all over the world. Specifically, one appropriate picture can be a catalyst that gives rise to the production of thousands of words and a multitude of creative and analytical thinking.

Not only models and pictures, but the teachers also reported making visual aids in textual form to facilitate their discussion and stimulate student thinking. The teachers always seemed to be ready with other forms of representation to supplement their discussion. For instance, Teacher Ces wanted to make sure that the content in the textbook was understood. This must be the reason why, *“I always prepare visual aids on Manila paper based on the content in the textbook.”* This was a similar reason for Teacher Ace who narrated, *“In addition, I need to make visuals so that the students will understand the lesson more easily”* but she was worried during its preparation as she commented, *“It takes time for me to do the visual aids but it is all right as long as the students learn the topic very well. I summarize the content in a visual aid.”* Teacher Des also knew the importance of preparing visuals - *“I supplement my discussion with visual aids based on the LM.”* According to Khan et al. (2015), visual aids in textual form are effective tools for making teaching effective, to facilitate the student’s learning and understanding of concepts. This is illustrated with what the teachers had experienced in their actual teaching. For example, Teacher Ace used visual aids in textual form to facilitate learning about the cell cycle and Mendel’s experiment, as well as to answer an exercise about Mendel’s experiment. As the students saw the exercise on the board, student thinking was stimulated as most of the students (as volunteers) raised their hands to answer on the board. Although Teacher Bes failed to mention it in the interview, she prepared visual aids in Manila paper for the discussion of Mendelian genetics, which stimulated student thinking as one student approached her and asked, *“What is the meaning of pure-breed?”* Likewise, the teacher used visual aids in textual form to discuss the details in the stages of meiosis, which stimulated student thinking, as one student

raised both hands, paused for a while to reflect on the question, then said, "*Ma'am I am ready*" as she asked, "*Ma'am, is sex cell the same as reproductive cell?*" Teacher Ces also prepared visual aids in textual form to summarize the complex stages of meiosis and to discuss the laws of segregation and independent assortment. For instance, after discussing the laws, student thinking was stimulated as some of the students were excited to see how genetics problems are solved on the board. As they went to the front to listen to the teacher closely; one student asked, "*Ma'am, what about if there are two (2) kinds of characteristics crossed? Is it possible?*" and another student also asked, "*so does it mean Ma'am if the recessive gene is masked, we only express the physical appearance if both genes are recessive?*" Finally, when Teacher Des discussed mitosis, as she posted a visual aid in textual form on the board, student thinking was activated, as one student raised her hand and asked, "*Where does mitosis take place?*" Similarly, student thinking was activated as two students raised their hands simultaneously, but where one immediately asked, "*Is mitosis very much different from meiosis?*" Moreover, when the teacher discussed genetics, one student was so interested with the lesson that she went to the front so that she could easily ask, "*Ma'am when is the recessive trait expressed?*" As observed, the teachers encouraged students' questions, which stimulated complex thinking. This is consistent with what Baranowska-Piasek (2002) had reported - forms of representations such as visual aids in textual form are a useful resource for teaching; they enable the development of critical thinking skill and reflective thinking skill, among others as students ask questions. This has been illustrated by the above cited cases.

The teachers added the use of personal illustrations in teaching cell division and Mendelian genetics. Teacher Ces wanted the creativity of her students in the making of

any visual aids by saying, *"I ask somebody to draw or illustrate some pictures in the textbook to make it larger and be appreciated.* On the other hand, two teacher cases (Teachers Ace and Des) *wanted* to show their own creativity. While Teacher Ace expressed that the content would still be based on the textbook as she said, *"I use personal drawing or illustration personal drawing or illustration, from the textbook,* Teacher Des felt proud by saying, *"I show them my own illustrations while discussing cell division."* In their actual teaching, both cases clarified the concept of cytokinesis by making a personal illustration of the process on the board. According to Eilam and Gilbert (2014), visual representations such as personal illustrations are important in teaching and learning science because these can shape engagement (interaction in the illustration) and motivation (interest to learn about an unfamiliar concept, for example, cytokinesis). Teacher Ces was not able to ask somebody to illustrate the process as she claimed that *"the time was just enough and there's no chance to do these things."* Interestingly, Teacher Ces reported the use of printed pages that she reproduces for student use as she narrated, *"Most of the time, I print important pages from a material, reproduce these and be given to all the students to supplement our discussion. These are very useful to facilitate imparting of knowledge to the students."* Printing of colored pictures for students' use was done outside the class period, where copies were given to the students in one afternoon. Moreover, the teacher made a personal illustration of the stages of mitosis shown in a quiz.

Teach to develop conceptual understanding, critical or analytical thinking skills and problem-solving skills

The teachers teach the students to develop conceptual understanding as the students learn to form the correct concepts about cell division and Mendelian genetics. Students' understanding of science involves students' development of conceptual understanding and critical thinking and other skills as the teachers use models and multimedia materials. This has been reflected in the teachers' interviews, to wit:

Learning about cell division and Mendelian genetics will make students understand the concept of cytokinesis, crossing over, homologous chromosomes, Law of independent segregation, Law of independent assortment and all the other concepts (dominant/recessive trait, phenotype/genotype etc). [Teacher Ace]

Learning about cell division and Mendelian genetics makes the students understand basic concepts of mitosis and meiosis (chromatid, cleavage furrow, cell plate, homologous chromosomes, synapsis, Law of Dominance, Law of Independent Segregation, Law of Independent Assortment, etc.) [Teacher Des]

I think students will have a very clear understanding of the concepts of cell division and Mendelian genetics. Students will also learn the basic concepts of mitosis like the chromatids overlap. Students will understand inheritance of traits upon learning genetics. [Teacher Bes]

Of course the students will become knowledgeable about the concepts of cell division and Mendelian genetics. The students will be able to explain how traits are inherited from the parents to offspring. [Teacher Ces]

As indicated in their responses, Teachers Ace and Des wanted the students to learn and understand “*cytokinesis, crossing over, homologous chromosomes, chromatid, cleavage furrow, cell plate, synapsis,*” etc. On the other hand, the concepts of Mendelian genetics that the teachers wanted the students to learn and understand are *dominant/recessive traits, phenotype/genotype, Law of Dominance, Law of Independent Segregation and Law of Independent Assortment,* etc. Teacher Bes simply mentioned teaching the students to have conceptual understanding on chromatids and inheritance of traits. Teacher Ces did not mention specific concepts but

generally, she wanted to teach her students the concepts involved in cell division and Mendelian genetics.

In their actual teaching, when Teachers Ace and Des mentioned the terms/concepts in cell division and Mendelian genetics, it was about defining or describing the terms so that the students would understand them easily. As the students understand the concepts, the teachers believed that they also learn to organize facts and ideas into a meaningful concept in science. As observed, they defined/described the cited concepts above as they used visuals such as models, pictures and other forms of representations. In so doing, the teachers helped the students to understand the concepts better. For example, using the model of mitosis, Teacher Ace described the chromosomes as she asked, “*How do you describe the chromosomes in mitosis?*” Similarly, Teacher Ces asked, “*How are the stages different from one another?*” As for Teacher Bes, she summarized the characteristics of each of the stages of mitosis. In the case of Teacher Des, using her visual aids with pictures and the model of mitosis, she discussed mitosis. According to Tang and Intai (2017), teachers help their students build understanding of scientific concepts by requiring the teachers to present visuals, resource materials, pictorial representations or problem of some sort. The teachers were also observed giving the students genetics problems to solve which also helped the development of the students’ conceptual understanding in genetics. This is consistent with what O’Dwyer et al. (2015) had reported that the ways for teachers to help students develop conceptual understanding include providing opportunities to apply learning and solve unique problems, spending time on conceptual activities such as word problems and having students discuss the reasons behind their answers to questions. The authors added that the benefits of teaching to develop conceptual understanding include students’ understanding where

the students can answer questions (answering questions in discussions) and ability to make explanations (explaining output in group discussions).

Aside from conceptual understanding, students' understanding of science involves teachers' teaching the basic concepts to develop critical thinking as well as other skills. The teachers narrated:

[Teacher Ace]: I think some skills are also learned by students to analyze the events that occur in each of the stages of mitosis and meiosis. There are also many skills used learn to solve genetics problems. Problem-solving skills may be useful for practical situations.

[Teacher Des]: In terms of skill, students learn the proper skills (analysis, critical thinking, problem-solving) in understanding about cell reproduction and Mendelian genetics. Yes. Since these concepts relate to their lives, then the skills learned may be applied.

As indicated in their responses, the teachers reported that they teach their students to develop thinking skills such as critical or analytical thinking skills and problem - solving skills. According to Kitota (2010), inquiry teaching can be used as an approach that can ignite thinking skills. For example, Teacher Ace always wanted to have an inquiry environment with critical students learning many skills when she gives them something they can work on as she shared, *"I think some skills are also learned by students to analyze the events that occur in each of the stages of mitosis and meiosis."* Because genetics involves problem-solving, the teacher also believed that *"There are also many skills used to learn to solve genetics problems,"* which the teacher opined that *"Problem-solving skills may be useful for practical situations."* Similarly, Teacher Des thought of considering both analytical and problem-solving skills that the students develop when they learn about cell division and Mendelian genetics because, *"In terms of skill, students learn the proper skills (analysis, critical thinking, problem-solving) in understanding cell reproduction and Mendelian genetics."* The teacher further realized that *"Since these concepts relate to their lives, then the skills learned may be applied."* Although Teachers Bes

and Ces did not completely mention the development of skills, they otherwise demonstrated these skills in their actual teaching along with the other teachers. Specifically, Teacher Ace developed the analytical skills of the students as they answered a blank table about the seven characteristics used by Gregor Mendel. As Teacher Bes pointed to the picture of the cell cycle after answering a student's question, she helped the students think critically as she said, "*yes very good but you can also consider finding the shortest stage.*" In Teacher Ces' discussion of the story about cell organelles, she helped the students develop analyzing and evaluating skills as she asked, "*why are the organelles complaining?*" Finally, Teacher Des helped the students to analyze critically Mendel's experiment as she discussed the experiment using an illustration. According to McNeill and Krajcik (2008), engaging the students in an inquiry environment can help them develop 21st century skills. The authors also emphasized that thinking skills should always be developed among the students so that the students will not rely on memorization. When teachers teach for understanding and not memorization, they are equipping students with the skills to succeed in the future (Omari & Chen, 2016). The ability to transfer skills and knowledge will be much more advantageous than information, which might become irrelevant. Teachers' teaching for the development of skills will relieve the burden on students to try to memorize information separate from how it can be utilized in a real world setting. Inquiry teaching plays an important role in solving problems in teaching and learning. In fact, it also plays an important role in developing students' thinking, to achieve success.

Correct/Prevent Misconceptions

Students' understanding of science involves correction/prevention of misconceptions as the teachers teach the correct content by using a textbook or doing an activity. The teachers

develop the students' conceptual understanding as the students learn to form the correct concepts about cell division and Mendelian genetics.

Using a textbook. The teachers reported that they make a summary of concepts with correct definitions/descriptions based on the textbook after their discussion. Such way of correcting misconceptions based on the textbook has been reflected in the teachers' interview, to wit:

Yes, I always make a summary of concepts based on the textbook every time I make a discussion. If the time is not enough to clarify, I give a handout. All teachers must assume the role of learning facilitator and encourage students to be active learners. [Teacher Ace]

Ahh... sometimes I check the textbook for the summary of concept. Sometimes I forget. If this does not happen (discussion of the summary of concepts on the next meeting) maybe due to some reasons – limited time or a school activity, I need to adjust by giving a one page hand-out.. Even a simple misconception has to be corrected, because sometimes the students are unaware that what they are thinking are incorrect. [Teacher Bes]

Oh yes... After the experiment, we use the textbook to determine the correct concepts involved in the activity. Post-interview: Since the students do not have yet a formal education about the cell, (since it is only in Grade 8 where this is completely discussed) it is expected that the students are always confused. [Teacher Ces]

As new concepts are introduced, I make it a point to summarize based on the textbook and available resources. Post-interview: As early as during the class discussion, I have to correct the misconception so that there will be no pattern of errors; it is corrected already. Otherwise, understanding stages of meiosis will be difficult and misconceptions will be hard to identify. [Teacher Des]

As indicated in their responses, the teachers recognize the importance of the textbook because they make a summary of concepts in correcting and preventing misconceptions. For instance, Teacher Ace wanted to do the summary of concepts right away “*every time I make a discussion*”, while Teacher Ces indicated doing it right “*after the experiment*” in order “*to determine the correct concepts involved in the activity.*” However, Teachers Ace and Bes gave possible reasons why they sometimes fail to make

a summary of concepts with corresponding adjustment to make. Teacher Ace believed that *“If the time is not enough for clarification, I give a handout.”* Aside from limited time, Teacher Bes recognized that *“a school activity”* as another reason why *“Sometimes I forget”* to make the summary of concepts but *“I need to adjust by giving a one page hand-out.”* Teacher Bes expressed her concern that *“Even a simple misconception has to be corrected, because sometimes the students are unaware that what they are thinking are incorrect.”* This is illustrated with what Teacher Bes has experienced in her actual teaching where she corrected a simple misconception of one student on “popularity” as the reason for Mendel’s use of garden peas in his experiment. The teacher summarized that the plants are easily propagated by self-pollination or cross-pollination, are readily available and have seven contrasting characteristics. This is consistent with what Lucariello and Naff (2020) had indicated, that alternative conceptions or misconceptions can really impede learning for several reasons - students generally are unaware that the knowledge they have is wrong, and misconceptions can be very entrenched in student thinking. As this may always be true, teachers should be aware that every misconception must be identified and corrected immediately. Teacher Des does not want to use only the textbook, but also other resources because *“As new concepts are introduced, I make it a point to summarize based on available resources.”*

In their actual teaching, it was observed that all the teachers corrected right away the misconceptions they identified during the discussion. According to the teachers, the correct concepts that they teach are based on what they read from the textbook. For example, when Teacher Ace asked about the importance of the chromosome and one student mistakenly answered that the *“chromosome is for the transfer of traits,”* she

corrected the misconception as she answered that it is the DNA that performs that role and explained further that *“the number of chromosomes in a cell is characteristic of the species where it belongs.”* It was interesting to note that some students were also active in correcting misconceptions such as the wrong meaning of “homozygous” which was corrected by one student. Teacher Ace explained that she encourages the students to be active learners by participating in correcting misconceptions because she believes that *“All teachers must assume the role of a learning facilitator and encourage students to be active learners.”* According to Sothayapetch et al. (2013), as a facilitator, a teacher facilitates learning when misconceptions are corrected. Likewise, Teacher Ces corrected to the class that *“it is the ribosome, not the nucleus that functions for protein synthesis”* and she had to repeatedly ask to make sure that the students have learned the correct concept. Teacher Ces must be very concerned with the students *“since the students do not have yet a formal education about the cell, (since it is only in Grade 8 where this is completely discussed) it is expected that the students are always confused.”* According to Savion (2009), initial beliefs prior to any formal education are called naïve theories, which are incredibly hard to extinguish. Thus, it is but right that teachers are always able to find ways in order to avoid students’ naïve theories. Meanwhile, Teacher Ces explained that in cases where there are many identified misconceptions during her discussion, she always makes it a point to make an adjustment. According to the teacher, in previous years, she would prepare a visual aid (in textual form) with the list of the misconceptions corrected based on the textbook and have it copied by the students. However, this school year, there were only few misconceptions identified, which Teacher Ces corrected right away in the class.

Teacher Des was observed to be the only teacher to use the textbook inside the room when she corrected a misconception. When one student asked for the type of cells where mitosis occurs, it was incorrectly answered by another student as “sex cells. ” Using the textbook under the teacher’s table, the teacher confirmed that “*the sex cells are for meiosis while body cells are for mitosis*” which enlightened the student thanking her for the correct information. As noted, she was very spontaneous to correct the misconception with a soft voice telling the students about it. Another misconception involved a video presentation on mitosis where the teacher asked the students to describe what happens to the chromosomes at the second stage. This was incorrectly answered by one student as she said “*they tend to disappear.*” Looking at everybody, Teacher Des slowly explained and answered correctly that “*if the chromosomes disappear, then there is no more cell division; what really happens is that the chromosomes move to the center.*” Right after her class, when asked about the immediate correction of the misconception, Teacher Des explained that “*as early as during the class discussion, I had to correct the misconception so that there will be no pattern of errors; it was corrected already. Otherwise, understanding the stages of meiosis would be difficult and misconceptions would be hard to identify.*” This is consistent with what Bensley and Lilienfeld (2015) had reported, that misconceptions can result in systematic patterns of error. Moreover, according to Hughes and Kaplan (2013), misconceptions can impede the learning of new knowledge and are often difficult to identify, strongly held, and highly resistant to correction through standard instruction. This is the reason why Teacher Des corrected the misconception immediately.

Doing an activity. Misconceptions can also be confronted through activities such as hands-on and minds-on activities or inquiry-based activities. Treating misconceptions may be done by structuring activities that will produce the needed conceptual change. As indicated in their responses, all the teachers consider doing an activity to correct misconceptions, to wit:

I also prevent misconception through an activity. [Teacher Ace]

I also do an activity. Post-interview: While some groups maybe fast to finish an activity, a few maybe very slow. I am sure the students got to understand about the garden pea's characteristics as used by Mendel. Since the activity is simple, I know both the fast and slow learners were able to follow. [Teacher Bes]

So I both do an activity and the textbook to prevent misconceptions. Post-interview: We were excited to view the stages of mitosis under the microscope; I was moving from one group to another so I really forgot; but prior to the long test, I had a review outside the regular class and I mentioned about it. I am aware that I had to correct it though a little late. [Teacher Ces]

I also use an activity to correct misconception. Post-interview: I always set a special schedule for a remedial class [Teacher Des]

As indicated in their responses, all the teachers reported that they do an activity when correcting and preventing misconceptions. Although the teachers did not mention in the interview the other details about doing an activity to correct and prevent misconceptions, they showed these otherwise in their actual teaching. For instance, when “homozygous trait” was incorrectly defined by two students, Teacher Ace corrected it by discussing the Law of Segregation, gave an example and later asked the students to do a short activity (solving simple genetics problems) where the concept of “homozygous” was clearly discussed. Similarly, when Teacher Des corrected a student’s misconception on chromosome movement, she corrected it initially through a discussion that commenced in an activity in the form of a short quiz. As the teacher instructed, “based on

the video, discuss and explain each of the stages of mitosis,” the students described the movement of the chromosomes in each stage of mitosis, after which she summarized to emphasize the correct concept about chromosome movement. Although correcting a misconception through a simple quiz was done, Teacher Des did the right thing in replacing the misconception with the correct concept. In one visit of the researcher, when asked about the result of the quiz in terms of correcting the previous misconception on the chromosomes, the teacher said that some of the students were able to describe it correctly while a few were still confused. Realizing the need to reteach and reach out to the other students, the teacher said, *“I always set a special schedule for a remedial class”*, which the teacher does prior to the long test. According to Santos (2020), a short activity may be performed to provide the students a first- hand experience, so that their misconceptions may be corrected. This is supported by Gooding and Metz (2011), who suggested that “we must provide our students with such opportunities for conceptual change. These may take the form of inquiry-based activities, or other minds-on experiences, and should help students reconstruct and internalize their knowledge.” This is also consistent with what Ates and Eryilmaz (2011) had reported that science activities help students enhance their understanding and replace their misconceptions with the scientific ones. Moreover, Smith (2020) suggested that having them do any activity can be used as a tool to reconstruct thinking.

After summarizing the correct concepts on the reasons why garden peas were used by Mendel in his experiment, Teacher Bes elaborated these by giving the students an activity. The activity involved presenting a visual aid with blank information about the cross of the seven (7) characteristics used by Gregor Mendel, where the volunteer-

students answered on the board. As observed, conceptual learning was successful because when the items (crosses of the different traits of garden peas) were presented and explained on the board, prior knowledge was revised and replaced with new, accurate information. It was noted that the student who had the misconception before recognized her lack of understanding about the garden peas and got satisfied (with a nod, implying satisfaction) with the correct information presented in the activity. According to Verkade et al. (2017), if prior conditions have been met and the students have recognized their lack of understanding, they will be motivated to search for more information to rectify their lack of knowledge. Teacher Bes further said that though this activity was performed by the students toward the end of the class period, *“I am sure the students got to understand about the garden pea’s characteristics as used by Mendel.”* The teacher added that though the activity is simple, *“I know both the fast and slow learners were able to follow.”* But she was always concerned with the students as she remarked, *“While some groups maybe fast to finish an activity, a few maybe very slow.”*

Meanwhile, in Teacher Ces’ case, although an experiment was performed by the students with her plan to correct a misconception (i.e. *it is the ribosome, not the nucleus, functions in protein synthesis*), correcting the misconception was done differently. When the students performed Activity 1, Teacher Ces recalled that one student asked her about the *“chromosomes that are colored.”* The teacher said that this would have been the chance to discuss about the nucleus which was part of what was stained. Upon discussing the nucleus, the teacher should have emphasized that while the nucleus is the control center of the cell (the structure found usually at the center), the ribosomes are the protein factories of the cell. However, the teacher was not able to do it this way because, *“we*

were excited to view the stages of mitosis under the microscope; I was moving from one group to another so I really forgot. With Teacher Ces' too much concern for the students, she still had her ways to be able to help as she shared, "but prior to the long test, I had a review outside the regular class and I mentioned about it. I am aware that I had to correct it though a little late." Although the correction was not done in the actual performance of the activity, Teacher Ces has shown the awareness in correcting the misconception. This is consistent with what Bamer (2010) claimed, that teachers should be aware of their students' misconceptions in order to successfully facilitate conceptual progression.

Although not indicated in the interview, there were some instances in the teachers' actual teaching that involved correcting/preventing misconceptions. For instance, the patience of Teachers Ace and Des for teaching slow learners to prevent misconceptions was observed. While Teacher Ace told the students to "study more", after finding that five (5) students failed in a quiz, Teacher Des spent much time in explaining the procedure of Activity 3 as she kept on asking, "can you do it at home?; any questions?" A good teacher patiently waits and may even give clues to prompt the stuck student, to encourage a free and fair classroom environment ("Patience is a trait every teacher should possess," *Times Reporter*, 2017). Moreover, the students' understanding of science involves assistance to students when doing/answering an exercise /activity. Three (3) teachers, (Ace, Ces and Des) assisted their students in answering an activity/exercise so as to prevent misconceptions, as all of them went from one student/group to another and checked on what the students were doing or how the students were answering. Osewalt (2020) supports this, as she claimed that teachers use

various methods to meet the needs of all students, including those who struggle.

Meanwhile, students' understanding of science also involves student learning as the teacher commended them for active participation during the discussion. Specifically, after the students' presentation on the stages of mitosis, Teacher Ace was observed to say "very good, all of you have an idea about the stages of mitosis, let us give everybody a round of applause." Very simply, Teacher Bes said, "yes, very good" as one student answered that based on the picture, "it is G1." Likewise, Teachers Ces and Des said "very good" as one student in T. Ces' class raised her hand and said, "in prophase, the cell membrane is still intact" while one student in Teacher Des' class raised his hand and confidently said, "it is in the nucleus." As observed, the students smiled and showed happy faces in all these instances. According to Morin (2020), praise, which seems to be synonymous to commending, is described as follows:

"Praise is one of the simplest and most powerful tools to engage and motivate your students. When used effectively, praise can turn around behavior challenges and improve students' attitudes about learning. Students who learn and think differently often receive negative feedback as a result of their struggles. That makes meaningful and appropriate praise even more important."

Use of multi-assessment tools

Test or activity, students' reaction, and participation. Students' understanding of science involves student learning through the teacher's use of multi-assessment tools such as a test or an activity, students' reaction, and participation. Such tools can be used by every educator to increase student engagement. All the teachers consider such multi-assessment tools, to wit:

... first, it is based on the reaction of the students. If I see that they agree or approve what I discuss, then I know they understand the discussion. Second, through a test

or an activity. If their score in test is okay, then I know they understand the concept. Through an activity, I know they understand the lesson if their output is ok. For those whose scores are low, I tell them that I will give an extra work [Teacher Ace].

It's simple... Through the test and activities done. If the scores are okay, I know they understand the lesson. [Teacher Bes]

...compared with the old curriculum where exercises are given before and after the lesson, in today's curriculum, it is performance-based so I know they understand if they can perform an experiment or they can solve problems during a test [Teacher Ces].

Through an assessment. If the activity is interactive they participate and while I talk they listen, I know they understand the lesson [Teacher Des]

As indicated in their responses, the teachers reported different ways of assessing student learning. Teacher Ace shared that “*it is based on the reaction of the students.*” She believed that “*If I see that they agree or approve what I discuss, then I know they understand the discussion.*” Similarly, Teacher Des emphasized that “*If the activity is interactive, they participate and while I talk, they listen, I know they understand the lesson.*” Teachers Ace and Bes considered both a test and an activity as tools for determining student learning. While Teacher Ace shared that “*If their score in test is okay, then I know they understand the concept*” and added that “*through an activity, I know they understand the lesson if their output is ok*”, Teacher Bes felt “*it's simple... if the scores are okay, I know they understand the lesson.*” Interestingly, Teacher Ace showed concern for the slow learners as she said, “*For those whose scores are low, I tell them that I will give an extra work.*” Teacher Ces seemed to be authentic with the kind of assessment tool she considered in determining student learning, as she pointed out that “*it is performance-based so I know they understand if they can perform an experiment or they can solve problems during a test.*”

In their actual teaching, the students' general reaction when the teachers validated their learning after doing an activity was "Yes or Yes Ma'am." Moreover, Teacher Ace had to ask in one activity, "How do you write the genotype of a person with normal digits?" to validate if they already knew what to do. Specifically, after knowing in a quiz that 10 got a perfect score of 20, 15 got from the range of 15-19 and the rest of the students failed, Teacher Ace realized that student learning had to be reinforced as she said, "For those who failed, practice to answer more genetics problems at home." Meanwhile, Teacher Bes had to ask "How do you determine the genotype in the following crosses?" to make sure that the students learned the basics of solving genetics problems as she asked volunteers to write their answers on the board. As for Teacher Ces' class, the students had an actual performance of an experiment, which was a performance-based activity while Teacher Des had many instances of students' active participation. In fact, Teacher Des had to enrich student learning as she added more items in the activity that compared mitosis with meiosis. According to Darling-Hammond (2015), "Teachers are allowed to immediately intervene, (instead of a quiz, a performance-based activity was done; reinforcing to practice more problems at home), or to offer new challenges for students who've mastered a concept or skill" (challenging the students to answer more items on differences between mitosis and meiosis).

Experiment, representations and problem-solving activities. Students' understanding of science involves student learning through an experiment, representations and problem-solving activities. All the teachers consider such multi-assessment tools, to wit:

I am sure students learn to experiment on plant and animal cells. Students learn to solve problems in Mendelian genetics using the Punnett square. [Teacher Ces]

Students learn about cell division stages and solving problems in Mendelian genetics [Teacher Bes]

Students learn about cell division diagrams, at least for mitosis which is basic, any kind of related diagrams, illustrations or drawing on cell division. For Mendelian genetics, students learn about the Punnett square [Teacher Ace]

Students learn about cell division representations like drawings or pictures. For Mendelian genetics, students learn to solve word problems. [Teacher Des]

As indicated in their responses, the teachers reported other ways of assessing student learning. Teacher Ces must be prepared enough to conduct an experiment because “*I am sure students learn to experiment on plant and animal cells*” while the rest of the teachers (Ace, Bes and Des) felt sure that “*students learn about cell division stages using diagrams, drawings or pictures or any kind of related diagrams.*” In addition, all the teachers expressed that “*students learn solving problems in Mendelian genetics using the Punnett square.*” The teachers’ use of these multi-assessment tools is consistent in their actual teaching. For example, in the conduct of the experiment, Teacher Ces observed the students’ learning about the mitosis stages as the students were able to manipulate the microscope as well as identify mitosis stages. Learning about cell division while conducting the experiment, one student initially asked, “*Ma’am is it possible to see the stages of mitosis in the activity?*” This is consistent with what Darling-Hammond (2015) had indicated about incorporating performance-based assessments (i.e.) as additional measure of student understanding. The author added that this kind of activity requires students to apply what they are learning to real world tasks, as well as apply their knowledge and skills. Moreover, the rest of the teachers (Ace, Bes and Des) used different forms of representations to assess student learning. For example, Teacher Ace made an illustration on the board using arrows to show the separation of genes. With

Teacher Bes, she prepared visual aids in Manila paper to discuss Mendelian genetics. In the case of Teacher Ces, she prepared a visual aid in textual form to summarize the characteristics of each stage of meiosis. Finally, Teacher Des had to use a picture to discuss the characteristics of the chromosome. According to Carolan et al. (2008), to develop understanding of science, students are introduced to, and expected to use, diverse representations such as models, tables, graphs, diagrams, science journals, multi-modal reports, and appropriate vocabulary and measurement for specific topics. This takes the role of the teacher to facilitate the use of representations for student learning. Further, all the teachers conducted problem-solving activities to enrich the students' understanding of the concepts in genetics.

Assignments and activities. Students' understanding of science involves student learning through assignments and a variety of activities. According to Suskie (2009), many activities can be used for assessment and any tangible output from a learning activity can be assessed. Aside from the common assignment, quiz and long test, group presentation and boardwork done by the teachers are also considered important assessment tools. All the teachers considered such multi-assessment tool as they narrated:

[Teacher Ace]: I also give assignments and a lot of activities. The module has limited activities so I prepare some. Based on experience, I do not give a quiz everyday due to time. Anyway, I have many activities for the students to work on. In the 5 activities in the LM, though I am not able to ask the students to perform all, I assess their output based on group presentation. I use a rubric for grading (time management – 5pts; creativity-5pts; cleanliness-5 pts; accuracy-5pts for a total of 20 pts.)

[Teacher Bes]: I also give assignments and a lot of activities. I seldom give a quiz due to limited time. Anyway, I can substitute an activity or assignment for a quiz I assess group work after the presentation to the class. I use the same rubric similar to Teacher Ace since we need to have the same system of assessment.

[Teacher Ces]: *I check assignments and a lot of activities . But I also give a quiz but it is only one or two quizzes You know we have only 10 days to finish the lesson so I opt to give minimal number of quizzes. Aside from the five (5) activities in the LM and from the list of activities I add, the assessment is always through group presentation. We in the science department follow one rubric, organization, subject knowledge, graphics/visuals, mechanics, eye contact and elocution (skill of expressive speech).*

[Teacher Des]: *I also give assignments, minimal quiz and many activities . As I said previously, the LM has very limited activities, so I need to add or improvise. If I do not do this, the students will not appreciate understanding genetics. As I believe in group work as an effective method to teach cell division and Mendelian genetics, I assess group output after presentation of results.*

1. Assignments. As indicated in their responses, all the teachers reported that they give assignments. All of the teachers shared a common answer about assignments, which was, “*I also give/check assignments.*” Assignments are tasks requiring student engagement and a final tangible product that enables teachers to assess what the students know and don’t know. Williams (2020) supports that assignments form a crucial part among the other assessment tools to measure progress and capabilities of a student. In the study, in some cases where time was not enough to discuss a topic, the topic intended to be discussed for the day was given as an assignment. On the other hand, where the element of time was the problem, most of the assignments given to the students were problem-solving tasks. Assignments are one of the most common ways to assess student learning. In their actual teaching , both Teachers Ace and Bes gave Activity 4 as an assignment, which they checked the following day. Other assignments both teachers checked involved problem-solving activities about monohybrid cross and dihybrid cross. In addition, Teacher Ace prepared an assignment about the stages of mitosis while Teacher Bes gave an assignment about researching on gametogenesis. Meanwhile, Teacher Ces prepared an assignment on

genetic disorders, while Teacher Des asked for a family picture. Moreover, Teacher Ces considered Activity 3 as an assignment, which she also checked and discussed the following day. In all these efforts of the teacher, giving a well-crafted assignment is to teach the pupils how to study. According to Dougherty (2012), well-crafted assignments hold the potential to make learning and teaching more focused and relevant because in the crafting process, teachers must be deliberate and highly aware of the context and content involved in an assignment.

2. Quiz. In the context of an assessment tool, a quiz may be considered a kind of activity. Due to time constraint, Teacher Ace was honest to say that “*Based on experience, I do not give a quiz everyday due to time,*” which is similar to what Teacher Bes had to say, “*I seldom give a quiz due to limited time.*” Teacher Ces had the same reason although she elaborated further as she said, “*But I also give a quiz but it is only one or two quizzes You know we have only 10 days to finish the lesson so I opt to give minimal number of quizzes.*” As for Teacher Des, she simply said, “*I also give minimal quizzes.*” In her actual teaching, Teacher Ace gave three (3) quizzes consisting of two (2) inquiry-based quizzes and one spelling quiz. The first inquiry-based quiz was about comparing mitosis with meiosis based on the daughter cells produced and occurrence of homologous pairing. The other quiz was on differentiating between dominant and recessive traits, and, homozygous and recessive traits. Teacher Bes did not give any quiz but she had additional activities which she substituted for the quiz and for the activities in the textbook that were not performed by the students. In the case of Teachers Ces and Des, they assessed student learning through two (2) quizzes. The two quizzes prepared by Teacher Ces were both about

the stages of mitosis. Similarly, one of Teacher Des' quiz was about the video clip on mitosis, particularly, the one that compared mitosis with meiosis. According to Teacher Des, the quiz was actually Activity 2 of the LM and she had to consider it a quiz that day because there was a limited time for giving it as a quiz on another day. She added that the students did not have any quiz about genetics, but there were additional activities done by the students. Most of the quizzes given by the teachers were fast assessments as soon as an activity (i.e. after video presentation, discussion on mitosis stages) ended. This is consistent with what Best (2020) had indicated that quizzes are often a go-to for teachers because they are fast, easy, efficient, and can cover a lot of content.

3. Group presentation. All the teachers considered group presentation as an important form of assessment. While Teacher Ace stated, *"In the 5 activities in the LM, although I am not able to ask the students to perform all, I assess their output based on group presentation,"* Teacher Bes shared, *"I assess group work after the presentation to the class."* Coming from the same school, both Teachers Ace and Bes reported that they follow the same rubric for assessment, which is composed of *"time management – 5pts; creativity-5pts; cleanliness-5 pts; accuracy-5pts for a total of 20 pts."* Meanwhile, Teacher Ces considered that *"the assessment is always through group presentation"* while Teacher Des emphasized that *"As I believe in group work as an effective method to teach cell division and Mendelian genetics, I assess group output after presentation of results."* Moreover, Teacher Des reiterated that *"In the science department, we follow one rubric - organization, subject knowledge, graphics/visuals, mechanics, eye contact and elocution (skill of expressive speech)."*

In their actual teaching, all the teachers considered group presentations in discussing mitosis and solving genetics problems. Specifically, for Teacher Ace, group presentations were evaluated through listening to their output. For example, in the small group discussion on describing the stages of mitosis, Teacher Ace gave the groups ample time to discuss the groups' answers and later the groups presented their output to the class, for the teacher's evaluation. Another group presentation Teacher Ace evaluated was Activity 2, where the groups made a comparison between mitosis and meiosis. During the evaluation, Teacher Ace was able to emphasize that homologous chromosomes are identical in structure. Teacher Bes evaluated a group presentation about the characteristics of the assigned picture of a stage of mitosis. As 20 minutes was given to complete the groups' discussion, Teacher Bes evaluated the groups' output as the presenters arranged themselves based on the correct order of the stages of mitosis (the basis was the assigned picture of a stage of mitosis per group). There was no definite score for the presentations although there were two (2) groups who answered the question completely. Teacher Ces evaluated quite a number of group presentations. For instance, the group presentation about the story-telling activity involved the groups' answers to the guide questions. Another group presentation Teacher Ces evaluated was a video presentation on mitosis where the groups illustrated the stages of mitosis. While one group got a good mark for a complete illustration, the rest of the groups got an incomplete mark for their illustrations. Likewise, Teacher Ces evaluated a group presentation on Activity 2 in which the groups worked on comparing mitosis and meiosis; only two (2) groups did not get all the correct answers. The presentation about a problem-solving activity

(Bikini Bottom Genetics), as well as Activity 4, was also evaluated as a group work. Finally, Teacher Des evaluated a group presentation involving a video presentation about the stages of mitosis and a problem-solving activity about dihybrid cross. All the presentations of the students were about the knowledge of a topic discussed for the day (i.e. stages of cell division and genetics problems). In all the presentations made by the students, it was observed that whether the students got perfect or imperfect scores in their presentations, the teachers assessed the students' output based on their knowledge of the topic. This was consistent with what Chivers (2007) had indicated that as a form of assessment, presentations are made by students to show their deeper understanding of a topic or text and to explain a process. Thus, it follows that all presentations should have some elements of teaching and learning as part of their purpose.

4. Boardwork. Teacher Ace prepared some boardwork for evaluation of students' learning. For instance, as some students did exercises on the board, Teacher Ace had to remind the students sitting in class to watch someone solve a problem on the board; they should follow the work of the person at the board, closely making sure they understand every step completely and double-check their work. In addition, Teacher Ace had to tell the students that if they had questions, or think they have spotted an error, they had to speak up immediately in a helpful way. Specifically, Teacher Ace prepared a blank table about the seven characteristics used by Gregor Mendel to explain the inheritance of traits. As she posted the visual aid on the board, many students volunteered to write the symbols. While the students were writing the answers on the board, Teacher Ace kept on asking "do you follow what we are

doing?" When one of the students wrote the wrong symbols, some students reacted and this made Teacher Ace call for another volunteer to change the answers. Another example was the boardwork about Activity 4, where the students were made to write and explain their answers on the board. Teacher Bes had a boardwork about Activity 4, where she asked for five volunteers to answer the activity on the board. As two volunteers had a hard time answering on the board, they got the wrong answers and for this, Teacher Bes had to call for another volunteer to change the previous answer. Another boardwork Teacher Bes prepared involved six (6) crosses wherein the students had to provide the genotypes using their own choice of letters. In the case of Teacher Ces, she prepared pictures of the stages of mitosis, which she posted on the board for a matching activity. As one student matched the pictures with the correct label, some students reacted to the answers and this made Teacher Ces call for another two (2) volunteers to correct the previous answers. After a quiz where most of the students had a low score, Teacher Ces prepared another boardwork involving the use of metacards to match the stages of mitosis to the correct label. While the students posted the cards, Teacher Ces had to go back and forth to check whether or not the students were looking at the board. As the answers were checked correctly, Teacher Ces called for volunteers to explain what happens to the chromosomes in each stage of mitosis. This boardwork provided an active interaction between Teacher Ces and the students. Likewise, Teacher Des also prepared a boardwork on identifying whether the given pair/s is/are homozygous or heterozygous. As the drill was written on the board, Teacher Des asked for an oral recitation of the answers. Another boardwork involved students' writing of their answers about Activity 3, in

which an active interaction between Teacher Des and the volunteers was observed as Teacher Des asked inquiry-based questions. In addition, Teacher Des checked Activity 3 and Activity 5 as assignments. The teachers prepared boardwork on these activities in order to check on students' understanding of concepts, as well as serve as an avenue for exercises and other activities. This is consistent with what Zakime (2021) had claimed that as in any other classroom resource or material, boardwork serves as a routine device that can be used to display relevant information (boardwork on Mendel's experiment) and to project exercises and activities (boardwork on the solution to genetics problem exercises). The author added that maintaining good boardwork practice is a simple way teachers can help the students learn. Creating a clear board during the lesson provides a clear record of the lesson, which will help students study and remember the language of the lesson.

Meanwhile, three teachers (Ace, Ces, Des) believe the need to modify the list of activities in the LM as they thought of adding more to the list. For example, Teacher Ace commented that *"The module has limited activities so I prepare some. Anyway, I have many activities for the students to work on."* Similarly, Teacher Ces shared that, *"Aside from the five (5) activities in the LM and from the list of activities, I add."* As for Teacher Des, she had to emphasize that, *"As I said previously, the LM has very limited activities, so I need to add or improvise. If I do not do this, the students will not appreciate understanding genetics."* In the case of Teacher Bes, she had to make a different modification as she remarked *"I can substitute an activity or assignment for a quiz."* In their actual teaching, there were instances where modification was made by the teachers. For example, Teacher Des had to modify the

items (basis of comparison) for differentiating mitosis with meiosis. Teacher Ces had to modify the list of activities in the LM by adding the activity about cell organelles and the activity, “Bikini Bottom Genetics”. Both Teachers Ace and Bes had to add problem-solving activities in genetics. This behavior of the teachers of “changing something” may be called innovation. According to Moreno (2000), innovation is an intentional process of change carried out by a teacher or a group of teachers who modifies contents, attitudes, ideas, cultures, models and introduces new methodologies or uses new resources and technologies in the process of teaching and learning. Similarly, Torres et al. (2017) supports that innovation generates changes in educational processes, teaching practice and results where the teacher must be involved and predisposed to change since he is the one who puts it into practice in its teaching management.

5. Objective test. Students’ understanding of science involves student learning as the teachers validate through exams and activities. All the teachers reported that they give the students a summative test as they narrated:

[Teacher Ace]: When I give a test, it is a combination of simple recall and application.

[Teacher Bes]: I give them a test of recall and analysis.

[Teacher Ces]: The test that I give is always a combination of objective and problem-solving questions.

[Teacher Des]: I give a test which is a combination of objective and practical questions.

As indicated in their responses, all of the teachers preferred a non- objective type of test. The test, as the teachers described it is “a combination of simple recall or objective type and application/analysis/problem-solving or practical questions.” This

was consistent in the actual administration of Summative/Long Test 1 and 2, where the items were patterned on how the teachers described it in the interview. As it is a DepEd order to use/apply the inquiry approach in teaching science, it is then a must that the Summative Test should also contain items that require the students to use many thinking skills. As Bhagat (2017) had emphasized, science is not simply a body of knowledge to be learned in an inquiry environment, but a way of thinking and problem-solving. Wilhelm (2014) supports that teachers should learn and teach how to ask essential questions to their students to encourage critical thinking and innovation. True enough, some of the test items in the Summative Test contained questions (multiple choice, table completion, matching type, situational analysis, problem-solving) that required the students to use critical thinking along with other thinking skills.

c. After the Lesson

Give extra work or remedial class to slow learners

After the discussion of the lesson, assessment follows. In the context of slow learners, assessment involves teacher's giving an extra work, a remedial class or reteaching, as well as extending patience. This has been reflected in the interview as the teachers narrated:

[Teacher Ace]: I know they understand the lesson if their output is ok. For those whose scores are low, I tell them that I will give an extra work. If more than 50% fails, I repeat the discussion by adding additional meetings. Sometimes, if the score is too low, I do not record it anymore. I give extra work for them to catch up. For the slow learners, if I think I need additional meetings for the problem solving activity as a review, I do it, just so the students will understand well. I need to assist the slow learners as they solve problems. I am concerned with the students because I know the topic is very abstract. This is the reason why I have to use a variety of teaching strategies

[Teacher Bes]: Of course, I have to wait for the output of the slow learners. While some groups may be fast to finish an activity, a few will be very slow

Otherwise, the slow learners will have no record of performance and this will be very unfair to them. If many fail, I do remedial classes. For the remedial class, it is a different make-up; I give the students extra activities since we do not have a common schedule. I give the students extra activities since we do not have a common schedule. This is to improve their learning as well as low scores. But any student can attend the remedial class. Sometimes, a remedial class is a performance of an activity. I really encourage the students to attend. The remedial class is done on a vacant period or a few minutes of student's lunch.

[Teacher Ces]: *For the slow learners, to make sure they understand before moving to another topic, I have to reteach the concepts. I also do remedial classes for the slow learners. I also do re-teaching, and conduct remedial classes especially if scores in test are low.*

[Teacher Des]: *I also give assignments, minimal quiz and many activities...I reteach if more than 50% failed. This is actually through a review and a remedial class. But I also give make-up exercises. The topic is difficult and I need to make the discussion easy for the slow learners to understand well. On Mendelian genetics, the topic is very abstract and difficult, so I really need a lot of strategies to make this easy to the slow learners*

As indicated in their responses, all the teachers reported about their concern for slow learners. For example, both Teachers Ace and Des felt that “if more than 50% fails,” they do some adjustment. While Teacher Ace said, “I repeat the discussion by adding additional meetings” Teacher Des pointed out that “This is actually through a review and a remedial class.. and I reteach.” Teacher Ace indicated so much concern for the slow learners as she explained that “For those whose scores are low, I tell them that I will give an extra work; Sometimes, if the score is too low, I do not record it anymore; I give extra work for them to catch up.” Likewise, Teacher Ces elaborated that “For the slow learners, to make sure they understand before moving to another topic, I have to reteach the concepts.” She added, “I also do remedial classes for the slow learners. I also do re-teaching.” With also a big concern for the slow learners, she emphasized the need to “conduct remedial classes especially if scores in test are low.” Teacher

Bes also considered that *"If many fail, I do remedial classes"* but she explained further that *"For the remedial class, it is a different make-up; I give the students extra activities since we do not have a common schedule."* The teacher added a reason for this make-up, which was *"... to improve their learning as well as low scores."* Teacher Bes continued that the remedial class is not only for slow learners, *"But any student can attend the remedial class; sometimes, a remedial class is a performance of an activity."* With concern for all of the students, she emphasized that *"I really encourage the students to attend; the remedial class is done on a vacant period or a few minutes of student's lunch."* Meanwhile, both Teachers Ace and Des realized the need for additional meetings and make-up exercises. While Teacher Ace emphasized *"For the slow learners, if I think I need additional meetings for the problem solving activity as a review, I do it, just so the students will understand well,"* Teacher Des shared that *"... I also give make-up exercises; the topic is difficult and I need to make the discussion easy for the slow learners to understand well."* Because genetics is such a difficult topic especially in applying its principle by solving problems, Teacher Ace had to say, *"I need to assist the slow learners as they solve problems; I am concerned with the students because I know the topic is very abstract; this is the reason why I have to use a variety of teaching strategies."* On the other hand, Teacher Des shared, *"On Mendelian genetics, the topic is very abstract and difficult, so I really need a lot of strategies to make this easy to the slow learners."* Interestingly, Teacher Bes expressed her special concern for the slow learners as she said, *"Of course, I have to wait for the output of the slow learners; while some groups may be fast to finish an activity, a few will be very slow otherwise, the slow learners will have no record of performance and this will be very unfair to them."* All these accounts focus on the importance of giving an extra work or a remedial class to the students especially to the slow learners.

The teachers showed specific instances where extra work and remedial classes were done in their actual teaching. For instance, after making a roll call and finding out that five (5) students failed in the quiz, Teacher Ace told them, “*to study more.*” Moreover, Teacher Ace provided additional meetings for the problem-solving activity in genetics (extra work). Because one student insisted on repeating Teacher Ace’s explanation of homologous chromosomes, the teacher had to teach it again. Also, in her discussion on homozygous and heterozygous traits, she had to repeat the statement of their difference as well as give specific examples. Likewise, when many raised their hands to ask about the lesson on dihybrid cross, Teacher Ace repeated the discussion as she gave another example. Specifically, she had two (2) sessions for the remedial classes which she did after their last period in the afternoon. As observed in one session, she concentrated on a one-on-one consultation with the slow learners particularly on how to solve problems involving monohybrid and dihybrid crosses. In the second session of the remedial classes, she asked the students to do the activity, “Dropping the genes,” where the students were asked to be paired with the opposite gender in order to understand the concept of inheritance. The group had only 12 pairs to perform the activity, while the rest of the students were asked to be observers. After Teacher Ace explained how the activity would be done, all the pairs started to do it. It was a noisy class where most of the students were laughing while others looked very focused and serious. Then after about 45 minutes, Teacher Ace discussed the concepts involved in the activity such as P , F_1/F_2 , dominant/recessive traits, genotype/phenotype, homozygous trait and heterozygous trait. After the remedial class, one student remarked that he did understand genetics. Teacher Ace said that the extra activity is not part of the textbook, rather, an activity that she previously did in her teaching practicum. She had extra three (3) problem-solving activities in genetics.

As for Teacher Bes, when she checked on the scores (quiz), half of the class passed while the rest failed. Nevertheless, she reminded those who failed to catch up by reading the module and the notes. Specifically, in the solving of a genetics problem involving dihybrid cross, her patience to wait was extended as she went from one student to another to check how the students were answering the problem. One remedial class Teacher Bes arranged was on “Human Heredity,” where the students were given genetics problems to solve. As the others were about to finish and submit the output, she had to understand the capacity of the other students so she patiently waited for them to finish the activity. She said that the extra activity is not part of the textbook, rather, an activity she took from her college laboratory manual. In the performance of the activity, Teacher Bes had to assist the students as she went from one student to another to check that they understood what they were doing. After about 15 minutes, Teacher Bes had to review first the basic genetics principles and later discussed the answers to the genetics problems. Teacher Bes explained that she had to do the extra activity either during lunch time or after their last period in the afternoon because the time allotment for the regular meeting was just enough for the planned topic. Teacher Bes shared that in all the extra activities that she has previously done, she reported that only a few students attended. When asked why, she reported that some students view this negatively; that the remedial class is intended only for the slow learners. Despite this, Teacher Bes said that she still encouraged all her students to attend the remedial class. Also, Teacher Bes really showed her willingness to repeat the discussion especially for the slow learners. For example, while one group of students found it hard to understand how the ratios of the genotype and phenotype were obtained in the given example, one member of the group asked for Teacher Bes to repeat which the teacher actually did.

In her actual teaching, Teacher Ces had to make sure that the students understand the stages of mitosis by reteaching. As she compared mitosis and meiosis using a Venn diagram, she showed the concern for slow learners by asking if they understood the concept. When the students showed understanding, Teacher Ces was prompted to proceed to the next lesson. Similarly, after discussing the Law of Segregation, Teacher Ces had to ask the class if they understood the concept before proceeding since the next lesson would focus on problem solving activities. Moreover, with a low score in a quiz, Teacher Ces had also to reteach about the stages of mitosis using big metacards as pictures. Further, Teacher Ces also had to reteach the basic genetics principles such as dominant and recessive traits, phenotype and genotype, etc. before discussing how to solve genetics problems. Meanwhile, one remedial class Teacher Ces prepared was the performance of the activity, "Modeling Meiosis", in one vacant afternoon period as she said "*anyway for those who still do not understand, attend the remedial class on Friday, 11:30-12:30.*" In this remedial class, using paper clips, clay, thread, broom sticks, the students were asked to simulate meiosis. Guided by a set of procedure printed on bond paper, in groups, the students performed the activity that Teacher Ces learned from a workshop. After about 30 minutes, Teacher Ces had a discussion again of the basic concepts of cell division using the said activity. Another remedial class involved solving genetics problems where there was a consultation of the students with her. Moreover, she said that only a few attended the remedial class because some of the students were very shy. In this case, she called each of the students to see her in the faculty room for a one-on-one remedial session which she did a number of times. Teacher Ces also prepared an activity in mitosis as an extra activity.

Finally, Teacher Des had to reteach the stages of mitosis, since the scores in the previous quiz were not good. Her reteaching about the differences between mitosis and meiosis served as

the student preparation for a quiz. In addition, Teacher Des made a reteaching on the basic genetics terms and she even gave an exercise/extra activity involving identifying whether the given pair/s is/are homozygous or heterozygous. Teacher Des had to reteach the Law of Segregation and Law of Independent Assortment in preparation for the long test. Meanwhile, she conducted a remedial class in the form of an activity, "Modeling Meiosis", the same activity that Teacher Ces asked her students to perform in their remedial class. The activity was done in one afternoon as Teacher Des used the period of one teacher who was absent that time. According to Teacher Des, the activity was very useful and effective in students' understanding of the basic concepts of cell division. As she was teaching the lesson again, she had to ask the students if they already understood the concept. Once Teacher Des had checked the students' understanding, she proceeded to the second part of the lesson. She said that she is always ready to discuss the concepts again especially if these concepts are difficult to understand.

Delos Ama (2017) supports holding remedial classes as he reported that it is a tutorial session given after a regular teaching to assist slow learners improve their learning or mastery of a lesson (cell division and Mendelian genetics,) when there is weakness in understanding a lesson and therefore needs an extra step to reinforce learning. As the students reinforce or enrich their learning through the remedial classes, the students are expected to improve learning or understanding of concepts. According to Khurshid and Bibi (2020), it is the basic requirement for the teacher while teaching slow learner students-make all the information concrete, as overt and explicit as possible in a remedial class. True enough, according to the teachers, most of the students were able to answer the genetics problems in the Summative Test and they attributed it to the remedial classes.

Development of Teachers' Pedagogical Content Knowledge

Institution-initiated Trainings. The participating teachers used four approaches in developing their PCK. The approaches involve institution-initiated trainings, self-study, collaboration with peers/peer consultation and self-reflection. Common among the four cases are the participation in institution-initiated trainings and collaboration with peers/peer consultation. The teachers' accounts on this approach are reflected in the interview responses, to wit:

I attended some seminar-workshops when I was just a college student. After the lecture of content by experts to update us, in the afternoon was the actual teaching practice. After the lecture of content by experts to update us, in the afternoon was the actual teaching practice. Because of this, I get to know more about cell division and Mendelian genetics and how these topics should be taught. During the lecture, we were given hand-outs and I still use these materials today so that I can master content. I remember, I was assigned to have a demo-teaching on using a model of mitosis using indigenous materials. I used broom sticks, thin rope, and clay. I remember, when I was making the model, the teacher-participants kept on asking me how I could show the movement of the chromosomes to the opposite poles etc. I really appreciated that I was involved in the activity and I got to experience to teach. Then I was able to observe the demonstration of other teaching practices by the other participants on inheritance of traits, human genetics and pedigree through small group discussion, reflective discussion, simulation, modeling etc. I do these strategies in my class now and I hope I can perfect it. Sometimes it depends on the situation. If it takes a longer time for a strategy to employ, I settle for a simple strategy such as the lecture method. [Teacher Ace]

Based on some in-service training seminars I attended about concepts in biology such as genetics, physiology and evolution, I develop mastery of content. It's very useful because I got to know new concepts and even correct my misconceptions. I appreciate the various teaching strategies such as experiments, modeling, simulations, problem-solving etc. that were demonstrated. I was inspired to do the same activities in my class now. Doing such activities frequently help me perfect discussing biology topics. [Teacher Bes]

In my case, yes, I got exposed to some teaching strategies due to my attendance in in-service trainings and other trainings. It has helped me develop the right pedagogy to teach biology. As I do attending these trainings, I become familiar with the strategies and I always use these in the classroom. My attendance to many seminars has helped me a lot. I became very confident and comfortable to teach bio topics. During seminars, hand-outs are given and I use these as my guide

in teaching the correct concepts in biology using specific strategies such as reflective discussion, small group discussion, simulations, experimentations, etc. I keep and study the hand-outs. I use specific strategies very frequently. I practice then if I fail, I practice again. For example, last year, I asked my class to make a "gel model" of the cell. It was a disaster because the class was not able to produce a good model, the gel was very difficult to manipulate. What happened was that, the model was messy and so with the room. So I need to perfect the procedure to try creating the better or modified model again, maybe, next year. [Teacher Ces]

My attendance to in-service trainings/workshops has helped me develop correct knowledge and learn specific teaching strategies to use. I learn the content by listening to the speakers of the workshop. As I learned the strategies from the seminar/workshops, I use them right away in my class. I make a list of the strategies, and then I choose from the list and use it when I start the discussion of a topic in biology. I use a specific strategy, I use it again until I become used to it. I use the major teaching methods such as lecture method, small group discussion and discussion method. For the specific technique, I use, experiments, individual-guided activity, demo-activities, simulations, etc. I have used the other techniques previously but this year I will use the lecture and discussion methods, specifically, small group discussion because I found these very effective [Teacher Des]

Apparently, attendance in trainings or workshops had enhanced teachers' understanding of biology or cell division and Mendelian Genetics. It also improved the way they teach biological concepts in their classes by adopting the strategies presented during trainings or workshops. As indicated in their responses, they applied these strategies in their classrooms, and they did not stop until they perfected their implementation.

These observations had confirmed the findings of empirical studies, which reported the effectiveness of informal or formal trainings in improving teachers' performance. Hussain (2004), for instance, reported that teachers who were trained through different in-service teacher training programmes were better performers than the untrained teachers. In addition, Mahmood (1998) has observed that students taught by trained teachers have greater achievements than those students taught by untrained teachers. Moreover, science teachers with in-service training were better in planning

subject content competence than the science teachers without in-service training (Shakoor, Ghumman, & Mahmood, 2013).

This improvement reflects the effectiveness of the trainings in developing teachers' pedagogical content knowledge. During trainings, teachers learn from the lecture, make interactions with the resource persons and with their fellow participants, and use learning materials. For instance, Teacher Des reported that she clearly understood the biological concepts by carefully listening to the lectures. On the other hand, Teacher Ces reported that she learned more from the trainings when she interacted with the resource speakers than just by simply listening to their lectures. Teacher Ace also reported to have learned more teaching strategies by observing and interacting with the other participants during trainings. She said that she learned such strategies as small group discussion, reflective discussion, individual activity, simulation, modeling, and the like, which she applied in her classes. Likewise, Teacher Bes got inspired to employ these strategies in her classes.

In addition, the learning materials have been useful for teachers in reviewing biological concepts and correcting misconceptions. Teachers Ace and Ces reported that they use the materials or handouts distributed during trainings in reviewing their lessons and correcting their students' misconceptions.

Self-Study. There are approaches however that are unique to either one or two investigated cases. Teachers Ace and Des reported using self-study in developing their content knowledge while adopting their mentor's teaching strategies in improving their teaching strategy. They used the learning materials such as textbooks, journals, and other

references they accumulated during their pre-service training for their self-study. These are reflected in the following responses, to wit:

My course in college, made me very comfortable to discuss cell division and Mendelian genetics using specific strategies. You know, it's good my college course was science so I've got many science subjects. We had many materials to read, read and read. We had the textbook, journals, other references. Reading these materials very frequently developed mastery of science concepts. Of course, I got to improve content. For the strategies, I learned these from my college teaching practicum. You see, my cooperating teacher was always using a lot of teaching strategies. I know some were inquiry-based when I observed her. I got to observe her use a project work such as a diorama which she used when she discussed about volcanism. Most of the time, she had an experiment and what she did was just to give the materials to the students, then the students would do their own experiment. In one lesson, she demonstrated the use of the laboratory apparatus where more discussion came from the students. Because her school had so many models, she used these frequently; she always stimulated the students to think. There were also simulations in the form of role-playing and games. Games were different; these were mind games where the students really have to think critically. She also showed film clips and video clips for reflective discussion. For problems in basic chemistry and physics, she had less discussion and more of problem-solving activities. I imitate what my cooperating teacher did. As I do it frequently, I become used to the teaching strategy but of course, I should also read and read for the content.[Teacher Ace]

I have kept some materials I used in my practicum in college which I read and use today. Reading and studying these materials help me master the concepts. I have also some biology textbooks which I always use for confirmation of correct concepts because you know, you can't teach if you do not have the knowledge. I should say, I am thankful that I majored in biology because I am comfortable to teach cell division and Mendelian genetics. For the teaching strategies, I got the idea from my mentor in the teaching practicum. My mentor was my cooperating teacher. When she just gives a lecture, the class gets bored. And the class is passive so the tendency is to end the class early. But when she prepares an experiment, all the students are active and they ask a lot of questions. I remember, one strategy she used was a debate on "euthanasia" and I commend my cooperating teacher for coming up with that activity because the students did a lot of thinking skills. I also remember other techniques she used such as small group discussion, film showing and demonstration activities. I promised to myself that when I teach biology, I will do what my mentor did, and this is what I do now. As I use different strategies, I also improve content.[Teacher Des]

Collaborate with Colleagues/Peer Consultation. All the teachers collaborate with colleagues regularly to prepare the lessons to be discussed. When they prepare what

content to discuss, the teachers reported that this is collaboration for professional learning. Generally, collaboration with colleagues involves consultation with peers who work together for mutual benefit. They narrated:

[Teacher Ace]: it is a must that we collaborate a week before the teaching of a lesson. I have been collaborating with my colleagues regarding the lessons to be discussed.

[Teacher Bes]: We meet every week before teaching a lesson. to be honest with you....before the discussion, I make it a point to collaborate with my colleagues about the topic. We have some discussions so that everybody will be guided on how the topics will be discussed. I do this because I am not very comfortable to discuss some concepts.

[Teacher Ces:] I see to it that I collaborate with them every week so that everybody will be guided. Being the head science teacher, we always collaborate with one another.

[Teacher Des]: We do it every week or should the need arise, we have to talk before discussing a particular topic. It is an SOP as ordered by our head science teacher that we collaborate with one another on the topics to be discussed.

As indicated in their responses, the teachers opted to maintain collaboration with colleagues regarding topics to discuss. It is actually a common practice among teachers as Teacher Des indicated, “*We do it every week or should the need arise, we have to talk before discussing a particular topic*” which was confirmed by Teacher Ces, being the head science teacher as she required the teachers to do it by saying, “*I see to it that I collaborate with them every week so that everybody will be guided.*” Similarly, Teacher Ace believes in the importance of collaboration as “*it is a must that we collaborate a week before the teaching of a lesson*” while Teacher Bes always remembered that “*We meet every week before teaching a lesson.*” Teacher Ace must be very proud about her constant collaboration with colleagues as she shared, “*I have been collaborating with my colleagues regarding the lessons to be discussed.*” According to De Jong et al (2019), in

collaboration, teachers can meet regularly to be updated with particular pedagogical knowledge and skills. This has been illustrated by the above cited cases.

Teacher Des has to be very obedient to her Head Science Teacher, who considers the need for reflective discussion once they talk with one another because, “ *It is an SOP as ordered by our head science teacher that we collaborate with one another on the topics to be discussed.*” This is consistent with what Planche and Donohoo (2018) had indicated, that teachers teaching inquiry as a collaborative learning design is a powerful vehicle for professional learning through its opportunities for reflective conversation. In the case of Teacher Bes, she was so honest about her need to collaborate for guidance as she humbly said, “*to be honest with you...before the discussion, I make it a point to collaborate with my colleagues about the topic. We have some discussions so that everybody will be guided on how the topics will be discussed.*” Recognizing her discomfort in teaching a lesson, Teacher Bes pointed out, “*I do this because I am not very comfortable to discuss some concepts.*” Although the head science teacher, Teacher Ces, also felt the need to collaborate for guidance as she reported, “*Being the head science teacher, we always collaborate with one another.*” This is consistent with what Davis (2003) had reported that an effective teacher collaboration is defined as engaging in regular routines, where teachers communicate for guidance in an effort to strengthen pedagogical expertise and push colleagues to try new things.

Regular collaboration is also a mandate from DepEd in terms of lesson planning and giving of departmentalized test as the teachers narrated:

[Teacher Ace]: *It is actually a year level collaboration for lesson planning, departmentalized LP and test.*

[Teacher Bes]: We collaborate with one another that is why we have common LP, test, etc.

[Teacher Des]: You must have observed that we have a common test and LP, that is the product of our collaboration. Collaboration is a must.

As indicated in their responses, the teachers recognized the need for collaboration such as when Teacher Ace emphasized that “*It is actually a year level collaboration for lesson planning, departmentalized LP and test*” which Teacher Bes similarly remarked, “*We collaborate with one another that is why we have common LP, test, etc.*” As for Teacher Des, when the researcher talked with her, she said that “*You must have observed that we have a common test and LP, which is the product of our collaboration.*” As illustrated in their actual teaching, the teachers were observed doing collaboration regarding their LP, test and the like. For instance, Teacher Ace was seen holding her lesson plan as she was about to submit it for checking. According to the teacher, the long test has also been submitted and checked by the head of the department. Both Teachers Bes and Des were observed to have consulted the head of the department for checking of lesson plans and assessment where Teacher Des emphasized, “*collaboration is a must.*”

Aside from collaborating to prepare the content to discuss, teachers collaborate in order to improve teaching practice and method. According to Ribeiro (2020), collaboration leads to more innovation, efficient processes, increased success, and improved communication. The author added that through listening to and learning from team members, you can help each other reach your goals. It takes hard work and a bit of time, but collaboration is worth it, for the benefits your team will gain. For example, the teachers reported to collaborate for mentoring, especially when a specific teaching strategy will be considered in teaching. This is a kind of innovation that the teachers may

adopt. If the strategy is effective after some colleagues try it in their class, the strategy will be adopted for use in their respective classes. Mentoring is also about borrowing of materials and asking supplementary materials that can be exchanged among the teachers.

As Teacher Ces narrated:

My constant collaboration with science colleagues is also very helpful because I get to be mentored. I can borrow materials from them and I can always ask them on additional activities and supplementary materials. It's like a roundtable discussion. One colleague will be asked to introduce one new or unique strategy she/he employed in the classroom. Then the members of the department will have to try the approach and if found effective, the teaching approach will be adopted to their respective classes.

Teacher Bes has similarly emphasized:

But before I employ this (a teaching strategy), I need to ask help from colleagues if this is all right to use. The final decision is always influenced by consultation.

Likewise, Teacher Des had a similar process of collaboration involving the use of lecture style and technology as suggested by her colleagues. She said she is used to the lecture style because of her previous teaching employment but collaboration with colleagues made her use the combined strategies where learning process becomes more meaningful.

As Teacher Des shared:

It's true that at times, I tend to always employ the lecture style method. Because I used to use this in the previous school where I worked before, I thought it is always fine to employ this approach. But I appreciate the regular consultation with my colleagues where my colleagues suggested to combine the lecture style method with technology so that the learning process becomes more meaningful. My colleagues told me to use any technology such as video animations from You Tube, multimedia presentation which may be downloaded from a good website, or even a short film.

Teacher Ace also pointed out the importance of consulting with experts as
“Collaboration is a venue for professional learning because I get to consult with

professional individuals with different expertise to share." According to Kelchtermans (2006); Vangrieken, Dochy, Raes, & Kyndt, (2015),

"Teacher collaboration is an important aspect of teachers' professional lives, as a means to continuously reflect on and improve the practice of teaching. In collaboration, teachers can critically reflect on teaching practices, provide collegial support or peer feedback, and collectively design teaching methods."

In their actual teaching, the teachers showed constant collaboration with their colleagues. For instance, when the researcher visited Teacher Ace, she was seen talking with her colleagues in the department for consultation on the implementation of a project work in the classroom. According to the teacher, she actually did the project work in one of her classes because she found it more innovative and more authentic than the previously used strategies. In another instance, during one of the researcher's interactions with Teacher Bes, the teacher revealed that her initial plan to introduce mitosis was to employ group reporting. She said that she had already assigned one group to be ready for the presentation of their output. However, as the day of the discussion was about to happen, the teacher told the researcher that she consulted her colleagues regarding the use of a more effective strategy for discussing cell division. She said that she was enlightened by her colleagues that group discussion is a better strategy to use. Without constant consultation, Teacher Bes would have settled with the group reporting which is more passive than small group discussion. As the teacher found out that the small group discussion is very effective in teaching content, she came to realize that she can use it in the discussion of other topics in biology, too. As a modification, she said that when she decides to incorporate multimedia presentation during her discussion and she mentioned that she has to always seek the approval of her colleagues regarding this. She was honest to admit that she is not a graduate of biology, that is why she is not confident to teach

some topics and this is the reason why she kept on emphasizing to always seek consultation with colleagues, make personal reflection, decide to use a strategy as suggested by colleagues and reflect afterwards whether to employ or not the suggested strategy. In the case of Teacher Des, she said that at times, when she consults with colleagues, it is about a specific strategy to use in teaching a specific lesson. She added that her colleagues seem to influence her to decide what teaching strategy to be employed in her class. According to Blanchard (2012), collaboration reinforces new styles of teaching and innovative approaches; it also fosters more effective classroom practices. This has been illustrated in the cited cases. Moreover, Teacher Des said that in one meeting with other science teachers, they had a review on the stages of mitosis and meiosis focusing on the main events that take place in each stage. According to the teacher, this collaborative meeting was very helpful because content knowledge is being checked and teachers can always improve their teaching of content. The teacher also remembered working with colleagues (one colleague was the other respondent in the study) on trying out Activity 1 in the laboratory room, which she perfected with patience. She remarked that the activity is tedious because of the preparation. However, she was not able to implement Activity 1 due to time constraint.

As the head of the department, Teacher Ces wanted to be mentored as observed in one of the researcher's visit at the faculty room where she was mentored by a colleague with expertise in biology (the mentor is a biology major graduate). According to Teacher Ces, mentoring always happens in the department regarding difficult lessons and teaching practice, problems in teaching, etc. In one instance, the teacher was seen in the laboratory room with a colleague trying out Activity 1. With the interest to learn about the activity,

the teacher kept on asking her colleague if the slide she prepared was okay. When asked, the teacher said that she had to practice so that content will be delivered correctly to the students. In another visit, after her last period in the afternoon (around 3pm), she met with a colleague to teach her the technique in solving genetics problems. In her actual teaching, she was observed confident enough in teaching the students how to solve genetics problems. As part of her everyday routine, she said that she always meets with her mentor regarding content of the lesson since she used to teach in Grade 7. As also observed, the teacher values collaboration and so for the difficult concepts written in the journal, she shared the list to the other science teachers for them to teach the concepts slowly. According to Lofthouse (2017),

Mentoring can form part of the social glue between colleagues. It encourages open discussions and creates opportunities for conversations. The mentor and the mentees work together to create a dynamic conversation in which there are opportunities to share problems, to pose and respond to questions, and to build solutions.

In another mentoring session, the researcher saw Teacher Ces and other faculty members of the science department in the school library as they listened to the sharing of a colleague about one teaching strategy (project work) in a roundtable discussion. When asked when to implement the strategy, the teacher said that she will try it some other time since she has already prepared another strategy, a story-telling activity. True enough in her actual teaching, she employed a story-telling activity to introduce cell division. As observed, the students enjoyed doing the discussion in small groups where there were active participation and interaction. As the teacher found this effective, she said that she will share this during one of their roundtable discussions.

Some teachers do the collaboration regarding answering genetics problems. For example, the researcher found Teacher Ace and another colleague in the science laboratory room where they worked together in answering genetics problems. To make the preparation complete, before going to her class, she had to try to solve genetics problems on her own. She revealed that every decision she makes is always influenced by her constant consultation with her head and other members of the Science Department. In another instance, Teacher Des described that when she consulted a colleague, they spent more than an hour to practice solving together some genetics exercises as she narrated, *“I want to make sure I am teaching them correctly how to solve genetics problems.”* She recalled that she asked many questions during the collaboration. True enough, when the class had to do Activity 4 and 5, she taught them the easy way to solve the exercises in genetics.

Other teachers consider collaboration as a venue for discussing and resolving issues and problems in teaching. For example, Teacher Des opined that when there is collaboration, it allows the teachers to come together and work by thinking and brainstorming on teaching issues and problems. The teacher reported that there was an instance when some of the science teachers met to brainstorm on doing an activity about the DNA. She claimed that they brainstormed whether or not this activity will be done considering the cost and limited time. After the meeting, they decided to do this activity at the latter part of the genetics topic. This is consistent with what Petrescu and Draghicescu (2017) had indicated, that collaboration represents an interactive-participative strategy, promoting team work, exchanging constructive idea by brainstorming and personal active participation. Moreover, Lepore (2020) reported that

“collaboration stimulates people to brainstorm by finding different ways to define issues and then come up with ideas by making connections. In another instance, Teacher Bes was seen by the researcher talk with some science teachers. She said that she confirmed some information about the fruitflies or “*bangaw*” that she mentioned in her class, which was corrected to be not “*bangaw*” but small flies found in rotting bananas and other fruits. Having known the correction, she accepted it positively. Synonymous to peer consultation, collaboration is characterized by the “right to accept or reject the suggestions of others” (Bernard & Goodyear, 1992). It can be used to describe relationships in which collaborators have neither the power nor the purpose to evaluate one another's performance. As peer consultation develops one’s professional sense of self and the members do not have direct supervisory responsibility for one another’s cases, the members simply offer suggestions, which members can accept or reject (Counselman, 2013).

Interestingly, Teacher Ace had also collaborated with her colleagues for some reasons. For example, she was observed attending a short meeting in the school library which was for collaboration on how cell division and Mendelian genetics should be taught. The head emphasized that the content should start with the chromosome and cell cycle until the specific stages of mitosis and meiosis. For genetics, the head added that Mendel’s experiment should be explained clearly so that this could be applied properly in solving genetics word problems. In another instance, the researcher saw Teacher Ace talk with a colleague on how to identify and explain easily the stages of meiosis using the model kept in the faculty room. Laughing together, the teacher had to do many trials to identify and explain the complex stages correctly.

Finally, Teacher Bes employed collaboration with peers to gain more confidence in teaching the content of the subject matter and knowledge on how to teach it. It can be noted that Teacher Bes is non-Biology major, hence she found it necessary to consult with her colleagues about the concepts she will be teaching. Teacher Bes narrated:

“I am not comfortable with biology so I have to consult my colleagues always before I start discussing a topic. Frequent consultation improves my content knowledge as well as the right teaching strategy to be used for teaching the concepts. As I do this frequently, I develop content as I teach it using a specific strategy.”

Shulman (1987) explained that colleagues who are good teachers themselves are an important source of information and encouragement for teaching development. They usually have a grasp of what is involved in facilitating learning. If colleagues are teaching in the same discipline as similar to one teacher, they are also the best judges of matters concerning content accuracy, currency and appropriateness (Shulman, 1987).

Self-Reflection. Though different in approaches used, these teachers have developed their pedagogical content knowledge through reflecting on their prior experiences and existing capacity. Oskarsson (2014) had indicated that “teachers both receive knowledge by learning from others, and produce new knowledge, in that they reflect upon the received knowledge in the light of their teaching practice and educational context.” As reflected in the interview responses of the participating teachers, reflection has helped them produce a kind of pedagogical content knowledge relevant for their specific context (Oskarsson, 2014). The teachers narrated:

[Teacher Ace]: Then I was able to observe the demonstration of other teaching practices by the other participants on inheritance of traits, human genetics and pedigree through small group discussion, reflective discussion, simulation, modeling etc. I do these strategies in my class now and I hope I can perfect it. If the students lack knowledge about the topic, they are not motivated to do inquiry-based activities.

[Teacher Bes]: I appreciate the various teaching strategies such as experiments, modelling, simulations etc.that were demonstrated. I was inspired to do the same activities in my class now. Doing such activities frequently help me perfect discussing biology topics. I know the knowledge capacity of my students so I collaborate with colleagues to make revision based on students' mental ability.

[Teacher Ces]: During seminars, hand-outs are given and I use these as my guide in teaching the correct concepts in biology using specific strategies such as reflective discussion, small group discussion, simulations, experimentations, etc.I keep and study the hand-outs. I use specific strategies very frequently. I practice then if I fail, I practice again. Even I always use it, I feel sad. Because, when I ask them with why or how questions, I observe that the students cannot express themselves. I believe that it is due to the fact that the content is lacking.

[Teacher Des]: I also remember other techniques she (her mentor) used such as small group discussion, film showing and demonstration activities. I promised to myself that when I teach biology, I will do what my mentor did, and this is what I do now. I know the activities in the Learner's module are inquiry-based but I need to have some modifications in the experiment/activities for better understanding of the students. I have to consider the background knowledge of the students. If the student does not have the basic background, use of the inquiry approach is not effective.

In addition, teachers' reflection and analysis of their practice result in self-study.

According to Cole and Knowles (2000), through systematic reflection and analysis of practice, teachers become responsible for their own professional development. Whitehead (2000) reported that the use of reflective practice could encourage teachers to make explicit links between their individual learning and teaching theory and classroom practice.

Active PCK Components in Using the Inquiry Approach

Knowledge of Instructional Strategies and Knowledge of Students' Understanding of

Science were found to be the active PCK components as the students showed active participation.

Knowledge of Instructional Strategies. The data from interviews (pre and post) and classroom observations confirm the ability of the teachers to select appropriate instructional strategies in using IBA. Except for Teacher Bes, the rest of the teachers started the lessons on cell division and Mendelian genetics with motivational activities, where there was student engagement because the students were motivated to participate actively and do critical thinking. This is consistent with what Tofade et al. (2013) had indicated, that motivational activities done in a classroom stimulate the students' recall of prior knowledge, promote comprehension, and, most importantly, build critical thinking skills. Where the lesson had to be continued the next day/s, the teachers also prepared simple motivational activities through a short review of previous or past lessons, through visual materials and through an activity. For instance, Teachers Ces and Des prepared an ice-breaker and asked students to bring a family picture, respectively, as simple forms of motivational activity where the students were energized and were observed to be so much engaged. This is consistent with what Chin and Osborne (2008) had indicated, that motivational activities create an inquiry environment that makes active learning very evident.

The interview and classroom observations also highlight the teachers' use of cooperative learning, where interactive activities were done to deliver the content more effectively as they could motivate students' participation. For instance, the group discussion on the stages of mitosis created an active environment, as the students exchanged ideas and opinions, participated actively, asked questions and did critical thinking to come up with an output. According to Alberta Learning (2002), cooperative learning involves students working actively in small groups to complete tasks or projects.

As “ active participants,” cooperative learning activities play an important role in encouraging the students to take responsibility for their learning. As observed, there was no instance of “laziness” or “inactive participation” of the students, as an activity was done for a group discussion.

All the teachers used models and prepared various forms of representations such as pictures, visual aids in textual form and personal illustrations along with a video presentation to help the students understand the concepts more efficiently. As observed, in using modelling and various visual materials, there was student engagement as the students participated actively when the teachers asked questions. Baranowska-Piasek (2002) claimed that, in general, forms of representations are a useful resource for teaching that enable the development of a wide range of thinking skills (i.e. describing skill, enumerating skill, analyzing skill, critical thinking skill, reflective thinking skill and creative thinking skill) because teachers are motivated to ask questions about what the students think on the representation they are viewing. In the study, it was observed that most of the questions asked by the teachers ranged from simple (what questions) to many of inquiry-based types of questions (why, how, in what way, what do you think will happen, etc.). According to Kawalkar and Vijapurkar (2011), teachers’ questions are important because they influence the nature of students’ thinking and they determine the quality and level of students’ participation. In addition, they can be indices of quality teaching. As observed, when the teachers asked questions, student thinking was stimulated actively so that the students came up with ideas and opinions (*i.e.* defining mitosis in own words; predicting ratios). Swan and Pead (2008) support that when a teacher asks good questions (how and why questions), the students are encouraged to

think critically and make reasoning. In addition, the students' responses are followed up in ways that encourage deeper thinking. Kawalkar and Vijapurkar (2011) also support that teachers' questions in the inquiry classroom not only explore and make student thinking explicit in the class but also serve to guide and scaffold it.

A variety of activities prepared by the teachers also promote active students' participation. Some of these activities include bringing a family picture, story-telling activity, oral activity, hands-on exercise and a drill. The students' bringing of a family picture in the classes of Teachers Ces and Des motivated the students to share the characteristics they inherited from their parents. As the students looked at the picture, they described what they saw. They were involved actively as they volunteered to be the first to share. On the other hand, the story-telling activity was a very effective approach where active students' participation was observed as the students exchanged ideas and communicated with each other. The last three activities involved a problem-based method where the students were active in solving problems (Martin-Hansen, 2002). According to Jones (2006), the problem-based method is an active process that stimulates students' self-learning and increases students' motivation. Guido (2016) supports problem-based method as it promotes long-term knowledge retention by encouraging students to discuss and answer teacher's questions about new concepts.

Knowledge of Students' Understanding of Science. This domain is also an active PCK component where the students are active and prefer to express their ideas by asking questions.

Chin (2008) reported that questions from students indicate that they have been thinking about the ideas presented and have been trying to link them with other things

they know as illustrated in the following instances. When Teacher Ace was implementing the motivational activity on taking a bath, one student was motivated to ask a question, *“Is there a scientific explanation for taking a bath?”* If this was not asked, the students might just link taking a bath to personal hygiene. In another instance, after seeing a video about the chromosome, one student of Teacher Des participated actively as he asked, *“Ma’am, how important are the chromosomes?”*, which the teacher discussed by showing its picture. If this was not asked, the students might just possibly link chromosomes to longitudinal structures of dividing cells as always seen in pictures in books. In Teacher Ces’ class, one student was so engaged while examining the chromosomes under the microscope that he asked, *“Ma’am, why are the chromosomes colored? What makes them colored?”* These are questions of inquiry, which made Teacher Ces explain that *“it’s due to the staining solution used to color the chromosomes to make them visible and evident.”* The student continued, *“So Ma’am, we cannot use just any dye to color the chromosomes?”* Teacher Ces said, *“Yes, because there are specific staining solutions that can only be absorbed by the chromosomes.”* These questions of inquiry might have prevented the student from linking staining solution to just an ordinary commercial staining solution that most students know.

Chin (2008) also pointed out that the source of students' questions is a gap or discrepancy in the students' knowledge or a desire to extend their knowledge in some direction as illustrated in the following instances. In the discussion of the cell cycle, as a gap in her knowledge, one student of Teacher Ace was very active to ask *“What is the importance of the Interphase”*, which Teacher Ace explained. If not asked, the gap in the student’s knowledge would have possibly remained to be that the interphase is a process

different from G₁, S and G₂. Another instance involved the student's question about the DNA as she asked Teacher Ace, "*Ma'am how important is the DNA?*" Similarly, as Teacher Bes used the Smart TV in teaching about the chromosome and cell parts, one student was so participative in the discussion as she asked, "*Ma'am what is the genetic material?*" If this was not asked, the student's idea would have been limited only to the DNA being a double helix (because this is always how it is described in books), so Teacher Ace explained that "*DNA is the genetic material passed across generations that is organized as beads on strings to form chromosomes*"; however, Teacher Bes simply said, "*it's the DNA.*" In another instance, when discussing about the cell cycle, one student of Teacher Ces asked, "*Ma'am, how is the nucleus related to DNA?*" This question extends student's knowledge as Teacher Ces explained that "*the nucleus contains the DNA that is organized in chromosomes.*"

Asking questions allows the students to articulate their current understanding of a topic, to make connections with other ideas, and also to become aware of what they do or do not know. In this regard, student-generated questions are also an important aspect of self-assessment (Black, Harrison, Lee, & Marshall, 2002). This was illustrated in the following instances. In one class of Teacher Ace, articulating her knowledge of the topic, one student asked, "*Ma'am, based on advanced reading, I came across about homozygous and heterozygous, what are these Ma'am?*"? Teacher Ace emphasized that "*some pairs may be homozygous which can be either dominant (AA) or recessive (aa) and heterozygous (Aa).*" One student who was not aware of the concept, further asked, "*Ma'am, what does it mean when the dominant trait prevents the expression of the recessive trait?*"? Using the previous example to understand the principle, Teacher Ace

said that in *“Tt, if T is dominant and t is recessive, then the trait is still dominant because the presence of T prevents the expression of t.”* Further, when one student of Teacher Des asked, *“Ma’am when is the recessive trait expressed?”* One student eagerly answered that *“it’s only when the trait is in homozygous condition; for example, Dd is still dominant but dd is recessive.”* Such questions of the students articulated what they do not know about some basic genetics principles and the clarifications by the teacher made facilitated students’ understanding of the concepts.

The questions may also stem from curiosity about the world around them, as well as events and interactions with real-world issues (Chin, 2008) as illustrated in the following instances. In one class of Teacher Ace, the students were actively involved by participating in the discussion as they raised their hands, recited orally and performed the solution on the board as one student asked curiously, *“Does it mean Ma’am, our chromosomes can’t be beyond 46?”* As the teacher said *“yes,”* she continued that, *“otherwise, we would be another organism.”* Moreover, as Teacher Ace’s students were very active in sharing about their family’s characteristics, one student said that *“We got the good traits from our parents,”* which made one student to react curiously (since it is true that there are also bad traits) by asking, *“What about the bad traits?”* Teacher Ace explained that *“Whether the traits are good or bad, these are actually the combined traits we got from our parents.”* She added that *“The principle behind is genetics, because it is the science of heredity and variation, and this is actually our lesson for the day. Heredity is the passing of traits from parent to offspring while variation refers to differences in characteristics.”* Further, in Teacher Ace’s discussion about cytokinesis, one student was very curious to know more about this concept as she asked, *“How is cell plate different*

from cleavage furrow?” The difference was clearly described as Teacher Ace drew the process on the board. With a curious mind, one student of Teacher Bes actively asked, “*Ma’am, what does diploid mean?*” in which Teacher Bes explained, “*it means $2n$, having a complete set of chromosomes.*” Another instance of curiosity (thinking ahead of possibilities) involved one student of Teacher Des who asked, “*Ma’am, does it mean it can never be XXY or XYY?*”, to which the teacher reacted that “*if it is the case, then, these must be specific disorders which we will discuss later.*” Further, when showing the model of meiosis, one student of Teacher Ace curiously asked “*Why does meiosis have to be very long?; why does it have many stages?*”, to which answers were discussed as the teacher used the model. Other questions asked based on curiosity that were clarified by the teachers are as follows:

“Ma’am, where are homologous chromosomes found?” “Can you describe what hemophilia is? Cry of the cat? and, what is the importance of getting probabilities in a cross?” [T. Ces’ student]

“Ma’am how did you arrive at the ratios?” [T. Bes’ student]

While students' questions serve useful functions for learners, they are also helpful to teachers in prompting reflective thought and student engagement (Pizzini & Shepardson, 1991) as illustrated in the following instances. When one student of Teacher Bes asked, “*Is meiosis very much different from mitosis?*”, this was answered by the teacher’s mention of some of the differences between the two processes. This allowed for further student engagement as other students asked related questions. One student asked, “*Ma’am, which is the longest phase?*” while another student further asked, “*Ma’am, is sex cell the same as reproductive cell?*” Likewise, on Mendelian genetics, when one student of Teacher Ces asked, “*Ma’am, what about if there are two (2) kinds of*

characteristics crossed? Is it possible?" This triggered another student to ask a question, too. The question asked was, *"What does it mean when we see AAB_?"*, which the teacher explained that *"the blank means that it's either dominant or recessive."* Moreover, when Teacher Des mentioned the germ cells, one student eagerly asked, *"What's a germ cell?"* while another student further asked *"Where does mitosis take place?"* To this, one student answered *"sex cells."* This conversation prompted in the teacher a reflective thought as she clarified, *"Isn't it that sex cells are in meiosis?"* Teacher Des further emphasized that *"Meiosis involves sex cells or germ cells while mitosis involves the somatic or body cells."* As another student asked, *"Ma'am, why are there 4 haploid cells in meiosis?"*, Teacher Des explained using a visual aid and that this is due to the fact that meiosis has *"two (2) stage types of division..."*

The Teachers' Mental Construct of IBA

The teachers' mental construct involves views and perceptions on the inquiry approach. Table 14a reveals teachers' mental constructs of IBA from interviews, while Table 14b reveals teachers' mental constructs of IBA from classroom observations, which involve that concept that the inquiry approach is a paradigm shift, student-centered, motivational, and promotes higher order thinking skills. However, they also viewed the approach as resource- and time-consuming and requires good prior knowledge and skills of students.

Table 14a. Emergent Themes on the Teachers' Mental Construct of IBA from Interviews based on Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – Teacher A, Teacher B, Teacher C and Teacher D).

me	Extracted Code	Description of Theme	Sample Response/Entry
a m	Implementation using inquiry is a paradigm shift and it is institutional	Teacher's perception of IBA as a paradigm shift means from traditional to new approach	Unknowingly, I am doing the paradigm shift because I used to do lecture in all of my discussions. where she allowed her students to discover the characteristics of chromosomes that are undergoing a cell division through a laboratory activity instead of simply doing a lecture presentation
- d	Inquiry approach is student-centered.	Teacher's perception of IBA as student-centered focuses on the students as the key players	The students learn to explore more on their own and explore through their initiative The inquiry approach makes the students become inquisitive and curious, and they also learn reflective thinking I always want my students to do reflective discussion through analysis of illustrations, diagrams, models.
uses art of ning	Inquiry approach is for the art of questioning	Teacher's perception of IBA focusing on the art of questioning means that the students are motivated to ask questions	The focus of the inquiry approach is the art of questioning. The inquiry approach is student-centered. She also said that "I believe I am always using the inquiry approach..."
es order g	Inquiry approach explores on student's initiative Inquiry approach makes curious and inquisitive students Teacher as facilitator develops student's critical thinking	Teacher's perception of IBA promoting higher order thinking skills is the main purpose of the new approach	The students learn to explore more on their own and explore through their initiative. I think students learn about cell division stages and solving problems in Mendelian genetics. Students learn to be very curious and inquisitive. The inquiry approach makes the students become inquisitive and curious, and they also learn reflective thinking. In using the inquiry approach, I think the teacher is the facilitator who should always ask critical questions where students learn to be very curious and inquisitive
tional	Inquiry motivates learning and skills development	Teacher's perception of IBA as motivational means students' active learning	In doing an inquiry-based activity in the classroom, the students are motivated to <u>learn</u>
quires rior dge lls of	Student's lack of content prevents doing inquiry in the classroom	Teacher's perception of IBA requiring good prior knowledge and skills of students lies on the role of the teacher	One limitation is characteristic of student. I have to consider the background <u>knowledge</u> of the students.
quires me es	Limited time for use of the inquiry approach Preparation is needed when inquiry is used Non-doing of experiment due to limited facility	Teacher's perception of IBA requiring more time and resources is one important limitation of the approach	Preparation and implementation are too long. Inquiry is useful but needs longer time to finish long and difficult activities. ... the time is not enough to make the preparation. A lot of preparation is needed to be able to perform an inquiry-based activity. It is difficult for me to facilitate the discussion if I am not prepared. But it is not easy to do it. A preparation is needed. I cannot do that with my class because we do not have the facilities.
ut ons	Inquiry is useful but not frequently used Inquiry-based activities in the module should be modified	Teacher's perception of IBA as useful but with limitations poses on the challenge to the teachers	A lot of preparation is needed to be able to perform an inquiry-based activity. ... I still find IBT <u>useful</u> but I do not do it frequently. I know the activities in the Learner's module are inquiry-based but I need to have some modifications in the experiment/activities for better understanding of the students A lot of preparation is needed to be able to perform an inquiry-based activity.

Table 14b. Emergent Themes on the Teachers' Mental Construct of IBA from Classroom Observations based on Constant Comparative Analysis of the Four (4) Teachers (Note: Color Coding of the Teachers – Teacher A, Teacher B, Teacher C and Teacher D).

Theme	Extracted Code	Description of Theme	Sample Response/Entry
a paradigm shift	Implementation using inquiry is a paradigm shift and it is institutional	Teacher's perception of IBA as a paradigm shift means from traditional to new approach	From lecture to using pictures and using the Smart TV From non-doing to conducting an experiment
student centered	Inquiry approach is student-centered.	Teacher's perception of IBA as student-centered focuses on the students as the key players	usually divides her class into four (4) or five (5) groups depending on the number of students present work on images of the stages of mitosis. She then allowed her students to work independently in answering the guide questions she prepared. The students conducted an experiment where they observed actual dividing cells The students had reflective discussion about the identify of an unknown picture of a cell. In a discussion that was student-centered, she never forgot to ask for questions or clarifications, solicit reactions or feedbacks, and inquire on misunderstandings or confusions.
focuses on the art of questioning	Inquiry approach is for the art of questioning	Teacher's perception of IBA focusing on the art of questioning means that the students are motivated to ask questions	As Teacher Cex had emphasized, questions do not only gather information about the story. They also process the creative, reflective, and critical thinking skills of the students
promotes higher thinking skills	Inquiry approach explores on student's initiative Inquiry approach makes curious and inquisitive students	Teacher's perception of IBA promoting higher order thinking skills is the main purpose of the new approach	After the discussion, she asked the students to present their synthesis before the class and encouraged other groups to ask questions about the presentations of their classmates. Teacher Ace believed that asking these questions indicates that the approach has aroused students' curiosity and interest to learn. The group then identified the functions of these organelles based on the story. They discussed among themselves <u>what</u> they have identified and later reported them before the class. The challenge on the students on "how traits are inherited" made them use their thinking skills. She observed that her students had always something to ask during her classroom teaching transaction
motivational	Teacher as facilitator develops student's critical thinking Inquiry motivates learning and skills development	Teacher's perception of IBA as motivational means students' active learning	Use of personal experience to motivate the class Use of Smart TV to show picture of a chromosome to motivate the class Use of a story-telling activity to motivate the class Use of a video to motivate the class to motivate the class
requires good prior knowledge and skills of	Student's lack of content prevents doing inquiry in the classroom	Teacher's perception of IBA requiring good prior knowledge and skills of students lies on the role of the teacher	her students actively engaged in the discussion and even provided a variety of answers based on their experiences while taking a bath. It is here where she introduced the concepts of cell division. to enhance students' learning, she discussed with them human reproduction emphasizing the specific traits inherited from parents as a background information for her discussion in Mendelian genetics. had a review on the stages of mitosis using the Smart TV so that she could link this concept to meiosis. Reviewing about the Law of Segregation and Law of Independent Assortment was necessary so that the knowledge learned can be applied in solving genetics problems.
requires more time resources	Limited time for use of the inquiry approach	Teacher's perception of IBA requiring more time and resources is one important limitation of the approach	had to search the net for a film on meiosis for the activity she planned for her regular class since they do not have the microscopes needed to observe the process. Aside from spending time to search for the right video clip, she also needs the time to show it to her class the process (cut-outs of mitosis stages) is tedious and time consuming and requires several preparations recalled the long hours she allotted for the preparation of the materials and developing the implementation strategy since the activity should be done within the allotted time for the topic modified Activity 2 for more knowledge to learn about cell division
useful but with limitations	Preparation is needed when inquiry is used Non-doing of experiment due to limited facility Inquiry is useful but not frequently used Inquiry-based activities in the module should be modified	Teacher's perception of IBA as useful but with limitations poses challenge to the teachers	Non-doing of an experiment Though Act 1-5 are all inquiry-based activities, the students performed 2 activities only Repeating certain parts of the lesson also ate time so Teacher Dev made adjustments by resorting to teacher centered discussion.

IBA is a Paradigm Shift. Grade 8 Teachers considered IBA as a paradigm shift, where they have to change the focus of the teaching-learning process from them, as the key knowledge holders, to their students. They reported that currently they need to consider inquiry in their teaching of science, as Teacher Bes had indicated in the interview. According to her, IBA *“is a paradigm shift because we consider the inquiry approach in our science teaching which we have not done before.”* The teacher reported that they (colleagues in the department) integrated inquiry-based activities in their current teaching-learning processes, which is by far, different from simply delivering a lecture as their former teaching strategy. Previously, Teacher Bes was just using the lecture method in teaching cell division and Mendelian Genetics. Under the new approach, she implements small group discussion or cooperative learning more often, as well as use a variety of learning materials in discussing about these topics. As she narrated:

“Unknowingly, I am doing the paradigm shift because I used to do lecture in all of my discussions; I want to change my practice that’s why I do group discussions frequently; I prepare a lot of learning materials which I did not do before; I just used the textbook before, I seldom used learning materials; I want to think that the learners understand more actively though the inquiry approach is hard to implement.”

Teacher Ces also reported a similar change in her teaching approach, where she allowed her students to discover the characteristics of chromosomes undergoing cell division through a laboratory activity, instead of simply doing a lecture presentation. She now allows her students to observe a specimen under a microscope to be able to answer inquiry questions like *“In what way is one stage of mitosis you observe different from the other stage/s observed by the other groups?”* With a limited number of microscopes in their school, she divides her class into small groups to explore and discuss the answers to

such a question. After her students reported their answers, she then supplements their knowledge with a clarification and correction of their misconceptions using their textbook. She narrates:

[Teacher Ces]: After the experiment, we use the textbook to determine the correct concepts involved in the activity so I both do an activity and the textbook to prevent misconceptions. It's not good that I only rely on myself.

In their actual teaching, while Teacher Bes showed a paradigm shift from lecture to using pictures and using the Smart TV, Teacher Ces maintained the conduct of an experiment about cell division. According to Blessigner et al. (2018), a paradigm shift is a radical change in the core concepts and practices of a given domain, discipline or field. Paradigm shifts can occur at any of these levels and may cut across these levels. This change has been precipitated by unprecedented demand for high quality and meaningful education at all levels across the globe. As indicated in the teachers' responses which are consistent in their actual teaching, there has been a paradigm shift from traditional to more innovative teaching practices.

IBA is student-centered. The teachers also considered IBA as student-centered, where it allows students to explore the concepts of cell division and Mendelian genetics on their own. Student-centered has been repeatedly mentioned in the interview and has been associated with students' self-exploration of the concepts, which allows them to become inquisitive and reflective as narrated by Teachers Bes and Ces:

[Teacher Bes]: The students learn to explore more on their own and explore through their initiative. I think students learn about cell division stages and solving problems in Mendelian genetics.

[Teacher Ces]: The inquiry approach makes the students become inquisitive and curious, and they also learn reflective thinking. I am sure students learn to experiment on plant and animal cells.

Dividing the class into small groups and providing them with guide questions in studying the stages of mitosis through models and other forms of representations is a common practice among the teachers and is perceived to be a student-centered learning environment. In Teacher Bes' actual teaching, student-centered environment was established during small group discussion, like the group activity on mitosis where she reported dividing her class into four (4) or five (5) groups, depending on the number of students present to work on the images of the stages of mitosis. She then allowed her students to work independently in answering the guide questions she prepared. She gave them time to discuss among themselves their answers to the questions. The group then chose a reporter who presented their answers to the whole class. At the end of the presentation, she then synthesized the points raised by the reporters and corrected the misconceptions presented. In another instance, she gave opportunity for the students to help each other in answering board work during the conduct of the problem-solving activities in genetics and Activity 4. Although aside from this circumstance, Teacher Bes created rather a passive, teacher-centered environment even when she combined her lecture with technology; passive, since students were silent during recitation but noisy during discussion; and teacher-centered, since Teacher Bes opted to discuss the entire lesson through the traditional lecture style method, because the class was not participating or sharing any of their ideas. Nevertheless, classroom technique specifically, cooperative learning, at least created a student-centered environment.

Teacher Ces believes that as the students learn to conduct an experiment that is inquiry-based, the students become inquisitive, curious and reflective thinkers. In her actual teaching, Teacher Ces was able to create and sustain a student-centered

environment during the entire observation period. Her enthusiasm and apparent concern for the well-being of her students influenced their rate of motivation to learn. Starting from the recall part about cell organelles in Day 1, she already established rapport with her students by asking questions they can easily understand and answer. She combined it with fitting praises and enjoyable interaction with her modulated voice to capture the attention of the students. A very good point went to Teacher Ces for actually performing an experiment in her class – something that the other three (3) teachers were not able to do. By preparing a slide of an onion root tip, the students were able to see a live demonstration of mitosis in action. Thus, specific classroom techniques employed by Teacher Ces created a student-centered environment. Her group activity about “Smart Workers of the Company”, the story of the cell parts working in a factory got the students engaged with the lesson, as they shared their own inputs and got into discussion with their classmates. The only thing Teacher Ces did in this activity was to ask questions and clarify the misconceptions of some students. Everything else - description, analysis, and reflection- was done entirely by the class. Moreover, the small group discussion on the stages of mitosis allowed the students to summarize main ideas and analyze the concepts. In small groups, the role of each *student* is to help other *students* to develop their own ideas. Sometimes coupled with videos, the cooperative learning employed by Teacher Ces allowed students to respond to what they have seen and to conduct a group analysis on the main ideas of presentations.

Moreover, Teacher Ces used some forms of representation that made students’ learning student-centered. For example, in the discussion of the stages of mitosis where she played a video, Teacher Ces constantly checked if the students understood what they

are seeing and occasionally dropped facts. After the video, she asked the class to describe each stage of mitosis, and dared other students who did not recite to react to the answers. Further, she used other forms of representation, such as pictures, personal illustrations, and visual aids in textual form about cell division and Mendelian genetics. As the students discussed the specific topic on their own in small groups, learning became student-centered. The problem-solving activities in Activity 2, 3, 4 and 5, which the students conducted, developed their problem solving skills where they integrated the theory of inheritance with practice and applied knowledge to solve particular problems. Such student-centered activities created a better learning experience among the students. More problem-solving exercises in genetics were done by the students, which took a student-centric approach. Her incorporation of a worksheet (“Bikini Bottom Genetics”), which was not part of the LM, was student-centered as the students analyzed and solved problems in genetics. The completion of problem-solving exercises allowed for a better understanding of the processes involved as well as the outcomes obtained. Another method she used was a role-playing activity as a springboard for the discussion of genetics. In this activity, a selected student acted as Gregor Mendel as he answered questions thrown by Teacher Ces during the presentation. Apparently, this had also been her method of checking if the students were reading their learning modules or not.

Similarly, Teacher Des reported that she uses cooperative learning as a form of student-centered learning approach. In her case, she allows her students to analyze illustrations, diagrams, or models of cell division, discuss them, and come up with concepts that describe the stages of the process. She considered the approach as effective

where students can talk about concepts and come up with good points or ideas. As she reported:

I always want my students to do reflective discussion through analysis of illustrations, diagrams, models. I think the group exercise is the best method to teach cell division because the students can talk anything about a concept, or an issue and they are able to come up with good points or ideas.

In her actual teaching, the student-centered environment was established as Teacher Des asked the students to go to the front to explain inheritance of traits in their family using a family picture. This motivational activity created a classroom where the students shared opinions, insights, ideas and own interpretation. Teacher Des focused on individual learning through this sharing, as she also acknowledged each student's insights, as she related them to the topic. This activity created a better learning experience among the students. Cooperative learning was also used by Teacher Des to create a student-centered environment. Coupled with a video presentation, the small group discussion on the stages of mitosis involved Teacher Des' asking "Why?" and "What do you think?", which were enough to encourage students to deepen their understanding of the concept. Moreover, Teacher Des asked the students to perform in small group discussion Activity 4 and 5, while Activity 3 was done individually. In these problem-solving activities, learners get to think "out of the box", looking for the correct solution, which involved communicating with group members while discussing a particular solution. This happened during the small group discussion when they discussed the solution to the genetics exercise. More group problem-solving exercises were done by the students, which made the student discuss and solve on their own. In one of the

presentations, when someone answered wrongly, she gave the class the liberty to correct him/ her or state their suggestions before giving the final answer.

Though Teacher Ace did not mention the student-centered nature of IBA in the interview, this was observed in her actual teaching. In a discussion that was student-centered, she never forgot to ask for questions or clarifications, solicit reactions or feedbacks, and inquire on misunderstandings or confusions. The students were quite comfortable with Teacher Ace; the only downside was them sometimes being too noisy in class. By frequently doing group discussions and sharing, Teacher Ace promoted class interaction and let the students take the limelight in presenting what they have learned about the lesson. For example, she asked the class to divide themselves into five (5) groups for a small group discussion on the stages of mitosis based on a model of mitosis. After 20 minutes of discussing, exchanging thoughts, and sharing opinions, a presentation took place with one student-representative in front. This student-centered activity allowed the students to come up with their own description of the characteristics of each stage of mitosis based on the given model. Another student-centered activity was Activity 2, which the students conducted to discuss how they could compare mitosis with meiosis in terms of four (4) characteristics. Just like the previous activity, the representative posted and presented the group's output on the board. This particular activity served as the continuation of the first activity that used a model where the students, on their own, worked on the differences between mitosis and meiosis. With a student-centered environment, the students are able to work independently. Similarly, the student-centered environment was evident as the students performed individually Activity 4 and Activity 5 of the LM. In these activities, guided by the knowledge created through the use of the

model of mitosis, the students learned using thinking strategies. Likewise, more problem solving activities involving monohybrid and dihybrid crosses created a student-centered environment because the students analyzed the problems independently.

Teacher Ace's construct of inquiry as student-centered must be because she made use of forms of representations in her discussion. For example, when she discussed mitosis, she used the model as she asked inquiry-based questions such as "*how do you describe the chromosomes in mitosis? and based on this model, in your own words, how do you define mitosis?*" Asking these questions made the students think critically and participate actively during the discussion, as the students were able to give their description of the chromosome. A student-centered environment was also observed in Teacher Ace's discussion of Mendel's experiment through a personal illustration. As she asked some inquiry-based questions, the students did specific thinking skills such as providing own examples to differentiate important genetic concepts. The focus of instruction were the students because instead of Teacher Ace, they were the ones who explained the answers to her questions. It could be noted, however, that the student-centered nature of the discussion was made possible through Teacher Ace's explanation of the experiment.

All these accounts of the teachers are consistent with what Bransford et al.(2000) had indicated, that by placing students at the center of instruction, there is a promotion of a learning environment more amenable to the development necessary for students to become independent and critical thinkers. The authors added that a student-centered learning is an environment that moves students from passive receivers of information to active participants in their own discovery process. Although such practice achieves

certain levels of student-centeredness like student cooperation, interaction, and reflection (Zeki & Sonyel, 2014), it fails to fully develop self-regulation and autonomy. The teachers still have certain dominance over the learning process of the students. According to Paris and Combs (2006), the teacher and students in a student-centered learning environment are co-participants in the learning process, while the teacher strives toward intense student engagement with the curriculum. Teacher's dominance may forfeit the student-centeredness in the learning process and reduce co-participation. Nonetheless, the use of small group discussion has effectively exchanged ideas among the students, which may have developed students' academic and social skills as evidenced by their participation and presentation (Zeki & Sonyel, 2014). Gorzycki (2010) supports that in small group discussions, the students are engaged in analyses, evaluations, problem-solving, and processing information. Moreover, the use of forms of representations and problem-solving activities likewise create a student-centered environment. As the teachers reported, while the students are able to talk in the small group discussion and are able to come up with good points or ideas, the use of representations during discussion of concepts as well as doing problem-solving activities involve active learning, in which students solve problems, answer questions, discuss, explain, debate, or brainstorm during class (Dochy et al., 2003).

IBA promotes higher order thinking skills and focuses on art of questioning. IBA has also been considered as an approach that develops higher order thinking skills of the students. The teachers looked at it as a teaching strategy that promotes the art of questioning, which in turn, allows the development of students' critical, reflective, problem-solving skills, as well as inquisitiveness and curiosity. As Teacher Ces had

indicated during the interview, the *“focus of the inquiry approach is the art of questioning; the inquiry approach makes the students become inquisitive and curious, and they also learn reflective thinking.”* According to her, it facilitates the asking of questions in the classroom although it is usually the teacher who initiates the asking or encouragement for them to ask questions; as Teacher Ace had also indicated, *“I encourage them to react by asking questions during presentations of output. I tell them they can ask any question that will require them to think critically.”* Teacher Ces considered characteristics of IBA as she narrated:

- I believe I am always using the inquiry approach as a form of any of the following:*
- a) intellectual discussion among students about the topic*
 - b) enhancing the query of a topic by art-of-questioning*
 - c) assessing thinking ability of students HOTS. Inquiry is for the art of questioning.*
 - d) understanding the mood of the students*
 - e) compelling myself as I enter the room*

In her classroom, Teacher Ces used a story-telling approach in discussing the functions of the different cell organelles (Appendix T). The story is about the complaint of a group of organelles as “company workers “ (mitochondria, lysosomes, ribosomes, Golgi bodies, and endoplasmic reticulum) who claimed that while their work is very tiring and routinary, the work of the other group of organelles (cell membrane, cell wall and chloroplast) is very light. To clarify the complaint, in an emergency meeting, the nucleus as the “head of the company” gives the workers a chance to defend their side. She divided her class into small groups where she distributed a copy of the story and a list of guide questions. The group then identified the functions of these organelles based on the story. They discussed among themselves what they have identified and later

reported them before the class. Students could ask questions about their classmates' presentations. Questions raised during the activity were as follows:

1. *Why are the organelles in the story complaining?*
2. *Do you agree or disagree with the first group of organelles in the story? Why?*
3. *How important are these organelles in the company? Give their duties.*
4.
 - a. *Why do you think the chloroplast agrees with the mitochondria?*
 - b. *In what way are they similar?*
 - c. *In what way are they different?*
5. *If you had the chance to be one organelle, which one would you like to be? Why?*

As Teacher Ces had emphasized, these questions do not only gather information about the story. They also process the creative, reflective, and critical thinking skills of the students as well as inquisitiveness and curiosity (Minigan, 2017; Cuccio-Schirripa & Steiner, 2000). She believes that as the students answer the questions, it develops their thinking and reflective skills as they connect the story with the roles of the organelles in cellular processes and even imagine themselves taking the roles of these organelles. It allows them to analyze and make judgment about what has happened (Porntaweekul et al., 2013) in the story vis-à-vis the functions of the organelles in the process of cell division. Moreover, the questions allowed them to analyze if their understanding of the story is right or help them evaluate if what they learned about the roles of the organelles is correct and consistent with what the literature is teaching. The story-telling activity prepared by Teacher Ces seemed to be the best activity for making an inquiry environment because of the way the questions were asked (why, how, in what way, if you had a chance...). The questions in the activity were open-ended, which were carefully prepared in advance by Teacher Ces. According to Clayton (2012), when questioning,

teachers should focus on posing open-ended questions of a consistent quality that allow students time to reflect and respond. In order to engage students meaningfully, questions should be prepared in advance. By doing so, teachers are able to wrestle with the essential to know content and ensure that questions are purposeful and aligned with the instructional goals for the lesson.”

On the other hand, Teacher Bes believes that IBA promotes the development of students’ higher order thinking skills because it allows them to synthesize their ideas after exploring independently and discussing among themselves the concepts of cell divisions and Mendelian genetics. She narrates:

The students learn to explore more on their own and explore through their initiative. I think students learn about cell division stages and solving problems in Mendelian genetics.

In her actual teaching, Teacher Bes used cooperative learning as an approach in teaching cell division and Mendelian genetics. She allowed her students to discuss the answers to the inquiry questions that she gave them. After the discussion, she asked the students to present their synthesis before the class and encouraged the other groups to ask questions about the presentations of their classmates. Although she added some inputs into the discussion and corrected their misconceptions, the entire activity has allowed students to evaluate independently certain ideas from their peers and thereby initiating a certain level of independence in the learning process. According to Leaders (2020), the ability to initiate independent learning is an important higher order thinking skill, just like flexibility, leadership, productivity, and social skills. Moreover, opportunities for testing reflective skills among the students still arose in Teacher Bes’ discussion of the reasons why the pea plant was used in Mendel’s experiment and her doing of problem-solving

activities in small group discussions. Not only did this promote interaction, but it also triggered the curiosity and inquisitiveness of the students. In addition, the students' investigative skills were put into test when they were doing board work since they would always be asked if they were sure about their answers. As observed, problem-solving activities and small group discussion employed by Teacher Bes promoted both the reflective and investigative skills of the students because they were made to solve and analyze problems in genetics.

Meanwhile, Teacher Ace considered IBA as an approach that supports the development of students' curiosity and inquisitiveness, which she believes could contribute to the development of their higher order thinking skills. According to her, "*students learn to be very curious and inquisitive.*" She observed that her students had always something to ask during her classroom teaching transactions. Although she has no available data to prove her claim during the interview, she believes that such behavior indicates the development of students' higher order thinking skills. In her actual teaching, she believed that students were able to critically analyze the information presented to them during the study session. According to Leaders (2020), where students start crafting their own questions or strategizing their inquiry, higher order thinking skill is developing. Yung (2020) had also purported that curiosity or being inquisitive is an important higher order thinking skill that could lead to an active and meaningful learning. Through asking questions, students could fill the knowledge gaps during a study session. Some of the questions the researcher was able to record during a classroom observation of Teacher Ace's class are presented.

Is there a scientific explanation for taking a bath?

Ma'am how important is the DNA?

Does it mean Ma'am, our chromosomes can't be beyond 46?

I heard about Interphase, what is the importance of the Interphase?

Why does meiosis have to be very long? why does it have many stages?

Ma'am, are there also similarities between mitosis and meiosis?

Ma'am, what does it mean when the dominant trait prevents the expression of the recessive trait?

Ma'am, does it mean there are always 16 possible outcomes in a dihybrid cross? What about in a monohybrid cross?

Ma'am what's the difference between monohybrid cross and dihybrid cross”?

Teacher Ace believed that asking these questions indicates that the approach has aroused students' curiosity and interest to learn. If this has not been the case, they would not be able to ask questions with an open mind (Salmons, 2016). This is important because curiosity could help them remember lessons that might have otherwise gone into one ear and out the other (Stenger, 2014). Likewise, it could enhance their love for learning (Mathis, 2015); hence, making their learning experience very pleasurable (Stenger, 2014). Nonetheless, Teacher Ace had indicated that the teacher will remain the facilitator for the development of students' curiosity and learning as she narrated:

In using the inquiry approach, I think the teacher is the facilitator who should always ask critical questions where students learn to be very curious and inquisitive.

Moreover, asking the students about their own traits that could be related to their parents' traits promoted reflective and investigative skills. Likewise, asking of inquiry-based questions using the model enhanced the skill of reflection and investigation since

the students were stimulated to think as well as define mitosis in their own words. She promoted critical thinking among her students by asking questions catering to the higher order thinking skills, like the differences between mitosis and meiosis and the reasons why pea plants were chosen by Mendel for his experiment. In every discussion, Teacher Ace made it a point to ask the class about the relevance of studying mitosis and meiosis and explain their application to our everyday lives. Problem-solving activities (Activity 2, 4, 5 and other activities) were also done frequently, either by group or individual.

Although not mentioned in the interview, in her actual teaching, Teacher Des promoted reflective and investigative skills among her students in both individual and group aspects. She focused on asking the “Hows” and the “Whys”, which really trigger critical thinking. For example, the motivational activity on the identity of cell made the students reflect and quietly express their thoughts. The challenge on the students on “*how traits are inherited*” made them use their thinking skills. Teacher Des also had a recitation activity on the board exercise about determining whether a trait is homozygous or heterozygous; this made use of investigative skill. As Teacher Des showed a modified illustration on the distribution of gametes, one student had the initiative to draw the same illustration on the board. Higher order thinking skills were also promoted by Teacher Des, through asking possible outcomes of error in meiosis and computing for the probability and ratios in monohybrid and dihybrid crosses through the students’ performance of Activities 2, 3, 4, 5 and even more problem-solving exercises in group discussions. Thus, reflective thinking is a part of the critical thinking process referring specifically to the processes of analyzing and making judgments on what has happened (Pomtaweekul et al., 2013).

IBA is motivational. Teachers also perceived IBA as an approach that motivates students to learn, as Teacher Des reported “*doing an inquiry-based activity in the classroom had motivated my students to learn.*” She believes that any inquiry-based activity that is presented to the students makes them motivated to learn the concepts taught to them. For instance, she observed that students had become more attentive and engaged when she used the sharing of personal experience as part of her strategy in teaching heredity in Mendelian Genetics. The activity was part of her inquiry-based teaching strategy, where she asked the students to observe their family picture and identify the traits they and their siblings have inherited from their parents. According to her, students’ attention was aroused through the activity, and they became more interested to listen to their classmates’ personal stories during the discussion. Bravo (2015) indicated that the use of personal stories increases the students’ engagement in the learning process, and it avoids making students feel inadequate or not knowing anything about the topic. Similarly, Kane (2013) reported that motivating students in an inquiry-based learning could result in increased student participation as well as student achievement and retention. Teacher Des reported that her “*students were motivated to solve word problem in Mendelian Genetics*” through the activity.

Teacher Des used media like educational videos as springboards for the discussion. Since the answers to her questions can be found in the videos, the students were very attentive in watching. The motivational activities, showing a video clip about the DNA, identity of a cell and bringing a family picture, made the students participate and interact actively. In the case of video presentation, Lands (2011) supports the use of this in classroom discussion because it can engage students, spark a conversation and

bring lessons to life. Communication through the use of video is also powerful and exciting to discuss lessons in science. Her resourcefulness could be noted, as she added more bases for comparing mitosis with meiosis. When nobody wanted to identify the other characteristics used by Mendel, using the LM, one student was motivated to answer. To add, Teacher Des really appeared comfortable when teaching, showing her mastery of the content she was discussing. This must have been observed also by the class which made them more eager to listen to what she was saying.

The rest of the teachers (Ace, Bes and Ces) did not mention about this construct of IBA in the interview, but this construct was observed otherwise in their actual teaching. For example, Teacher Ace used a similar approach, i.e. connecting the lesson with her students' realities, in discussing cell division and observing similar outcomes. In her case, she connected cell division with the students taking a bath every morning, where dead cells are peeled off and replaced with new ones through mitosis. She reported that in so doing, students learn to connect mitotic cell division with how their body maintains its health and protection against external forces. According to her, the students *"understand that body cells need to divide for growth, survival and replenish old tissues, which are important in maintaining good body condition."* This could possibly support what Napitupulu and Munanadar (2017) had observed that when lessons are connected to students' real-life situations, they could easily acquire the knowledge taught to them. Hence, Teacher Ace is confident that her students obtained the *"knowledge of cell division and the various events that occur in each stage of the process."* The success of the inquiry approach relies heavily on the inquirer. Thus, the teacher must have the ability to catch the attention of her students and sustain it throughout the class period. Teacher

Ace achieved this using vocalics, or the variation on the loudness and softness of her voice while discussing. She also posed questions that were easily relatable to the students, like when she asked them about the science behind regularly taking a bath or the reason why we share a lot of similarities with our parents. It is also important to note that Teacher Ace was very persistent in soliciting responses from her class- a characteristic which is highly valued for the inquiry approach. It was also observed how reluctant the students were at the beginning of the class, since this new method of inquiry is something they were not quite used to. But through constant motivation, Teacher Ace was able to make the students answer comfortably and correct them should there be any mistake or misconception in their responses. For example, when the answers to Activity 2 were solved on the board, two (2) groups were worried to go to the board but with motivation, they posted their answers in front. Another example involved a board work on determining the seven (7) contrasting traits used by Mendel; some volunteers were asked to correct/check the groups' answers posted on the board. The fill-in-the-blank visual aid posted on the board containing questions about the dihybrid cross motivated the students to participate in the discussion. Although she did it too late, calling inactive students to recite and not only those who were raising their hands was a very good practice to keep the energy alive inside the classroom. Representation in the form of interactive visual aids in textual form and problem-solving exercises also motivated the students to participate and learn.

Most often, during the recall part of her lesson, Teacher Bes always reminded the students to refer to their LM since nobody was able to answer her questions. By immediately giving the answer without motivating the class to think deeper, Teacher Bes

managed to allot more time for her discussion. One possible factor why the students were not able to answer her queries, aside from lack of knowledge about the content, might be her soft voice, which did not help much to motivate her students to answer. Although Teacher Bes followed an inquiry instruction that is structured inquiry, in which the teacher provided the students with hands-on problem to solve, it is assumed she did not have the complete passion at all to do the inquiry approach in her classroom. This was apparently seen in the manner of her questioning, wherein instead of starting to ask the students to describe the chromosomes, she proceeded right away in asking its function. However, eventually, she managed to urge the students to answer and participate, like when she asked for the difference between mitosis and meiosis and one student bravely answered. Another instance was her motivation for the students to go to the board to answer an exercise about the concept of the recessive trait, dominant trait, homozygous trait, heterozygous trait, genotype, phenotype, P and F₁ based on the cross of the seven (7) characteristics used by Gregor. Though the observation of Teacher Bes' teaching, motivation was too minimal; these observations prove that the inquiry approach is motivational.

Teacher Ces had a consistent level of energy and enthusiasm which evidently influenced the vibe of the students, making them very receptive to the new lesson. It was also noticeable how she used praises from time to time whenever somebody answered. This indeed motivated other students to answer also. She was also very persistent in encouraging the students to discuss in front, after group activities. There were also ice-breaker acts from each group to serve as a breather from the technical lessons being discussed. Although some were still shy and did not dare to recite, Teacher Ces made

sure to ask if they are still following through the discussion and if not, repeats it before shifting to another topic. The students' performance in the two motivational activities on cell division and Mendelian genetics motivated the students to do critical thinking, react, participate and interact. Also, the students in small groups were motivated to illustrate the stages of mitosis. There were spontaneous answers of the students with regard to the characteristics of the stages of mitosis. With Teacher Ces' motivational voice and dynamic teaching, the students were motivated to recite and participate. All these observations prove that the inquiry approach is motivational.

Motivation plays a crucial role in learning. Inquiry approach is a motivational means that in an inquiry environment, the teacher is able to energize and direct the behavior of the students toward specific goals. As the teacher motivates the students in different ways, the students acquire knowledge, increase initiation, persist in activities, improve achievement, and develop a sense of discipline (Napitupulu & Munanadar, 2017).

IBA requires good prior knowledge of students. In the implementation of IBA, the teachers observed that the approach requires students' good prior knowledge and skills to make it effective, and to create a productive learning experience. Teachers Des and Ace, for instance, indicated in the interview that they have difficulty implementing the approach with students who lack a prior knowledge of the topic. Teacher Des commented that *"I have to consider the background knowledge of the students; if the student does not have the basic background, use of the inquiry approach is not effective."* Thus, she always makes sure that she connects her discussion to a real-life experience of the students. Connecting the lesson to real-life situations could somehow assure that students

have the prior experience needed for a productive use of the approach. For instance, when introducing the concept of Mendelian genetics, she asks her students what traits they inherited from their parents. As she reported:

The day before I start the lesson, I ask my students to bring family pictures. On the day of the discussion, using the pictures they brought, I will ask them, how similar are you to your father? Mother? Can you explain what makes your characteristics similar to your parents? I assume that their answers will lead to the science of Genetics, and it is here when I start the lesson.

She believed that by doing this approach, she is able to initiate students' interest to learn. Likewise, to enhance students' learning, she discusses with them human reproduction, emphasizing the specific traits inherited from parents as a background information for her discussion on Mendelian genetics. Both information, i.e. the observed traits inherited by the students from their parents and the discussion on human reproduction, now serve as the students' prior knowledge, which she believed has effectively facilitated students' learning with IBA. She reported that when students' prior knowledge is inappropriate or inaccurate, it hinders learning. But having the accurate and appropriate background information, students become more interactive and the session become more productive. Students learn more readily with IBA when provided with the appropriate prior knowledge. Olagoke et al. (2014) reported similar observations and concluded that inquiry-based teaching is more effective when the students already have a strong knowledge of the subject matter at hand. Ambrose et al. (2010) had also indicated that students learn more readily when they can connect what they are learning to what they already know. According to Hailikari et al. (2008), the importance of prior knowledge on IBA is to ensure that the teacher's expectations of what students should learn is consistent with the students' actual knowledge gained. Inaccurate knowledge

usually leads to misconceptions (David, 2017) and distortion of the students' view of the new information presented to them (Via, 2016).

On the other hand, Teacher Ace reported that students' motivation to engage in IBA depends on the level of students' knowledge of the topic. She commented that "*one limitation is characteristic of students; if the students lack knowledge about the topic, they are not motivated to do inquiry-based activities.*" With this observation, she also connects her lesson in cell division with the students' real-life experiences, such as taking a bath as earlier discussed. She believed that such reality readily presents the essence of cell division as a process that replaces worn out tissues in the body. Doing it could arouse the interest of her students to actively participate in the discussion. In fact, she reported that when she asks questions related to taking a bath, her students actively engage in the discussion and even provides a variety of answers based on their experiences while taking a bath. It is here where she introduced the concepts of cell division. As she narrated,

Before I discuss, I ask them, "after taking your breakfast, what do you do as you prepare to go to the school"? Most of the students will answer, "I take a bath". And then I will ask them to think critically why taking a bath is important".

The students will give a variety of answers. Then I tell them that taking a bath is a way of removing dead cells/dirt from our body. From here, I introduce the process of cell division starting with the concept of cell cycle. The students can easily analyze the activity which can be used as a springboard to discuss cell division."

As indicated also in her interview response, Teacher Ace uses the answers of her students as her springboard for discussing cell division. She supplements the prior knowledge of her students with the concepts that she needs to introduce to them. Diaz (2017) had considered prior knowledge gained from an experience as "the mesh that

would connect, link, relate, and associate to new information.” However, he indicated that such knowledge should be “reconstructed into a new and improved knowledge.”

In her actual teaching, Teacher Ace made sure that prior to discussing a new topic, she conducted a short review about the past lesson. This approach of making a review activates the students’ prior knowledge. During the recall phase, majority of the class participated, hence Teacher Ace was able to clarify ideas and answer questions from the students. Yet, it was observed that when it was time to ask the students any idea about the current lesson, the class went silent. Some had ideas but were afraid to raise their hand because of uncertainty, while majority had no idea at all and did not raise their hands simply because they did not know the answer, indicating the students’ lack of prior knowledge. These situations not only consumed time, but tested Teacher Ace’s ability to encourage her class to speak up. Over time, one by one, the students started to answer, although there were responses the teacher wanted to have but could not get, since her students lacked the background knowledge about some topics in cell division and Mendelian genetics. Specifically, Teacher Ace had a review on cell parts so that the nucleus’ function could be linked to the DNA and chromosome. Another example was a review on the cell parts so that this knowledge could be linked to the important role of the nucleus. Moreover, Teacher Ace had a review on the stages of mitosis so that it could be linked to the role of mitosis. In so doing, learning the new lesson was stimulated. The last example was the review on the concept of homozygous and heterozygous traits, P, F₁/F₂, dominant/recessive traits, genotype/phenotype so that such knowledge could be linked to monohybrid and dihybrid crosses.

Meanwhile, for the skills, Teacher Des meant it to be something about the skills learned by the students in an inquiry environment, as she said, *“I do not want the spoon-feeding mechanisms because the students will not become curious; this is the reason why I still decide to use it because the students are motivated to learn.”* Chhem (2000) stressed the disadvantages of spoon-feeding that can do harm to the students. First, spoon-feeding does not stimulate active participation from the students and only fosters rote learning. Second, spoon-feeding does not promote independent learning and creativity. Finally, students lack initiative and problem-solving skills because they have not been trained to search for data by themselves. It was good that in Teacher Des’ actual teaching, she asked the students to solve problems in genetics through cooperative learning to overcome spoon-feeding (Samah, et al., 2009). It was also evident that Teacher Des had a good grasp of the art of questioning, as she was able to ask questions which motivated the students to answer. She checked if students could still follow her discussion; asked the opinion of the class in certain issues, like the effect of errors during meiosis; and guided students toward understanding by simple inquiries. Understanding concepts through the inquiry approach requires a student’s prior knowledge. Specifically, Teacher Des had to make sure that the chromosome and cell cycle were completely understood so that she could link these to mitosis. In so doing, mitosis properly discussed inquiries. Another example involved asking the students’ background knowledge on mitosis so that Teacher Des could link it to meiosis. Moreover, the knowledge on gamete formation was linked to the Law of Segregation, which was further understood because an illustration was made by Teacher Des on the board. Often, she also repeated what she tackled, just to make sure that everybody understood the concept.

The hand activity on the stages of mitosis was also used to activate the students' prior knowledge. All these observations prove that the inquiry approach requires a student's prior knowledge. To enhance students' learning, she discussed with them human reproduction, emphasizing the specific traits inherited from parents as a background information for her discussion in Mendelian genetics.

Although not mentioned in the interview, Teachers Bes and Ces had demonstrated the importance of prior knowledge in their actual teaching. What happened in Teacher Bes' actual teaching proved how dependent inquiry approach is significant to the students. Despite her effort in doing a recall or short review at every beginning of the lesson, the objective was not met, because the students were not answering. Furthermore, one possible reason why her class could not answer her questions might be due to her manner of asking questions. Instead of asking for a definition of a concept straight ahead, a teacher must practice the art of inquiry to successfully engage the students with the lesson. One way to exercise this method is by asking the class about things that they usually do in everyday life (like what Teacher Ace did), in order for them to recognize the connection between the technical terms they are studying and their everyday lives. This approach is a way of activating the students' prior knowledge. Often Teacher Bes reminded her students to always refer to their LM, but she made use of additional resources like videos and pictures flashed through the Smart TV. Nevertheless, Teacher Bes had a review on the stages of mitosis using the Smart TV so that she could link this concept to meiosis. Another example involved reviewing the lesson on genetics terms which Teacher Bes applied to solving problems involving monohybrid cross. Forms of representation, like pictures and other resource such as videos used by Teacher Bes in the

review, were effective in enhancing the prior knowledge of the students so that this knowledge could always be linked to the new knowledge.

Meanwhile, most of the questions posted by Teacher Ces during recall and abstraction were answered by the students; however, there were still instances when the class would go silent. Despite her reminder to peruse the LM prior to class discussion, most still did not have the initiative to read in advance. This led to the extension of the time for recall and discussion, since Teacher Ces always tried to modify her questions just to solicit a response. But when nobody really talked, she was pushed to give the answer to her own question, which is something that must be avoided as much as possible. However, over time, it was observed that the students became more comfortable in answering Teacher Ces' questions since most of these inquiries were based on describing, comparing then defining the concepts. For example, Teacher Ces had to ask the students about the chromosomes in each stage of mitosis so that the students' knowledge on this could be applied to the topic in the new lesson (chromosome behavior in each stage of mitosis). Reviewing about the Law of Segregation and Law of Independent Assortment was necessary so that the knowledge learned can be applied in solving genetics problems. The hand activity on the stages of mitosis was also used to activate the students' prior knowledge. True enough, the inquiry approach requires a strong student's knowledge.

According to Donovan and Bransford (2005), students come into the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concept. Many of the students' everyday experiences create misconceptions about specific concepts in science. Thus, the students'

prior knowledge in the understanding of the concepts must be addressed in order to evoke a conceptual change. Olagoke et al. (2014) added that inquiry-based teaching is more effective when the students already have a strong knowledge on the subject matter at hand. While this is true, teachers should not stop from using the inquiry method with those students who do not have prior knowledge or have not yet gained “internal guidance. Teachers activate the students’ prior knowledge by creating activities, such as motivational activities, interactive lecture, brainstorming and practical activities that build relevant background knowledge (Keene & Zimmerman, 1997). Lewis et al. (2010) opined that illustrations or drawings can also be used to activate prior knowledge.

IBA is time- and resource-consuming. Although the teachers provided the above positive perceptions on IBA, they also reported some limitations of the approach, one of which is time- and resource-consuming. All of them reported that they need to spend more time preparing and implementing the inquiry lessons and activities. Some of the teachers’ comments on IBA limitation are presented.

Preparation and implementation are too long. [Teacher Ace]

But I still find IBT useful but I do not do it frequently. Inquiry is useful but needs longer time to finish long and difficult activities. ... the time is not enough to make the preparation. In the module there is one experiment in mitosis; I cannot do that with my class because we do not have the facilities; The microscopes are not working properly so I cannot motivate my students to do it. If there are activities that are not very clear, we look for other activities or we modify the activities. [Teacher Bes]

A lot of preparation is needed to be able to perform an inquiry-based activity. [Teacher Ces]

I know the activities in the Learner’s module are inquiry-based but I need to have some modifications in the experiment/activities for better understanding of the students. It is difficult for me to facilitate the discussion if I am not prepared. [Teacher Des]

Aside from time constraint, IBA is also resource-deficit. Teachers need to be innovative or creative to be able to develop inquiry-based activities as Teacher Bes had indicated during the interview *“If there are activities that are not very clear, we look for other activities or we modify the activities.”* Although the modules indicate the activities to be done for the topics of cell division and Mendelian genetics, their school lacks the resources for some of the activities. Teacher Bes pointed this out during the interview, to wit: *“In the module, there is one experiment in mitosis; I cannot do that with my class because we do not have the facilities; The microscopes are not working properly so I cannot motivate my students to do it.”* Teacher Des also commented that *“I know the activities in the Learner’s module are inquiry-based but I need to have some modifications in the experiment/activities for better understanding of the students.”* Hence, they need to search for alternative activities to deliver the necessary learning to the students. For instance, Teacher Ace had to search the net for a film on meiosis, for the activity she planned for her regular class, since they do not have the microscopes needed to observe the process. Aside from spending time to search for the right video clip, she also needed the time to show it to her class. Unfortunately, they lack the necessary time during class hours. Thus, she had it shown in one of the vacant periods of the students. As such, she commented that *“preparation and implementation are too long in using the IBL.”* As much as how inquiry approach sounds promising, it is really time-consuming. There were also times that Teacher Ace did not finish her lesson. There were also episodes on quite a slow-paced discussion flow, since the teacher continuously asked questions, which took a long time to be answered by the students, like her method of questioning about mitosis, meiosis and dihybrid cross. The reluctance of the students to

answer consumed more time than usual. Also, a lot of times, the students did not comprehend the explanation behind the concepts (like in Independent Assortment), so Teacher Ace often repeated her discussion. Furthermore, the time it took to solve problems on the board during the discussion of the Principle of Dominance took longer than expected, since the concept was not clearly understood by those who answered. The same scenario happened also in doing the dihybrid cross, which was repeated numerous times. It was also observed that out of the five (5) activities in the LM, only three (3) activities were performed by the students. These observations prove that the inquiry approach is time-consuming; longer time is needed for the preparation and implementation. Teacher Ace really tried to do the inquiry approach throughout the 10 day discussion of cell division and Mendelian genetics, but the time was not enough to do it completely. However, the number of instances where the time was found to be limited does not imply poor teaching and poor PCK of Teacher Ace. The instances served as evidences to prove that the inquiry approach is truly time-consuming.

In her actual teaching, Teacher Des also experienced the problem of lack of time to actually finish the content scheduled to be discussed. Since soliciting answers from the class took a longer time than usual, the range of content was narrowed down to fit into the remaining time. It might be the reason why she often went straight to discussing the main lesson instead of asking the students to define the terms or describe what happens in such processes like meiosis and mitosis. Repeating certain parts of the lesson also took up a lot of time, so Teacher Des made adjustments by resorting to teacher-centered discussion. Lack of time was also the reason why she resorted to asking the students to answer Activity 3 and Activity 5 as assignments though Activity 2 and Activity 4 were

done in the classroom. The few observations on Teacher Des' teaching show the lack of time that may indicate that Teacher Des preferred to discuss everything on her own, resulting in almost a complete discussion, although the content may suffer and students would become less exposed to the inquiry approach. Nevertheless, these observations prove that the inquiry approach is time-consuming.

Teacher Ces reported similar experiences during the interview. She narrated to have done a lot of preparations to be able to come up with the story-telling activity for cell division. She recalled the long hours allotted for the preparation of the materials and developing the implementation strategy since the activity should be done within the allotted time for the topic. She needed to time her discussion and the implementation of the activity to ensure that everything will be done within the study session. There were only few observations on Teacher Ces' teaching showing lack of time. Every activity she used took 20 minutes or longer, excluding analysis and synthesis. However, it can be said that the time was well-consumed for each meeting. The time it took to actually engage the students to the topic was short, so the bulk of the time was allotted to performing Activity and Abstraction of the 4As. When she prepared visual aids to discuss meiosis, since the visual aid was loaded with too much information, she decided to just read the information without further explanation and clarification. There were also instances when Teacher Ces was not able to wrap up the lesson and evaluate her students, so she postponed it for the next meeting. The students were able to perform all the activities in the LM in the classroom. Activity 3 and Activity 5 were given by Teacher Ces as an assignment. Nonetheless, such instances on Teacher Ces' teaching prove that the inquiry approach is time-consuming.

In the case of Teacher Bes, she had to cut out pictures of mitosis in doing an activity related to cell division. She found this important to maintain her students' interest in learning about mitosis, albeit the tedious and time-consuming process that requires several preparations (e.g. looking for the appropriate pictures, cutting them out, planning how they would be implemented, etc.). Nonetheless, she did this so that "*students will have a very clear understanding of the concepts of cell division.*" She believes that she needs to scaffold the learning of the students with this activity to help and guide them achieve their learning goals. Jamal and Shah (2015) had indicated that scaffolding is helpful in guiding students interact with the lesson, materials, and their peers. Scaffolding activities require teachers to restructure their learning activities or use alternative activities. Teacher Bes discussed the lessons in a fast-paced manner, but still she often did not finish the lesson before the class ended. This might be attributed to the time allotment for the activities and discussions. A huge chunk of class time was dedicated for doing the activities in the LM and combined with unnecessary noise and disorder; the time got prolonged than necessary. There were also no closure or wrap-ups before dismissal nor simple evaluation or synthesis. Although Activities 1-5 are all inquiry-based activities, the students performed two (2) activities only - Activity 2 and Activity 4, which could be due to lack of time and facility. It can be noted that Teacher Bes guided the students on how to answer some problems in monohybrid cross and dihybrid cross to maximize the time for the class. Time was also the element why Teacher Bes missed the Activity and Analysis components of the 4As. Missing these components implies that Teacher Bes also missed some important concepts of cell division and Mendelian genetics. The effect would be shortchanging the content knowledge of the students.

Hooley (2014) reported that inquiry-based learning is very time-consuming both in the preparation and application/implementation and that any inquiry-based activity does not occur automatically, or without much trial and error. Gutierrez (2014) supports the difficulty and time consuming nature of inquiry approaches as an important challenge in implementing inquiry-based teaching. Mike (2017) had also indicated that it takes time and preparation to develop a full inquiry-based class. Dell'Olio and Donk (2007) added that it takes a lot more effort for a teacher to scaffold a lesson than to simply give students the required information. Nevertheless, the authors pointed out that by scaffolding a lesson and then allowing student inquiry to guide it, teachers are offering students a way of thinking that will last a lifetime and this is through using the inquiry-based approach in the classroom. The authors also highlighted the need for teachers to be well-versed in inquiry and inquiry-based methods to use inquiry thoughtfully and appropriately in their classrooms.

Teachers' Practice of Inquiry Approach in Teaching Cell Division and Mendelian Genetics

As per order by DepEd, the instructional plan/lesson plan of all teachers following the inquiry approach should contain the 4As that teachers need to do in the classroom - Activity, Analysis, Abstraction and Application. In general, for cell division and Mendelian genetics, the instructional plans/lesson plans prepared by the teachers consisted of the following.

- | | |
|--------------------|--|
| <i>Activity</i> | • <i>Motivational activity/ies</i> |
| <i>Analysis</i> | • <i>Analysis of the activity in relation to cell division (cell cycle, stages of mitosis and meiosis) and</i>
• <i>Mendelian genetics (Mendel's experiment, Law of Segregation, Law of Independent Assortment)</i> |
| <i>Abstraction</i> | • <i>Abstraction of the general idea about cell division and Mendelian genetics (with emphasis on the dominant and recessive traits that can be passed from parents to offspring, highlight that Law of Segregation involves monohybrid cross while Law of Independent Assortment involves dihybrid cross, emphasis that a monohybrid cross involves one trait while a dihybrid cross involves two (2) traits)</i> |
| <i>Application</i> | • <i>Application of cell division (cell division may be observed using the microscope; Importance of cell division is recognized as mitosis and meiosis are compared)</i>
• <i>Application of Mendelian genetics (Punnett Square predicts the outcome of a cross through problem-solving activities)</i> |

In the study, the observations on the teachers' classroom teaching were analyzed by determining how they implemented the 4As in their discussion about cell division and Mendelian genetics. The number of meetings allotted for the discussion on cell division and Mendelian genetics was 10. Analysis of each of the teacher's teaching is presented as looking into the elements of the 4As, and discussing how the teachers performed these elements in their teaching activities.

The concepts of cell division and Mendelian genetics were completely discussed by Teachers Ace and Des based on the DepEd's learning competencies. During the whole duration of the observations, the two teachers followed the 4As: Activity, Analysis, Abstraction and Application in teaching cell division and Mendelian genetics. While Teacher Ace followed an inquiry instruction that is structured inquiry in which the teacher provided the students with hands-on problems to solve, Teacher Des followed two (2) kinds of inquiry approaches - learning cycle and structured inquiry. For example, in the performance of Activity 3, the students followed the guided-inquiry procedures in the LM, followed by teacher-led discussion of their

findings. This activity was given as an assignment and the findings were discussed by the students along with Teacher Des. In her supervision of the students' performance of the other activities, she followed an inquiry instruction that is structured inquiry.

The concepts of cell division and Mendelian genetics were incompletely discussed by Teacher Bes based on the DepEd's learning competencies. Teacher Bes did not have the Activity and the Analysis components, making the implementation of 4As incomplete. Teacher Bes followed an inquiry instruction that is structured inquiry in which the teacher provided the students with hands-on problems to solve. On the other hand, Teacher Ces almost completely discussed the concepts of cell division and Mendelian genetics based on the DepEd's learning competencies. She provided many inquiry-based activities for enrichment of student learning. Depending on the activity, there was variation in the type of inquiry instruction that was followed by Teacher Ces. For example, in the performance of Activity 1, she followed the learning cycle type of inquiry, which started with guided-inquiry procedures in the LM followed by teacher-led discussion of their findings. On the other hand, the performance of problem-solving activities involved structured inquiry.

How the teachers implemented the 4As in their discussion about cell division and Mendelian genetics are indicated.

Activity Component of the 4As. Except for Teacher Bes, the other teachers (Ace, Ces and Des) used motivational activities when they introduced cell division and Mendelian genetics. The activities shown in Table 15 involve questions asked by the teachers.

Table 15. Activity Component of the 4A's

Cell Division		Mendelian Genetics	
Activity: Sharing of Personal Experience 1. Do you always take a bath? 2. Do you scrub your body when you take a bath? 3. What is it that you remove from your body as you use a scrubbing pad? 4. Can you explain what this removal of dead cells means?		Activity: Sharing of Personal Experience 1. Look at each other and look for the "good traits" you see. 2. How did you get these good traits? 3. Did you find any bad traits?	
None		None	
Activity: Story-telling 1. Why are the organelles complaining? 2. Do you agree or disagree with the first group of organelles? Why? 3. How important are these organelles in the company? Give their duties. 4. a. Why do you think the chloroplast agrees with the mitochondria? b. In what way are they similar? c. In what way are they different? 5. If you had the chance to be one organelle, which would it be? Why?		Activity: Role Playing Now, I would like to introduce to you, our guest for today, Gregor Mendel. 1. Who is Gregor Mendel? 2. What is the work of Gregor Mendel? 3. What is he fond of? 4. Are you familiar with garden peas? 5. Can you enumerate the 7 characteristics of peas that Mendel used? 6. When do we say a trait is dominant? Or recessive? 7. But when will the recessive trait be expressed? 8. What if you cross white with white, will red be expressed? 9. But if you cross pollinate (pure-breeding with contrasting trait), will red be expressed? 10. But if you consider the F ₂ , will red be expressed? 11. Now, how do you differentiate between a phenotype and genotype? 12. What about homozygous and heterozygous? Can you differentiate? 13. Very good but remember that you can also use pure-bred for homozygous and hybrid for heterozygous.	
Activity: Short video clip Part 1 Let us have a short video clip about the DNA 1. Do you remember the parts of the cell? 2. Which do you think is involved in cell division? 3. Based on the short videoclip, where do you find the DNA; what about the chromosome and the genes? Part 2 1. Are you ready to know about the cell cycle? 2. I will show you a picture and what you need to do is to tell me what kind of cell this is. 3. Are you sure it is a plant cell? What about the others? 4. How do you classify a blood, is it a tissue or a cell? Just like the blood, the cell has to undergo a cycle; can anybody describe the cell cycle?		Activity: Sharing of Personal Experience 1. Did you bring a family picture? 2. Can I ask for three (3) volunteers in front to share by answering the question, which of your traits are similar to your father? Mother? 3. What makes one's traits similar to the parents? 4. Today we will discuss the history, basic terms and principles of genetics. Are you ready for the discussion?	

Analysis Component of the 4As. Except for Teacher Bes, the rest of the teachers made an analysis of the activities they conducted as indicated in Table 16.

Table 16. Analysis Component of the 4As

	Cell Division	Mendelian Genetics
T. Ace	<p>Sharing of Personal Experience The teacher analyzed the activity as she explained that when taking a bath, the presence of dead cells removed from the body means that the human cells divide. She emphasized the scientific basis why people have to take a bath.</p>	<p>Sharing of Personal Experience The teacher analyzed the activity as very useful in students' understanding that the inheritance of traits is from parents to offspring.</p>
T. Bes	None	None
T. Ces	<p>Story-telling Activity The teacher analyzed the story-telling activity as she provided the students with an understanding of the important role of the nucleus in cell division as well as value the important functions of the different cell parts. The teacher analyzed the activity as a springboard to introduce cell division.</p>	<p>Role Playing Activity The teacher analyzed the role-playing activities as she discussed about Gregor Mendel and his experiment in order to establish the concept of inheritance.</p>
T. Des	<p>Short video clip The teacher analyzed the activity as she paved the way in learning about the DNA which introduced the students to the cell cycle and cell division. Realizing that the DNA is found in the nucleus, the motivational activity provided complete information as to the important role of the nucleus in cell division. Though not discussed at the start of the lesson, Teacher Des' discussion on the analogy of human blood cell and cell was also significant in understanding the need for every cell to undergo cell division following a specific cell cycle.</p>	<p>Sharing of Personal Experience The teacher analyzed the activity as she explained inheritance of traits across generations which was significant in students' understanding that every trait of a child is inherited from parents.</p>

Abstraction Component of the 4As. Based on the Grade 8 LM, the specific topics discussed under cell division and Mendelian genetics are the chromosome, cell cycle, mitosis, meiosis and Mendelian genetics.

In discussing about the chromosome, Teachers Ace and Des had the complete discussion in terms of its parts and characteristics. Teacher Des even added the

distinction between XX and XY human chromosomes. On the other hand, Teachers Bes and Ces had an incomplete discussion of the chromosome. While Teacher Ces used a picture of the chromosome in discussing the nucleus only, Teacher Bes did not show any picture and did not discuss any part of the chromosome although she discussed its general characteristics. Nevertheless, all the teachers had a complete discussion of the cell cycle, specifically the substages and their characteristics using a picture. Likewise, all the teachers had a complete discussion on the stages of mitosis and their characteristics. On the role of mitosis, which is for growth, repair and development, except for Teacher Bes, the rest of the teachers (Ace, Ces and Des) discussed it. For meiosis stages and characteristics, Teacher Des had the complete discussion as she described in detail the events that happen in each stage. Teacher Ces had almost a complete discussion of meiosis though she did not discuss the substages of prophase 1. Teacher Ace discussed about the substages of Prophase 1 but did not describe the stages of Meiosis II. Teacher Bes seemed to have the incomplete discussion as she only enumerated Meiosis II, although she discussed the stages of Meiosis I. In terms of the role of meiosis, both Teachers (Ace and Des) had the complete list which they discussed thoroughly. Teacher Bes did not discuss any role of meiosis while Teacher Ces, at least mentioned one role, which is for genetic variation. While Teacher Bes mentioned one difference only (meiosis is for sex cells; mitosis is for body cells), the rest of the teachers were able to discuss completely the differences between mitosis and meiosis. Finally on Mendelian genetics, Teachers Ace and Des had the complete discussion of Mendel's experiment followed by Teacher Ces and then, by Teacher Bes who had an incomplete discussion. Similarly, in discussing the laws of heredity, Teachers Ace, Ces and Des had the

complete discussion as they distinguished between Law of Segregation and Law of Independent Assortment, and, between monohybrid and dihybrid crosses. Teacher Bes did not discuss about laws of heredity and the types of crosses.

Below are the abstraction components of the teachers:

The Case of Teacher Ace

I. The Chromosome

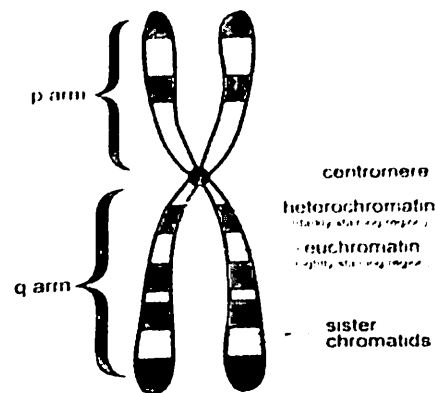


Figure 8. The Parts of the Chromosome Based on LM

- chromatid - one of the paired strands of the duplicated chromosome
- centromere - the region where the spindle attaches during cell division
- euchromatin - the lightly staining region of the chromosome
- heterochromatin - is the darkly staining region

Characteristics of the chromosome:

- the number of chromosomes in a cell is characteristic of the species where it belongs
- there are some examples-humans have 46 chromosomes; dogs have 52; corn has 20. For us humans, we are diploid(2n) while sex chromosomes are haploid (n)
- the male chromosomes are XY while the female chromosomes are XX.
- Chromosomes can't be beyond 46, otherwise we could be another organism

II. The Cell Cycle

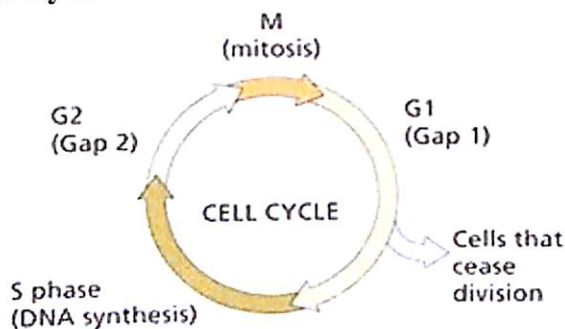


Figure 9. The Cell Cycle

The events of the cell cycle are the following:

- G₁ phase: cell attains optimal size
- S phase: DNA Replication occurs, chromosomes are formed
- G₂ phase: assembly of microtubules

Interphase: during interphase, the cell mainly grows and matures in preparation for the M-phase or Mitosis. It is the non-dividing stage while cell division or simply mitosis is the dividing stage.

III. Mitosis

- during mitosis, the chromosomes, which have already duplicated, condense and attach to the spindle fibers that pull one copy of each chromosome to opposite sides of the cell.
- The results are two daughter cells.
- The stages of mitosis:
 - a. Prophase: The chromatin becomes chromosomes in prophase, the first stage of mitosis. The chromatin coils tightly together to form into separate chromosome strands during this phase.
 - b. At metaphase, chromosomes align to form at the metaphase plate.
 - c. During anaphase, the chromosomes split, condense, and fibers shorten.
 - d. At telophase, chromosomes decondense and are surrounded by a new membrane of the nucleus.
- At telophase, cytokinesis or division of the cytoplasm takes place; in plant cells, it forms a cell plate while in animal cells, it forms a cleavage furrow.
- Mitosis is a type of cell division involving prophase, metaphase and telophase leading to formation of two nuclei
- **Role of mitosis:** mitosis is for growth and development. So we have to take care of our body, if we don't take a bath, then all the dead cells are in our body and so we will not grow.

IV. Meiosis

- there are many stages of meiosis than there are in mitosis because "meiosis has two parts – Meiosis I, composed of Prophase 1, Metaphase 1, Anaphase 1

and Telophase 1, and Meiosis 2, composed of Prophase 2, Metaphase 2, Anaphase 2 and Telophase 2.”

- there are specific stages of Prophase 1
- The **number of chromosomes** remains the same within species; does not double or triple for every generation.
- **Meiosis** must take place to reduce the chromosome number in half. It takes place in plants and animals during gamete formation or gametogenesis.
- **Meiosis** undergoes 2 rounds of division to produce 4 daughter cells, each with half the chromosome number as the original parent cell and with a unique set of genetic material as a result of exchange of chromosome segments during crossing-over.
- **Meiosis I** consists of:

- **Prophase I** which has the following substages:

- **Leptotene**: each chromosome is made up of two long threads of sister chromatids
- **Zygotene**: chromosome begin to pair off as homologues
- **Pachytene**: chromosomes contract; crossing-over takes place through formation of a chiasma; after crossing-over, the sister chromatids may no longer with identical with each other based on the genetic material they contain
- **Diplotene**: paired chromosomes begin to uncoil
- **Diakinesis**: paired chromosomes disperse in the nucleus

- **Metaphase I**: the paired chromosomes arrange themselves along the equatorial plate

- **Anaphase I**: spindle fibers form and attach to the centromeres; homologous chromosomes separate and move toward the poles through the spindle fibers

- **Telophase I**: chromosomes reach their respective poles; cytokinesis follows and 2 daughter cells are formed; each cell is haploid; followed by Interphase II; each chromosome has 2 sister chromatids and therefore necessary to undergo further division

• **Meiosis II** is mitotic in nature and consists of:

- **Prophase II**
- **Metaphase II**
- **Anaphase II**
- **Telophase II**

• **Meiosis II** has these stages which are identical with mitotic stages; result to 4 daughter cells, 2 from each cell from Meiosis I, with one half the diploid chromosome number and with only one sister chromatid for each chromosome

• Meiosis is different from mitosis based on the information presented in Table 17.

Table 17. Comparison of Mitosis and Meiosis

Basis	Mitosis	Meiosis
<i>Number of daughter cells produced (number)</i>	2	4
<i>Number of chromosomes is halved or reduced (Yes/No)</i>	No	Yes
<i>Pairing of homologous chromosomes take place (Yes/No)</i>	No	Yes
<i>The daughter cells produced are always identical in terms of genetic material (Yes/No)</i>	Yes	No

- Homologous chromosomes are chromosome segments that are identical in structure. Homologous chromosomes undergo crossing over where a segment of sister chromatid of one chromosome is exchanged with the same segment of the sister chromatid.
- **Role of meiosis:**
 - meiosis is for the production of sex cells or gametes, specifically sperm cells and egg cells which are needed for spermatogenesis (sperm cell production) and oogenesis (egg cell production)
 - meiosis is for variability which means that as sex cells unite during fertilization, new organisms are produced.
 - meiosis may not always proceed normally and accidents may happen. In humans, some accidents have been known to cause abnormal conditions such as Down syndrome. For example: Down syndrome is due to extra chromosome at chromosome 21 while Cat's cry or cri-du-chat is due to loss of chromosome 5. When something is wrong with meiosis, it may explain the occurrence of some disease.
 - Meiosis maintains reduced chromosome number that's why sex cells are haploid or n. n refers to the symbol for chromosome number."

V. Mendelian Genetics

- Gregor Mendel is the Father of Genetics
- Genetics is the science of heredity and variation. Heredity is the passing of traits from parent to offspring while variation refers to differences in characteristics.
- Mendel's experiment:

Table 18. Mendel's Two Experiments

- Mendel was a monk in a monastery in Brunn nin (now Czech Republic) who performed experiments with the garden pea.
- Mendel made selective cross-breeding of common pea plants (*Pisum sativum*) over many generations and he observed seven traits that only occur in one of two forms:
 1. flower color is purple or white
 2. flower position is axil or terminal
 3. stem length is long or short
 4. seed shape is round or wrinkled
 5. seed color is yellow or green
 6. pod shape is inflated or constricted
 7. pod color is yellow or green
- The experiment showed blending of traits in pea plants.
- In hybridizing between pea varieties;

P generation	<ol style="list-style-type: none"> 1. removed stamens from a purple flower 2. transferred pollen from the stamens (male organ) of white flowers to the carpel (female organ) of the purple flower
F ₁ generation	<ol style="list-style-type: none"> 3. pollinated the carpel that matured into a pod 4. planted the seeds from the fruit (pod) 5. examined the offspring which were all purple flowers (the result is same as reciprocated the cross by transferring the pollen from the purple flowers to the white flowers)
F ₂ generation	<ol style="list-style-type: none"> 6. allowed the purple offspring flowers to self-pollinate
- In cross-pollinating plants that either produce yellow or green peas exclusively, Mendel found that the first offspring generation (F₁) always has yellow peas. Then the following generation (F₂) consistently has a 3:1 ratio of yellow to green. Mendel realized that this was the key to understanding the basic mechanisms of inheritance.

Mendel's first experiment

Characters studied	Parents (P)		First filial generation (F ₁)
	Dominant	Recessive	
Seed shape	Round	Wrinkled	Round
Seed color	Yellow	Green	Yellow
Seed coat color	Colored	White	Colored
Pod shape	Inflated	Constricted	Inflated
Pod color	Green	Yellow	Green
Flower position	Axial	Terminal	Axial
Stem length	Long	Short	Long

Mendel's second experiment

Characters studied	Hybrid (F ₁)	F ₂ Generation produced by self-pollinating F ₁ hybrids	
		Round	Wrinkled
Seed shape	Round	Round	Wrinkled
Seed color	Yellow	Yellow	Green
Seed coat color	Colored	Colored	White
Pod shape	Inflated	Inflated	Constricted
Pod color	Green	Green	Yellow
Flower position	Axial	Axial	Terminal
Stem length	Long	Long	Short

The Conclusions:

1. that the inheritance of each trait is determined by "units" or "factors" (**genes**) that are passed on to offspring unchanged
 2. that an individual inherits one such unit from each parent for each trait
 3. that a trait may not show up in an individual but can still be passed on to the next generation.
- In this experiment, the starting parent plants were **homozygous (BB or bb)** for pea color or having two identical forms (or **alleles**) of the gene. The plants in the F₁ generation were all **heterozygous (Bb)** or having two different alleles. The actual genetic makeup of the pea plants is its **genotype (BB, Bb or bb)** while the **phenotype** (yellow or green) refers to observable physical characteristics.
 - With all of the seven pea plant traits that Mendel examined, one form appeared **dominant (yellow)** over the other, **recessive (green)**. Both alleles can be passed on to the next generation unchanged. The recessive did not appear in the F₁.
 - based on the results of his two experiments, Mendel hypothesized that there was a factor in the plants which controlled the appearance of a trait, and this factor is the **gene**.
 - since two alternative expressions of a trait (e.g. round or wrinkled seed) were possible, Mendel hypothesized that the traits were controlled by a pair of genes called **allele**.
 - Mendel noted that for each trait he studied, there is one trait that **dominates** the other, for example, the trait for round seeds is dominant while the trait for wrinkled seed is **recessive**, trait that did not appear in F₁.
 - A **dominant trait** is represented by, for example R for round seed while r for wrinkled seed is **recessive** and since genes occur in pair, a pure-breeding wrinkled seed plant is RR and a pure-breeding wrinkled seed plant is rr.”
 - RR and rr are **genotypes** which refer to the genetic make-up of an organism while RR as dominant round and rr as recessive wrinkled are **phenotypes** which refer to the physical appearance
 - RR and rr are **homozygous** (having same/identical alleles) and Rr as **heterozygous** (having different alleles)
 - Mendel used the garden pea in his experiment because of the following:
 - the pea is so easy to propagate by pollination
 - it has seven contrasting traits, so Mendel was motivated to use it in his experiment
 - **Monohybrid cross** involves one type of trait only and the principle involved is Law of Segregation.
 - **Law of Segregation** states that each allele in a pair separates during meiosis or gamete formation. Given S for smooth skin and s for wrinkled skin, if there is a heterozygous pair Ss, each separates as S and s. To elaborate the law, it is as follows:

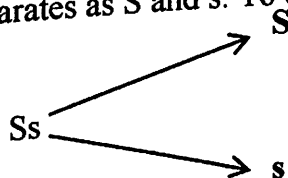


Figure 10. Law of Segregation

- **Principle of dominance** states that the dominant trait dominates or prevents the expression of the recessive trait. For example, in Tt, if T is dominant and t is recessive, then the trait is still dominant because the presence of T prevents the expression of t.
- For example: In pigs, black body is dominant over white body. If two pigs, both homozygous for black and white bodies are mated, (a) what would be the appearance of the F₁ hybrid? (b) If the F₁'s are mated, what would be the appearance (with ratios) of the offspring?"
 - when BB is crossed with bb, the resulting F₁ is Bb (all black)
 - when the F₁'s (Bb) are mated, Bb x Bb, using the Punnett square, the resulting offspring is 3 black: 1 white.
- **Dihybrid cross** involves two traits and the principle involved is Law of Independent Assortment.
- **Law of Independent Assortment** states that pairs of alleles separate or segregate independently from each other during gamete formation.
- It is explained as follows:

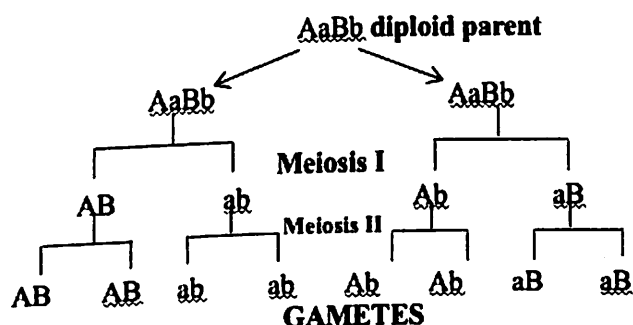


Figure 11. Chromosomal Basis of Law of Independent Assortment

- An example is as follows:
Given that inflated seed is dominant while constricted seed is recessive, and long stem is dominant while short stem is recessive, give the G.R. and P. R. of a cross between a heterozygous plant with a homozygous recessive plant. You are provided with the male and female gametes below:

Given:
 P – inflated seed; p-constricted seed
 L – long stem; l-short stem
 P₁: PpLl x ppll

Solution using the Punnett Square:

	PL	Pl	pL	pl
Male Female pl	PpLl	Ppll	ppLl	ppll

Genotypic Ratio (G.R.): 1PpLl: 1Ppll: 1ppLl: 1ppll

Phenotypic Ratio (P.R.): 1 plant with inflated seed and long stem: 1 plant with inflated seed and short stem: 1 plant with constricted seed and long stem: 1 plant with constricted seed and short stem

The Case of Teacher Bes

I. The Chromosome

- The chromosome is very important in cell division which is found in the nucleus of the cell.
- The nucleus contains the genetic material which is the DNA (Deoxyribonucleic acid).
- Chromosomes may be diploid ($2n$) meaning it means $2n$ has complete set of chromosomes.
- Chromosomes, found in the cell's nucleus, are very important in cell division.

II. The Cell Cycle

- Cell cycle is all the events that can occur during the lifetime of a cell. The cell can be not dividing or dividing.
- Whenever the cell is not dividing, it is referred to as interphase. When the cell divides, it is just cell division.
- The interphase is divided into G_1 or gap 1, S or synthesis and G_2 or Gap 2. **In G_1** , growth is happening, and protein synthesis is also happening but toward the end of G_1 phase, the cell is preparing for the S phase. **In S phase**, the cell makes copies of its chromosomes through replication. This part of the cell cycle is called S phase because the cell is going to synthesize new chromosomes. During **G_2 phase**, a lot of protein synthesis and more cell growth occur.
- It is illustrated this way:

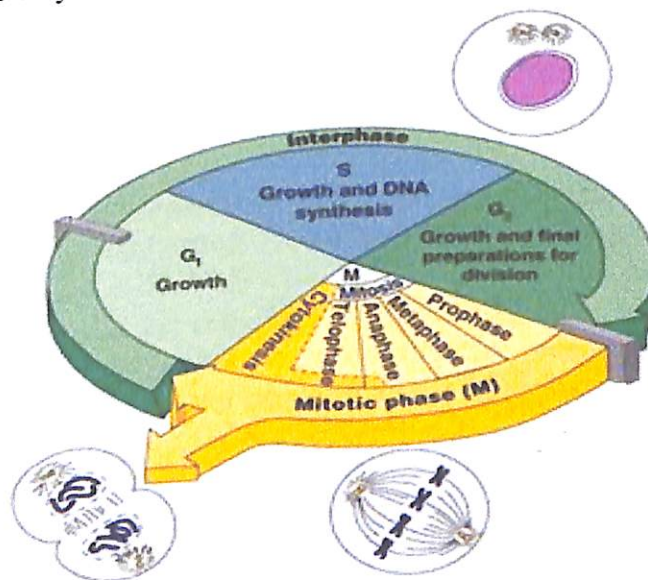


Figure 12. The Cell Cycle

III. Mitosis

- The last part of the cycle is mitosis.
- M-phase (Mitosis) is composed of four stages; Prophase, Metaphase, Anaphase and Telophase.
 - Prophase: the chromatids start to uncoil, the nucleolus disappears
 - Metaphase: the chromosomes align themselves to the center and spindle fibers connect to the centromere.
 - Anaphase: the chromosomes divide and get pulled to opposite poles
 - Telophase: new nuclear membrane is formed

IV. Meiosis

- Meiosis is a two-stage form of cell division that is used only in the sex organs to produce gametes.
- Meiosis I consists of:
 - Prophase I which has the following substages:
 - Leptotene
 - Zygotene
 - Pachytene
 - Diplotene
 - Diakinesis
 - Metaphase I: the paired chromosomes arrange themselves along the equatorial plate
 - Anaphase I: spindle fibers form and attach to the centromeres
 - Telophase I: chromosomes at opposite poles; nuclei form
- Meiosis II is mitotic in nature and consists of:
 - Prophase II
 - Metaphase II
 - Anaphase II
 - Telophase II
- Meiosis is different from mitosis based on the following:
 - Meiosis involves sex cells, mitosis involves body cells.

V. Mendelian Genetics

- Mendel's experiment:
 - Gregor Mendel, an Augustinian monk who was interested in investigating how individual traits are inherited. He wanted to find out whether both parents contribute equally to the traits of the offspring. He also wanted to know if the traits in the offspring are produced from the blending of traits of the parents.
 - Before doing the experiment, first produced pure-breeding pea plants by pollination for many generations until all the offspring had the same features as the parents.
 - When Mendel has pure-breeding plants, he cross-pollinated peas with contrasting traits. The pure-breeding peas constituted **parental or P₁** and all of the offspring of these crosses resembled one another while the offspring of the first cross are called the first **filial generation of F₁** which could also be called **hybrids**
- Pure-breed means having the same genes.
- Mendel used the garden pea in his experiment because of the following:

- these plants are easily propagated by self-pollination or cross-pollination
- readily available
- have seven contrasting characteristics
- Using the Punnett Square, the ratios of the genotype and phenotype may be determined.

Given that *C* is for curly, *c* is for curly. If *CC* is crossed with *Cc*, find the ratios of the genotype and phenotype:

Using the Punnett square,

Female/	<i>C</i>	<i>C</i>	
Male			
<i>C</i>	<i>CC</i>	<i>CC</i>	
<i>c</i>	<i>Cc</i>	<i>Cc</i>	

Genotypic Ratio *2CC:2Cc*
 Phenotypic Ratio *4 curly*

Or

Genotypic Ratio *50% homozygous curly :50% heterozygous curly*
 Phenotypic Ratio *100% curly*

- The gametes are the sex cells or the reproductive cells; P is the parental generation and the genotypic and phenotypic ratios are computed using the Punnett square.

The Case of Teacher Ces

I. The Chromosome

- The nucleus is the control center of the cell; it controls all the activities of the cell and one activity is cell division.
- The nucleus contains the DNA that is organized in chromosomes.
- The structure:

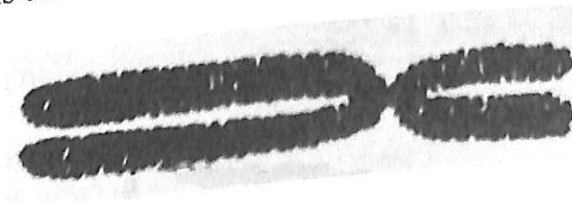


Figure 13. The Chromosome Based on the LM

II. The Cell Cycle

- the interphase as the stage in which the cell does not divide

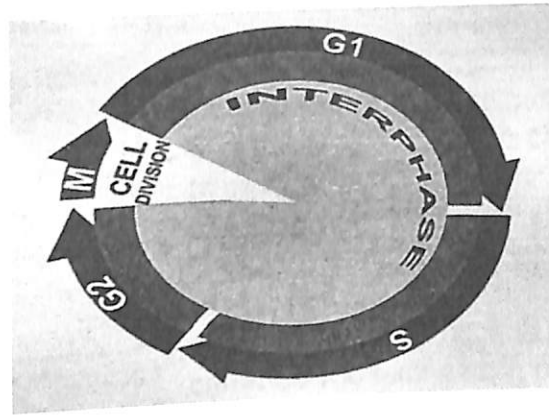


Figure 14. The Cell Cycle Based on the LM

- **Its substages:**
 - G₁ (first gap phase) is the period where cell organelles and other substances are synthesized and the period where cell grows initially. It is also characterized by protein and RNA synthesis
 - S (synthesis phase) is the period where DNA synthesis or replication occurs and chromosomes duplicate.
 - G₂ (second gap phase) is the period when mitochondria and chloroplasts divide and the spindle begins to form. It is the rapid cell growth

III. Mitosis

- It involves somatic cells.
- The stages of mitosis:
 1. Prophase
 - Nuclear membrane and nucleoli are present
 - Thicker and shorter chromosomes because of repeated coiling; each chromosome is made up of two sister chromatids
 - The two chromatids are still attached at the centromere
 2. Metaphase
 - Nuclear membrane disappeared
 - Chromosomes align at the metaphase plate
 - Each fiber binds to the kinetochore, a protein
 3. Anaphase
 - Paired centromeres of each chromosome separate toward opposite pole as being pulled by the spindle fiber
 - Each chromatid is a full-fledged chromosome
 4. Telophase
 - Chromosomes at the opposite poles which uncoil
 - New nuclear membrane forms; spindle fibers disappear
 - Cytokinesis takes place to forms two daughter cells
- Role of mitosis:
 - Mitosis is for growth and repair

IV. Meiosis

- | | | |
|-------------------|--------------|--|
| Meiosis I | Prophase 1 | <ul style="list-style-type: none">• Chromosomes begin to condense• In synapsis, homologous chromosomes loosely pair up• In crossing over, nonsister chromatids exchange DNA segments• Each pair of chromosomes forms a tetrad, a group of four chromatids |
| | Metaphase 1 | <ul style="list-style-type: none">• Tetrads line up at the metaphase plate, with one chromosome facing each pole• Microtubules from one pole are attached to the kinetochore of one chromosome of each tetrad• Microtubules from the other pole are attached to the kinetochore of the other chromosome |
| | Anaphase 1 | <ul style="list-style-type: none">• Pairs of homologous chromosomes separate• One chromosome moves toward each pole• Sister chromatids remain attached at the centromere and move as one unit toward the pole |
| | Telophase I | <ul style="list-style-type: none">• In the beginning of telophase I, each half of the cell has a haploid set of chromosomes; each chromosome still consists of two sister chromatids• Cytokinesis usually occurs simultaneously, forming two haploid daughter cells |
| Meiosis II | Prophase II | <ul style="list-style-type: none">• A spindle apparatus forms• In late prophase II, chromosomes (each still composed of two chromatids) move toward the metaphase plate |
| | Metaphase II | <ul style="list-style-type: none">• The sister chromatids are arranged at the metaphase plate• Because of crossing over in meiosis I, the two sister chromatids of each chromosome are no longer genetically identical• The kinetochores of sister chromatids attach to microtubules extending from opposite poles |
| | Anaphase II | <ul style="list-style-type: none">• The sister chromatids separate• The sister chromatids of each chromosome now move as two newly individual chromosomes toward opposite poles |
| | Telophase II | <ul style="list-style-type: none">• The chromosomes arrive at opposite poles• Nuclei form, and the chromosomes begin decondensing |

- Differences between mitosis and meiosis:
 - there are Meiosis 1 and Meiosis 2 and there are specific stages involved in each
 - mitosis involves body cells or somatic cells; meiosis involves sex cells or gametes or reproductive cells.
 - Mitosis vs. Meiosis:

Mitosis: Divided from a somatic cell; produces 2 daughter cells; all daughter cells have 46 chromosomes; no synapsis; for growth & development

Meiosis: Divided from a gamete; produces 4 daughter cells; all daughter cells have 23 chromosomes; involves synapsis in Prophase 1; for genetic variation

Similarities: Ways for cells to divide; same number of chromosome as the original; both have basic phases; both processes undergo interphase and the basic phases of the organisms undergoing the processes will not change the chromosome number. For example, if humans are involved, even if the cell divides, its chromosome number is still 46

V. Mendelian Genetics

- Gregor Mendel is the Father of Genetics.
- He worked on garden peas with seven (7) characteristics: Seed shape, seed color, seed coat color, pod shape, pod color, flower position and stem length
- A **dominant trait** is expressed while a **recessive trait** is not expressed or it is hidden. The symbol for dominant is big letter while the symbol for recessive is small letter.
- The **recessive trait** is only expressed when the genes are both homozygous
- **Genotype** is the paired symbol; **phenotype** is the physical appearance. For example WW is genotype while white (for WW) is the phenotype. WW or ww is homozygous or pure-bred while Ww is heterozygous or hybrid.
- A **dihybrid cross** happens if there are two (2) kinds of characteristics crossed
- **Law of Segregation** happens during gamete formation in a monohybrid cross. In Mendel's experiment, Y is yellow while y is green. If YY and yy is crossed, let us use the Punnett square to separate the gametes.

	Y	Y
y	Yy	Yy
y	Yy	Yy

So the genotype of F₁ is 4Yy and the phenotype is 4 yellow or all yellow

- **Law of Independent Assortment** happens during gamete formation in a dihybrid cross. In the previous visual, Y is yellow while y is green and, R is round and r is wrinkled. If YYRR and yyrr is crossed, let us use the Punnett square to separate the gametes.

	YR	YR	YR	YR
yr	YyRr	YyRr	YyRr	YyRr
yr	YyRr	YyRr	YyRr	YyRr
yr	YyRr	YyRr	YyRr	YyRr
yr	YyRr	YyRr	YyRr	YyRr

So the ratio of the genotypes will be 16 YyRr
And the ratio of the phenotypes will be 16 yellow, round or all yellow, round

- Probability is important so that we will know what will happen in a given cross."

- A lot of diseases are associated with problems with the chromosomes such as Down syndrome, hemophilia and cry of the cat or “cri-du-chat.” Hemophilia is prolonged bleeding while cri-du-chat is cry of the cat due to deletion 5 (deletion of chromosome 5).

The Case of Teacher Des

I. The Chromosome

- The DNA, chromosome and the genes are found in the nucleus.
- The chromosome is the physical carrier of the gene
- The DNA in cells usually found as a loosely unwound long molecule called **chromatin** during a cell’s life. However during cell division it exists as a coiled and very compact structure called a **chromosome**.
- Made of two identical halves called **chromatids**
- Two chromatids attached together are called **sister chromatids**
- Sister chromatids are attached at a point called the **centromere**
- **There are 2 types of chromosomes. 1. Autosomes** – Somatic or body cells have a diploid ($2n$) number of chromosomes. **2. Sex Chromosomes** – Gametes or sex cells (sperm and egg) have a haploid (n) number of chromosomes. The two haploid (n) gamete cells combine during fertilization to produce a diploid organism. Males have sex chromosomes **XY** while females have **XX**.
- **The structure:**

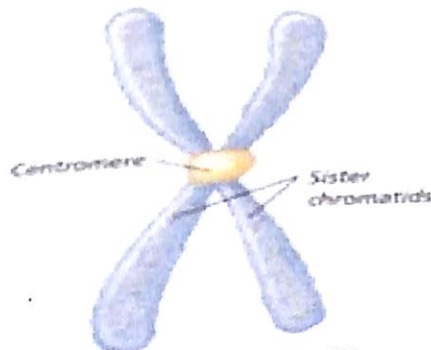


Figure 15. Parts of the Chromosome

II. The Cell Cycle

- Cell cycle is the timed sequence of stages that a cell passes through between one division and the next.
- It is the cycle of cell growth, replication of the genetic material and nuclear and cytoplasmic division.
- The cell cycle oscillates between mitosis and the interphase.
- The structure

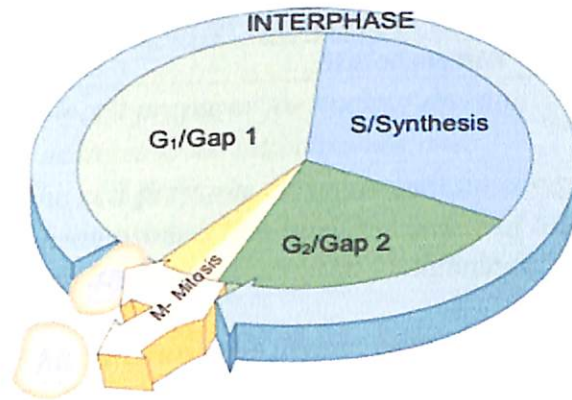


Figure 16. The Cell cycle (from other source)

- The cell cycle can be divided into stages.
 - Interphase- non-dividing stage divided into
 - G₁ stage - Gap 1
 - S stage - synthesis
 - G₂ stage - Gap 2
 - M – mitotic cell division
- G₁ - increase in cell volume
 - inhibition of water and nutrients
 - synthesis of cytoplasmic organelles
- S - DNA synthesis/ replication
 - synthesis of histones and components of the chromatin
- G₂ - synthesis of RNA and proteins necessary for chromosome assembly
- G₁ is the longest while mitosis is the shortest

III. Mitosis

- Cell division is the process by which cells multiply. It involves
 1. Karyokinesis- division of the nucleus
 2. Cytokinesis – division of the cytoplasm
- There are two types of cell division, mitosis and meiosis
- It is the process of cell division which results in the production of two daughter cells from a single parent cell.
- In this process, the daughter cells are identical to one another and to the original parent cell.
- It is divided into 4 stages: Prophase, Metaphase, Anaphase, Telophase

Table 19. Summary of the characteristics of the stages of mitosis

<i>Stage of mitosis</i>	<i>Major event/s</i>
<i>Prophase</i>	<ul style="list-style-type: none"> • <i>The cell prepares for nuclear division</i> • <i>Packages DNA into chromosomes</i>
<i>Metaphase</i>	<ul style="list-style-type: none"> • <i>The cell prepares chromosomes for division</i> • <i>Chromosomes line up at the center of the cell</i> • <i>Spindle fibers attach from daughter cells to chromosomes at the centromere</i>
<i>Anaphase</i>	<ul style="list-style-type: none"> • <i>The chromosomes divide; Spindle fibers pull chromosomes apart</i> • <i>½ of each chromosome (called chromatid) moves to each daughter cell</i>
<i>Telophase</i>	<ul style="list-style-type: none"> • <i>The cytoplasm divides; in animal cells, cleavage furrow forms while plant cells form cell plate</i> • <i>DNA spreads out; 2 nuclei form</i> • <i>In animal cells, the cell membrane pinches in to form the 2 new daughter cells</i> • <i>In plant cells, new cell wall forms between two nuclei to form the 2 new daughter cells</i>

- Cytokinesis involves cleavage furrow in animal cells and cell plate in plant cells
- Role of mitosis:
 - *mitosis is for growth and repair*

IV. Meiosis

- Meiosis is the type of cell division by which germ cells (eggs and sperm) are produced.
- In meiosis, one parent cell produces four daughter cells.
- Daughter cells have half the number of chromosomes found in the original parent cell.
- During meiosis, DNA replicates once, but the nucleus divides twice; four stages can be described for each division of the nucleus

First division of Meiosis

Prophase 1: Each chromosome duplicates and remains closely associated. These are called sister chromatids. Homologous chromosomes are identical chromosomes paired together so that crossing over is possible.

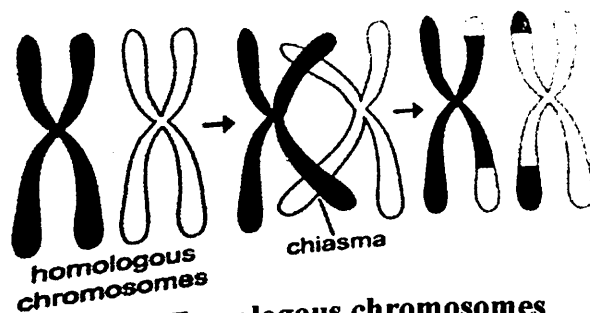


Figure 17. Homologous chromosomes

- Leptotene - Each chromosome is made up of two long threads of sister chromatids as a result of replication during S phase of the cell cycle.

- Zygotene - The chromosome begin to pair off; pairs of chromosome are called homologous chromosomes and this pairing process is exact.
- Pachytene - Crossing over takes place during this stage where segment of the sister chromatid of one chromosome is exchanged with the same segment of the sister chromatid of the homologous chromosome through chiasma
- Diplotene - The chromosome begins to uncoil.
- Diakinesis - The paired chromosomes disperse in the nucleus.

Metaphase 1: Chromosomes align at the center of the cell.

Anaphase 1: Chromosome pairs separate with sister chromatids remaining together.

Telophase 1: Two daughter cells formed with each daughter containing only one chromosome of the chromosome pair.

Second Division of Meiosis

Prophase 2: DNA does not replicate.

Metaphase 2: Chromosomes line up at the center of the cell

Anaphase 2: Centromeres divide and sister chromatids move separately to each pole.

Telophase 2: Cell division is complete. Four haploid daughter cells are formed

- Mitosis vs. Meiosis
 - meiosis involves sex cells or germ cells while mitosis involves the somatic or body cells
 - there is 1 division only in mitosis while there are two (2) divisions in meiosis
 - Meiosis involves sex cells.
 - There are Meiosis I and Meiosis II.
 - There is crossing over in Prophase I involving homologous chromosomes.
 - Four daughter cells are produced.
 - Crossing-over is an interchange of genes or segments between homologous chromosomes.

Table 20. Differences between mitosis and meiosis

<i>Basis of comparison</i>	<i>Mitosis</i>	<i>Meiosis</i>
1. <i>Number of daughter cells produced</i>	2	4
2. <i>Occurrence</i>	<i>All body cells</i>	<i>Sex cells/gametes</i>
3. <i>Chromosome number of parent cell</i>	<i>Diploid</i>	<i>Diploid</i>
4. <i>Chromosome number of daughter cells</i>	<i>Diploid</i>	<i>Haploid</i>
5. <i>Kind of cells produced</i>	<i>Various body cells</i>	<i>Sex cells/gametes</i>
6. <i>Function</i>	<i>Growth and development</i>	<i>Genetic variation</i>
7. <i>Copy of chromosome present</i>	2	1 copy each
8. <i>Pairing of homologous chromosomes</i>	None	Yes at prophase 1

- **Role of meiosis:**
 - there is genetic variation because meiosis involves the sex cells that unite during fertilization to form a new individual; as long as there is union of gametes, there will always be new and different individuals

- when meiosis does not take place normally, there is an effect on the chromosomes leading to some genetic disorders
- meiosis maintains the reduced chromosome number, such that only half comes each from the father and the mother

V. Mendelian Genetics

- **Genetics** is the study of genes; science of heredity and variation
- **Inheritance** is how traits, or characteristics, are passed on from generation to generation. It is what heredity is all about.
- **Variation** is about the differences of members of the same species.
- **Chromosomes** are made up of genes, which are made up of DNA.
- Genetic material (genes, chromosomes, DNA) is found inside the **nucleus** of a cell.
- **Gregor Mendel** is considered "The Father of Genetics"

Gregor Mendel ...

- Is an Austrian Monk.
- Experimented with "pea plants."
- Used pea plants because:
 - they were available
 - they reproduced quickly
 - they showed obvious differences in the traits
- Understood that there was a "**factor**" that carried traits from one generation to the next.

Table 21. Teacher Des' version of explaining genetics terms

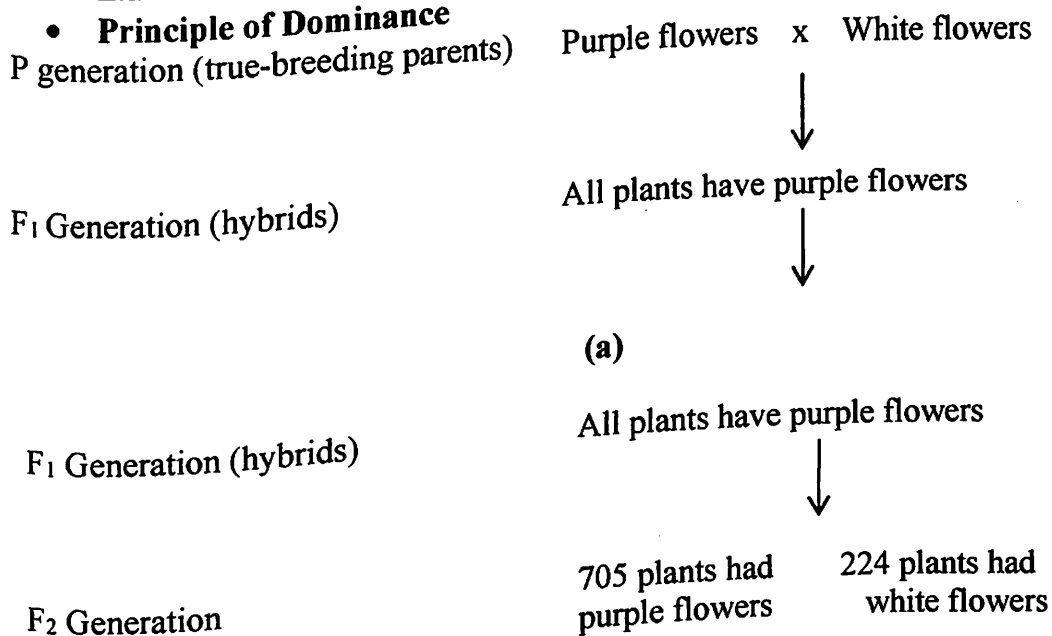
She discussed that...	For example, tallness (T) is dominant over shortness (t).
• Dominant traits are traits that are expressed.	For example, shortness (t) is recessive; tallness (T) is dominant.
• Recessive traits are traits that are covered or not expressed.	In Tt, the alleles are T and t.
• Alleles/genes are the different forms of a characteristic.	In a monohybrid cross, it is composed of 4 squares; in a dihybrid cross, it is composed of 16 squares.
• Punnett Square is the grid to show how crosses are made.	For example, whether it is in a monohybrid or dihybrid cross, it is possible that 100%, 75%, 50% or 25% will be dominant or recessive
• Probability is the chance or percentage that something will occur.	TT, Tt, tt
• Genotype is the genetic make-up or the types of genes (Alleles) present	TT or Tt is Tall, tt is short
• Phenotype is the physical characteristic or what it looks like.	TT, tt
• Homozygous means two of the same alleles.	Tt
• Heterozygous means two different alleles.	parental generation
• P	first filial generation (offspring in the 1 st gen.)
• F ₁	second filial generation (offspring in the 2 nd gen.)
• F ₂	

Table 22. Mendel's experiment

P generation (true-breeding parents)	Purple flowers	x	White flowers
	↓		
F ₁ Generation (hybrids)	All plants have purple flowers		
	↓ Self-pollination in F ₁ plants		
F ₂ Generation	¾ of plants have purple flowers		¼ of plants have white flowers

- The **dominant trait** dominates or prevents the expression of the **recessive trait**
- Dominant traits are represented by capital letter.
Ex. Seed shape - Round (RR)
- Recessive traits are represented by small letter
Ex. Wrinkled (rr)

• **Principle of Dominance**



Ratio 3:1

(b)

• Probability and Punnett Square

		<i>Sperm from F₁ flower</i>	
		$\frac{1}{2} P$	$\frac{1}{2} p$
<i>Eggs from F₁ flower</i>	$\frac{1}{2} P$	$\frac{1}{4} PP$	$\frac{1}{4} Pp$
	$\frac{1}{2} p$	$\frac{1}{4} Pp$	$\frac{1}{4} pp$

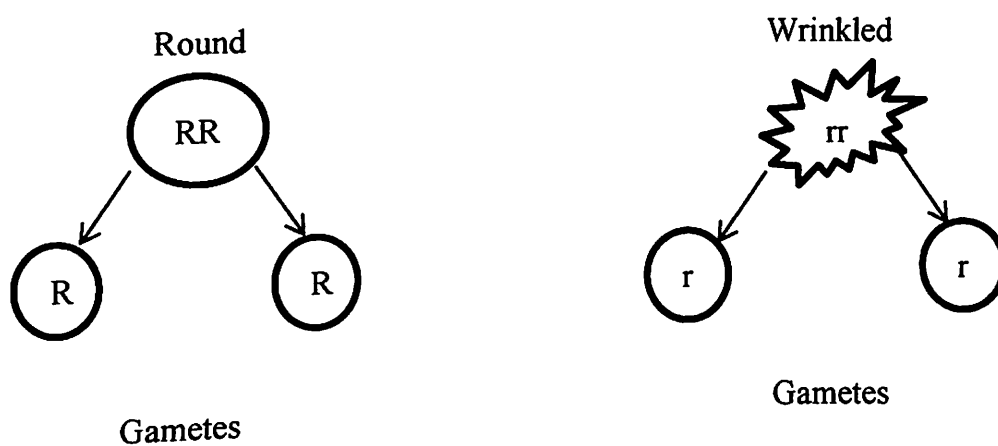


Figure 18. Gamete formation

- **Law of Segregation** states that each of the pair of genes segregates from each other during gamete formation.

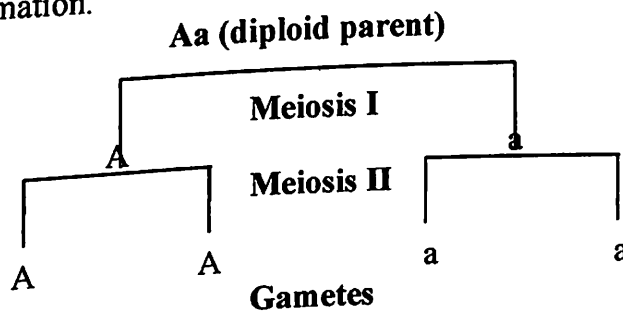


Figure 19. Law of Segregation

- Law of Segregation is the principle involved in a monohybrid cross, a cross involving one trait.
- In a **dihybrid cross** that involves two (2) traits, the principle involved is the **Law of Independent Assortment**.
 - The law involves the distribution or assortment of one pair of factors is independent of the distribution of the other pair.
 - This explains why traits are inherited independent of each other. The law applies to factors / genes that are found on separate chromosomes.
 - The segregation of one pair of factors is not affected by the segregation of the other pair.
 - Therefore, the distribution of the gametes will be at random.

Application Component of the 4As. The application component describes the application of the concepts/principles learned by discussion or explanation, conducting an experiment,

doing an activity and solving problems. Teacher Bes was not able to start the lesson through a motivational activity but through another approach, she was able to implement activities under this component of the 4A's. Below is the application component of the 4A's of the teachers.

Table 23. Application Component of the 4A's

Cell Division	Mendelian Genetics
<ol style="list-style-type: none"> 1. Explanation of the need for taking care of the body by taking a bath so that the dead cells would be removed so as not to disrupt growth 2. Doing Activity 2 (Comparing mitosis and meiosis) to understand better the differences between mitosis and meiosis with emphasis on genetic variation and reduction of chromosome number 	<ol style="list-style-type: none"> 1. Performance/Doing of Activity 4 and Activity 5 to understand the concept of inheritance as well as Laws of Segregation and Independent Assortment 2. Solving more genetics problems to enrich the understanding of the concept of inheritance as well as Laws of Segregation and Independent Assortment
<p>Doing Activity 2 (Comparing mitosis and meiosis) to understand better the differences between mitosis and meiosis with emphasis on genetic variation and reduction of chromosome number</p>	<p>Performance/Doing of Activity 4 to understand the concept of inheritance</p>
<ol style="list-style-type: none"> 1. Conducting an experiment on Observing Mitosis (Activity 1) 2. Doing Activity 2 (Comparing mitosis and meiosis) to understand better the differences between mitosis and meiosis with emphasis on genetic variation and reduction of chromosome number 	<ol style="list-style-type: none"> 1. Performance/Doing of Activity 3, 4 and Activity 5 to understand the concept of inheritance as well as Laws of Segregation and Independent Assortment 2. Solving more genetics problems through "Bikini Bottom Genetics" to enrich the understanding of the concept of inheritance as well as Laws of Segregation and Independent Assortment
<p>Doing Activity 2 with additional items as basis (Comparing mitosis and meiosis) to understand better the differences between mitosis and meiosis with emphasis on genetic variation and reduction of chromosome number</p>	<ol style="list-style-type: none"> 1. Performance/Doing of Activity 3, 4 and Activity 5 to understand the concept of inheritance as well as Laws of Segregation and Independent Assortment 2. Solving more genetics problems to enrich the understanding of the concept of inheritance as well as Laws of Segregation and Independent Assortment

General pattern of the teachers' decision-making process in using the inquiry approach

The teachers' decision-making process was patterned on the three (3) models of decision making, namely, Rationale Comprehensive Model, Incremental Model and Bounded Rationality

Model. The teachers followed a specific model in specific instances as indicated in the interview and in their actual teaching.

The Incremental Model. As the decision to use IBA is mandated by DepEd, which is indicated in Table 24 (a & b), the decision-making process of the teachers follow the Incremental Model. According to Gelder (2009), the model is remedial such that emphasis is on correcting or improving existing policies. It also considers an alternative to make a better policy.

Table 24a. Emergent Themes on the Teachers' Decision to use IBA from Interviews based on Constant Comparative Analysis of the Four (4) Teachers. (Note: Color Coding of the Teachers-Teacher Ace, Teacher Bes, Teacher Ces, Teacher Des)

Theme	Extracted Code	Description of Theme	Sample Response/Entry
decision to use IBA is mandated by the institution	Decision to use inquiry is institutional	Teacher's decision to use IBA is a DepEd order	<i>You know, we have been using the traditional method...we need to follow the DepEd order that we use inquiry</i> It is still my decision to use the inquiry approach in teaching science and it's a DepEd order. <i>Well, it's really very difficult to decide; but we need to abide by the rule of DepEd; though this is the case, the decision-making should be a long process</i>
decision to use IBA is based on the teacher's experience and peer advice	Consultative decision-making process Decision to use <u>inquiry is</u> experience-based	Teacher's decision to use IBA is based on consultation with colleagues and personal experience	<i>Then I will consult my colleagues about it to weigh the evidence for the use of film analysis</i> <i>But before I employ this, I need to ask help from colleagues if this is all right to use.</i> <i>Oh no, inquiry instruction is laborious. I find it very hard especially if the teacher does not have any experience.</i> <i>...you know, in my experience with the first school where I taught, I really did inquiry instruction.</i> <i>After I use this in my class, I need to have some reflections again whether or not this strategy will be used in my next lesson</i>

Table 24b. Emergent Themes on the Teachers' Decision to use IBA from Classroom Observations based on Constant Comparative Analysis of the Four (4) Teachers. (Note: Color Coding of the Teachers-Teacher Ace, Teacher Bes, Teacher Ces, Teacher Des)

Theme	Extracted Code	Description of Theme	Sample Response/Entry
The decision to use IBA is mandated by the institution	Decision to use inquiry is institutional	Teacher's decision to use IBA is a DepEd order	All decided to use IBA as required by DepEd
The decision to use IBA is based on the teacher's experience and peer advice	Consultative decision-making process Decision to use inquiry is experience-based	Teacher's decision to use IBA is based on consultation with colleagues and personal experience	All decided to use IBA through peer consultation and personal experience

Before the implementation of the K-12 curriculum, there was no inclusion of the inquiry approach in the DepEd framework of teaching science. However, improving the existing policy was needed as an alternative approach. Under the new basic education curriculum, i.e. K-12 curriculum as embodied in Republic Act No. 10533 of 2012, teaching shall use pedagogical approaches that are constructivist, inquiry-based, reflective, collaborative, and integrative. Similar embodiment has been circulated to all public and private schools in the country through DepEd Order No. 021 Series 2019. Highlighted in this order is the mandate that all schools shall use pedagogical approaches that are inquiry-based, which puts a premium on questioning, investigating, proving, probing, explaining, predicting, and establishing connection of evidences. Hence, teachers are obliged to use such approach despite the limitations they encounter in using it. Such decision has been reflected in the teachers' interview responses, to wit:

You know, we have been using the traditional method... we need to follow the DepEd order that we use inquiry. [Teacher Ace]

It is still my decision to use the inquiry approach in teaching science and it's a DepEd order. we have to abide by the order of DepEd and this is a change we need to accept [Teacher Ces]

Well, it's really very difficult to decide; but we need to abide by the rule of DepEd; though this is the case, the decision making should be a long process. this preparation is a big leap from the traditional method... it's a big change in the educational system [Teacher Des]

As indicated in their responses, the teachers decided to use IBA in compliance with the DepEd order although they consider it as a big leap from using the traditional method. Since they are mandated to use it, Teacher Ces just considers it as a “*change that we need to accept*” though Teacher Des found it very difficult to decide. She even looked at it as a “*big change in the educational system*” probably, because they have been so accustomed to using the traditional lecture method in their teaching-learning transactions as what Teacher Ace commented: “*we have been using the traditional method.*” Teacher Ces also expressed similar difficulty, especially that she has no prior experience of implementing it. Nonetheless, she still feels to abide by the order of DepEd. Although Teacher Bes failed to mention about deciding to use IBA in the interview, she was observed to prepare inquiry-based activities in her actual classes along with the other teachers. The decision to adopt the IBA is a remedial approach (as another characteristic of the Incremental Model) to improve the traditional method of teaching science.

The Bounded Rationality Model. As indicated on Table 24 (a & b), the decision to use IBA is based on the teachers’ experience and the pattern of decision-making process involved is the bounded rationality model. This pattern is based on the premise that decision making is not rational and decision making is characterized with little processing of information and satisficing (accept an available option) (Lunenburg, 2010). Despite their feeling of being obliged to use IBA, the teachers still consider the use of the approach, especially the use of specific inquiry-based activities, as a personal decision. For instance, Teacher Ces commented that “*It is still my decision to use the inquiry approach in teaching science.*” As a personal decision, teachers develop a system of decision making, which is based on reflection on their use of a strategy. UMass

Dartmouth (2020) had indicated that a systematic decision-making process can help teachers make more deliberate, thoughtful decisions by organizing relevant information and defining alternatives. The system can increase the chances that they will choose the most satisfying alternative possible. Ray (2018) also emphasized that “our mastery of the decision-making process plays a big part in the outcome of our lives.” “You can learn a decision-making process that allows you to quickly assess the best choice and make it based on data that supports the objectives and goals you’ve been tasked to achieve.”

The teachers’ decision to use IBA based on their reflection involves recalling the effectiveness of the strategy as evidenced by the performance of their students. If the strategy is effective, they are more inclined to use it again in their next teaching-learning transactions. But when it is not, they decide to shift to another strategy. This follows the Bounded Rationality Model, that is shifting right away to a better option or strategy. As Teacher Des narrated:

...you know, in my experience with the first school where I taught, I really did inquiry instruction... I recall the experience; the usefulness of a specific strategy I previously used. But it is possible that the inquiry in my mind is not effective anymore this time so I need to consider other alternatives. I weigh the evidences-is this strategy I used previously still effective today or there is a more appropriate strategy now? I choose the specific strategy which I think is better then, I use it in my class.

Teacher Ces reiterated a similar process as follows:

Oh no, inquiry approach is laborious. I find it very hard especially if the teacher does not have any experience... Suppose I am thinking of using a research, simulation, or project work, I need to try it. If the performance of my students is best for using a project so I decide to use project work. But it should be a continuous process of reviewing the strategy so if there is a need to modify it.

This is consistent with what Steffy et al., (2000) had reported. According to them, teachers’ decisions to re-use a teaching strategy is influenced by their evaluation on how

such strategy affects his or her students' achievement. This is illustrated with what Teacher Ces had experienced in her actual teaching where she decided to shift from the lecture method to the use of a storytelling activity. Using the former approach, she observed that her students remained passive and dis-engaged. Thinking that this environment is not conducive for learning, she decided to explore the use of a storytelling strategy in her class. She learned about the strategy in one of the workshops she attended. When implemented in her class, she observed that the strategy had improved her students' participation in the discussion of cell division, thereby, reducing the impacts of passivity and disengagement on students' learning. But just as what Teacher Ces had emphasized, the process of reflection is continuous and the decision to re-use the strategy depends on the outcome of their reflection as she said, "*it should be a continuous process of reviewing the strategy.*"

This case highlights the importance of teacher's reflection in the teaching-learning process. According to Lotter and Miller (2017), if teachers reflect immediately on what they had done in their classrooms, they will have time to practice new instructional strategies and gain insights on how to handle student learning issues. They will be able to assess the effectiveness of a strategy and decide whether to use it again or not. As Teacher Des had emphasized, "*I weigh the evidences-is this strategy I used previously still effective today or there is a more appropriate strategy now?*" Likewise, Teacher Bes highlighted that, "*After I use this in my class, I need to have some reflections again whether or not this strategy will be used in my next lesson.*" Through this process of reflection and evaluation, these teachers can attain a continued professional growth, which may sustain their effectiveness as teachers throughout their careers. As Steffy et al.

(2000) had indicated, reflection facilitates learning and continued professional growth among teachers, which could improve their ability to be effective throughout their careers.

The Bounded Rationality Model is satisficing - that is, finding a satisfactory and sufficient solution rather than the best one (Hoy, 2019). For the teachers, a change of approach (from traditional method to a new strategy) makes them become satisfied as they reflect on it, although it may not be the best alternative.

The Rational Comprehensive Model. As indicated in Table 24 (a & b), the decision to use IBA is also based on peer advice and the pattern of decision-making process involved is the Rational Comprehensive Model. According to Gelber (2009), the Rational Comprehensive Model consists of a structured four-step response - identifying the problem, generating alternative solutions, selecting a solution and implementing and evaluating the solution.

Aside from using reflection as a means for making decisions, the teachers also employ peer consultation, where they seek advice from their peers regarding the use of a specific IBA strategy. For instance, Teacher Ace usually consults her colleagues regarding the use of a strategy for the teaching of mitosis. She reported that *"I will consult my colleagues about it to weigh the evidence for the use of film analysis."* Teacher Bes has the same approach and reported that *"Before I employ this, I need to ask help from colleagues if this is all right to use."* In both cases, peer consultation has become an important part in teachers' decision making. The process of consultation could help them improve their sense of professionalism and effectiveness in teaching. Counselman (2013) had indicated that peer consultation develops one's professional

sense of self because it offers multiple perspectives on the same problem. The author added that attaining such multiple perspectives could reduce teachers' anxiety, clear confusions, and mistakes, and enhance ability to overcome their struggles with teaching. As it provides feedback and advice about teaching, peer consultation could support a mutual growth among peers in decision making (Benshoff, 1994).

In an actual teaching activity, Teacher Ace followed the steps of the Rational Comprehensive Model as she employed a project work strategy in discussing the characteristics of mitosis instead of a traditional method (identifying the problem). She reported that at first, she was thinking of employing a different teaching strategy (generating an alternative solution). However, upon consultation with her colleagues and the head of the Science Department, she decided to use the project work approach, which was originally not part of her lesson plan (selecting a solution). She said that her colleagues' advice and her readings with some journals and science magazines about the approach made her decide to use it instead of her originally chosen strategy. Their advice had allowed her to realize the important role of this strategy in developing students' critical thinking skills. Thus, peer consultation becomes an important part of her decision-making process because it has given her the opportunity to gain more insights about a strategy and therefore increased her confidence of using it in her class (implementing and evaluating the solution).

Teacher Bes reported a similar process of choosing a specific strategy for a lesson in cell division and Mendelian genetics. In one instance, she was supposed to employ group reporting for the topic of the stages of mitosis that seemed to be a passive method (identifying the problem). She consulted the idea with her colleagues who suggested the

use of small group discussion instead. Although she had already assigned a group to present their report, she decided to shift to the use of a small group discussion, as she received more positive feedback from her colleagues regarding this strategy (generating an alternative solution). After she implemented the strategy, she herself observed the effectiveness of the strategy for her class. This has made her decide to explore the use of the strategy for the other topics in Biology, although she made some modifications like incorporating multimedia presentations in the implementation (implementing and evaluating the solution). According to Miller (2007), good peer consultation could lead to a successful ethical or wise decision making as individuals may receive views or ideas generated based on experience and/or expertise. These views or ideas are necessary to weigh all options presented to individuals (Twombly, 2020). But since they are generated through experience, it may be wiser to adopt them in a teaching-learning process. This has been illustrated by the earlier cited cases. On the other hand, Mike (2019) indicated that peer consultation can possibly provide valuable feelings or insights needed to come up with the best decision. Since these feelings or insights are shared among peers, they can provide a strong support to teachers' decisions regarding the use of a strategy or teaching in general. Although emotions are mostly neglected in education research (Sutton & Wheatley, 2003), they significantly influence teachers' cognition and motivation. Shared positive emotions toward a certain strategy can increase teachers' comfort with the strategy. Teachers will feel more confident to use the strategy when more peers expressed similar emotions toward its use.

Influencing Factors for the Teachers' PCK and Decision Making

The four (4) teachers' individual differences in terms of educational background, number of years of teaching and professional development program attendance (Table 25) were also considered as factors that might determine the teachers' type of decision-making process as well as their PCK level.

Table 25. Teachers' Individual Differences in terms of Educational Background, Number of Years of Teaching and Professional Development Programs Attended

	Educational Background	Number of years of teaching	Professional Development programs attended	PCK level	Type of Decision-making process
Ace	BS degree in Mathematics and Science Teaching (BSMST), major in Biology	6	Has attended one seminar about K-12 curriculum preparation and approaches	High level	Incremental model to Rational comprehensive model
Bes	BS degree in Agricultural Education, major in Animal Science; has earned some units in MA Education, major in Educational Management	19	<ul style="list-style-type: none"> Has attended trainings and seminars on Secondary Education Curriculum focusing on science teaching approaches Has attended a series of seminars in preparation for the K-12 curriculum implementation with emphasis on the inquiry-based approach Has attended a series of seminar-workshops on enhancing Biology teaching in Genetics, Physiology, Ecology and Biodiversity for Grades 7, 8 and 9 with focus on experiments, modelling, and hands-on activities 	Low level	Incremental model to Bounded rationality model to Rational comprehensive model
Ces	BS degree in Secondary Education, major in General Science. She just finished MA in Administration and Supervision in 2014	10	<ul style="list-style-type: none"> Has attended a number of trainings and seminars in preparation for the K-12 curriculum implementation in order to enrich science teaching Has attended Teaching Strategies, Seminar on Innovative Way of Teaching Science Has attended Seminar-Workshop series on Enhancing Biology Teaching on Genetics, Physiology, Ecology and Biodiversity for Grades 7, 8, 9 Teachers Has attended The joy of Teaching: Teaching from the Heart, Has attended Teaching Strategy Seminar for High School Teachers 2014 Has attended Innovative Teaching -Learning in the 21st Century: Trends, Tools and Tips 	Moderate level	Incremental model to Bounded rationality model
Des	BS degree in Secondary Education specializing on Biological Sciences	3	<ul style="list-style-type: none"> Has attended a seminar on Teaching Strategies in Science Has attended a seminar on Encouraging Children's Discoveries Has attended a seminar on Developing Critical Thinking Skills through the Art of Questioning Has attended a seminar on Differentiated Instruction in a Differentiated Classroom 	High level	Incremental model to Bounded rationality model

As indicated in the table, Teachers Ace and Des have a high level of PCK, followed by Teacher Ces with a moderate level, and lastly Teacher Bes who has a low level of PCK. Teachers Ace and Des were consistent to have a high level of PCK, as they discussed the different topics of cell division and Mendelian genetics completely. Both these teachers graduated with Biology as the major or specialization, which exactly matched what they teach. Teachers Bes and Ces are graduates of a related course only and this must be the reason why there were many instances in the interview and actual observation of their classes that they missed to discuss or explore some important concepts making their discussion incomplete. As Shulman (1987) had noted, when teachers have a good understanding of what their students know and can do as influenced by their educational background, they are able to identify appropriate content, sequence and pace lessons, modify or extend activities for students' particular needs, and choose effective methodologies and representations. Nevertheless, as the teachers are either graduate of Biology or related sciences they were able to make the necessary decision-making process when they used IBA in teaching cell division and Mendelian genetics. Further, the number of years of teaching did not serve as a factor for the teachers to have a high level of PCK. As indicated in the table, Teachers Ace and Des who belong to PPST Career Stage 1/Beginning Teachers are beginning teachers whose number of years of teaching are 6 and 3, respectively have a high level of PCK. On the other hand, Teachers Bes and Ces who belong to PPST Career Stage 2/Proficient teachers whose number of years of teaching are 19 and 10, respectively have a low level and an average level of PCK, respectively. In addition, the teachers' list of professional development programs attended did not help them maintain a high level of PCK. Both Teachers Ace and Bes come from School A while Teachers Ces and Des come from School B. Teacher Ace has attended one seminar only while Teacher Bes has

attended more professional development programs. Meanwhile, Teacher Ces has attended more seminars than Teacher Des. Nonetheless, regardless of the number of professional development programs attended, they were able to make the necessary decision-making process when they used IBA in teaching cell division and Mendelian genetics.

Revised Conceptual Framework

In this study, the educational background has been found as the major factor that influenced a teacher's PCK (specifically Knowledge of Content) leading to the adoption of IBA and its sustainable use. Educational background basically involves all the teachers' qualifications, particular courses and majors they have ever undergone. As observed, there is also the influence of their mental construct to practice. The revised conceptual framework is indicated in Figure 20.

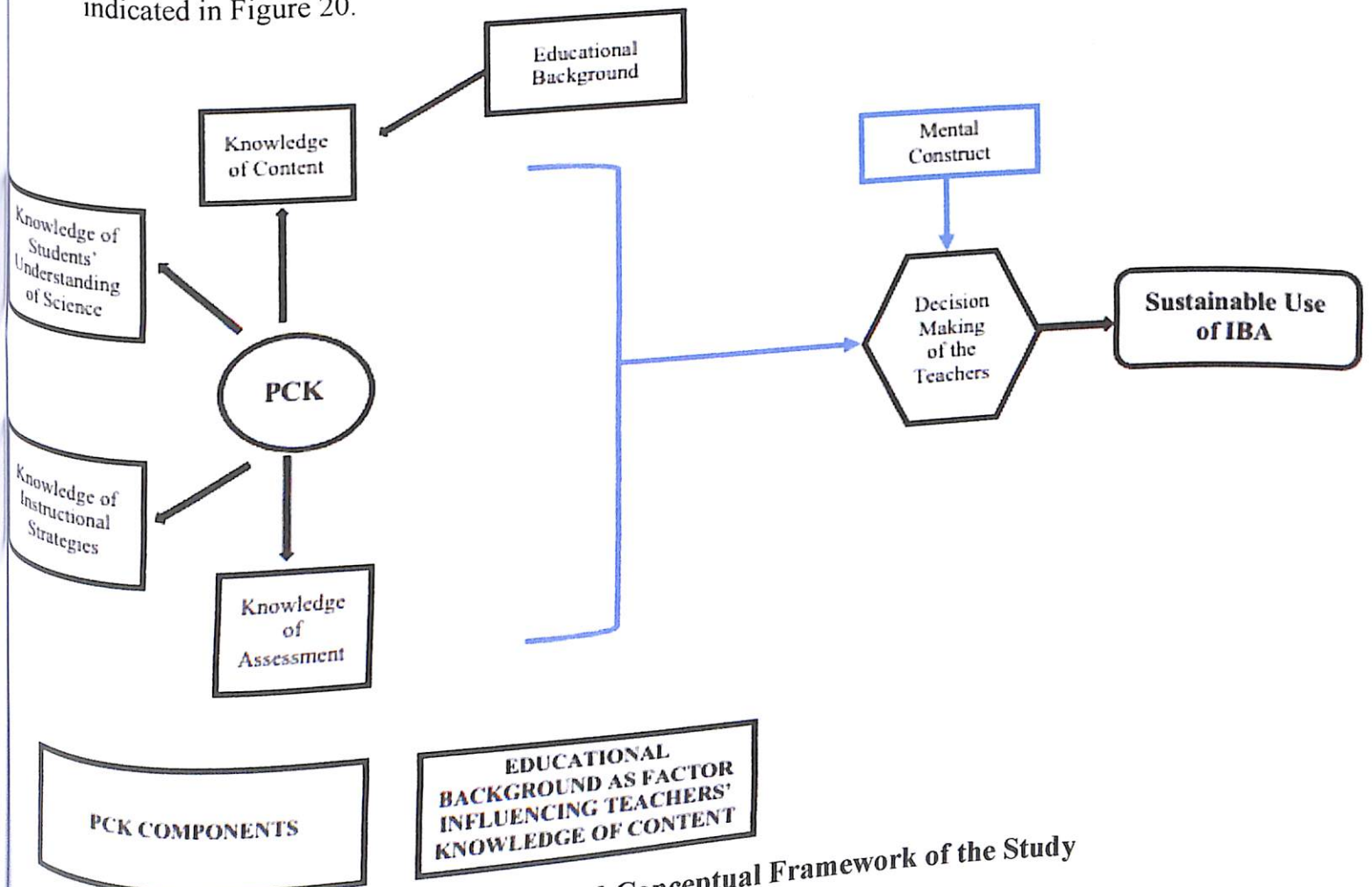


Figure 20. Revised Conceptual Framework of the Study

According to Yin et al. (2015), the most widely studied aspect of teacher effectiveness is teacher background characteristics, since several specific background characteristics have been examined in the research literature, including degrees, coursework, credentials, experience, test scores, and the prestige ratings of teachers' undergraduate institutions. UVermont (2018) reported that eighth-grade science teachers without educational background in science are less likely to practice inquiry-oriented science instruction. Likewise, Kolbe and Jorgenson (2018) revealed in their study that teachers with undergraduate or graduate degrees in science continued to use inquiry-oriented instruction throughout their careers at a higher rate than their peers. The authors added that "This suggests that even having an undergraduate minor in science better positions a teacher to adopt and integrate reform-oriented science teaching, compared to teachers with little-to-no formal education in science or engineering." Further, Goldhaber and Brewer (1997) found that having a master's degree did not make a difference among 10th grade mathematics teachers, unless the degree was in mathematics. Mathematics teachers with a bachelor's degree in mathematics also performed better than mathematics teachers whose degree was not in mathematics.

This means that having a quality foundation in scientific principles and a blueprint for delivering lessons through the teachers' educational background in science are incredibly impactful for the content knowledge they need in the sustainable use of IBA. Moreover, as indicated in the figure, the individual differences did not influence the teachers in their decision-making process for the sustainable use of IBA.

Chapter 5

SUMMARY, CONCLUSIONS and RECOMMENDATIONS

Summary

This qualitative multi-case study was conducted to determine the general pattern of the PCK of four (4) Grade 8 science teachers who used the inquiry approach in teaching cell division and Mendelian genetics. The other objectives were to find out how they developed their PCK, enumerate the active components of their PCK when using the inquiry approach, determine their mental construct of the inquiry approach, describe how they practice the inquiry approach, and find out the general pattern of their decision-making process. Through interviews, classroom observations, and analysis of artifacts such as lesson plans and tests, the data were collected and analyzed using constant comparative analysis.

In the following section, brief answers to the research questions were presented, grounded in the data. A short discussion and interpretation of the findings and inferred patterns common across cases are also provided.

1. *What is the general pattern of the PCK of the participating biology teachers who use the inquiry approach in teaching cell division and Mendelian genetics?*

The general pattern involves that before the lesson, teachers do any activity as an instructional strategy (knowledge of instructional strategy). During the lesson, teachers teach the content (knowledge of content) using cooperative learning that is supported by the use of models and multimedia materials (knowledge of instructional strategies). This teaching of content facilitates student learning (knowledge of students' understanding of science) by the students' developing of critical thinking, the teachers' use of multi-assessment tools, the students' developing of conceptual understanding and the teachers' correcting/preventing

misconceptions. After the lesson, in the context of slow learners, assessment follows, through giving an extra work or a remedial class (knowledge of assessment). While three teachers (Ace, Ces and Des) start with a motivational activity, Teacher Bes starts the lesson through another approach. Results also show that in relation to the PCK components, the emergent themes were identified. For knowledge of content, the identified theme was clear discussion of the basic concepts of cell division and Mendelian genetics. The identified emergent themes for knowledge of instructional strategies were use of cooperative learning, starting a lesson with motivational activities, use of models and multimedia materials, and use of a variety of activities. The identified emergent themes for knowledge of students' understanding of science were develop or stimulate students' critical thinking by asking questions, use of multi-assessment tools, teaching to develop conceptual understanding, critical or analytical thinking skills, and problem-solving skills and correct/prevent misconceptions. Finally, for knowledge of assessment, the identified theme was giving extra work or remedial class to slow learners.

There was integration of the PCK components with the highest frequency between knowledge of instructional activities and knowledge of students' understanding of science. On the other hand, knowledge of content and knowledge of students' understanding of science had the least frequency of integration.

2. *How did they develop their PCK?*

There are four (4) approaches that the teachers used to develop their PCK, namely, institution-initiated trainings, self-study, consultation with colleagues or peer consultation and self-reflection. Common among the teachers were their participation in institution-initiated trainings and consultation with colleagues or peer consultation. Teachers Ace and

Des developed their PCK through self-study. In addition, self-reflection was also found to develop the PCK of all the teachers.

3. *What components of their PCK are more active when using the inquiry approach in teaching Cell division and Mendelian genetics?*

The two (2) PCK components found active when using the inquiry approach in teaching cell division and Mendelian genetics were knowledge of instructional strategies and knowledge of students' understanding of science. In these components, it was found out that there were many observations of active student interaction.

4. *What is their mental construct of the inquiry approach?*

The observed teachers' mental constructs of the inquiry approach were, namely, inquiry approach is a paradigm shift, student-centered, motivational, and promotes higher order thinking skills. However, they also viewed the approach as resource- and time-consuming and require good prior knowledge and skills of students.

5. *How do they practice the inquiry approach in teaching Cell division and Mendelian genetics?*

By analyzing how the teachers employed the 4As of the DepEd's inquiry instruction, the practice of the inquiry approach in teaching cell division and Mendelian Genetics was determined. In discussing cell division and Mendelian genetics, Teachers Ace and Des followed completely the 4As of inquiry instruction, namely, Activity, Analysis, Abstraction and Application. Two teachers (Ace and Des) followed the 4As: Activity, Analysis, Abstraction and Application in teaching cell division and Mendelian genetics as they discussed completely the concepts based on the DepEd's learning competencies. Teacher Ces discussed almost completely the concepts of cell division and Mendelian genetics while

Teacher Bes discussed the concepts incompletely, missing some of the components of the 4As of inquiry instruction.

6. *What is the general pattern of the decision-making process of the biology teachers in using the inquiry approach?*

The teachers followed the four (4) models of decision-making process in different instances. Teacher Ace's decision-making process followed the Incremental Model in a specific instance and Rational Comprehensive Model in another instance. Teacher Bes followed the Incremental Model, Bounded Rationality Model, and Rational Comprehensive Model in different instances. Both Teachers Ces and Des followed the Incremental Model and Bounded Rationality Model in different instances, too.

Influencing Factors for the Teachers' PCK and Decision Making

Based on their educational background, Teachers Ace and Des were consistent in having a high level of PCK as they discussed the different topics of cell division and Mendelian genetics completely. Thus, the number of years of teaching and professional development programs attended did not influence the teachers in having a high level of PCK. Nevertheless, as the teachers have individual differences (educational background, number of years of teaching/teaching experience, number of professional development programs), they were able to make the necessary decision making when they used IBA in teaching cell division and Mendelian genetics.

Conclusion

The results of this study addressed the major areas of arguments presented as follows. After an in-depth analysis of the teachers in terms of their PCK and inquiry instruction, it can be concluded that the number of years of teaching/teaching experience does not guarantee

expertise. Moreover, it was found out that there is an observed relationship between PCK and decision-making process of the teachers which implies that having a teacher's knowledge will be a useful basis for teacher's actions. With the observations on the PCK components of each of the teachers, the teachers showed specific decision-making process in specific instances to implement the inquiry approach. Results also indicate that it is not true that this relationship may only be observed among teachers in the private sector but also in the public sector as well. The findings also indicate that professional development seminar attendance did not influence the teacher's PCK and decision-making process. The four (4) knowledge bases according to a combined model of PCK of Chick et.al ,(2006); Cochran et al. (1991), Sothayapetch et al., (2013) and Magnusson, (1999) were useful in studying about the teachers' PCK and decision making. Finally, result shows a relationship between the teacher's mental construct of IBA and practice. How the teachers formed their mental constructs relied on how they discussed the topics.

1. Based on results, it can be concluded that the relationship between PCK and the inquiry approach holds true not only for preservice teachers and experienced teachers but also for beginning teachers.
2. Results indicate that the decision to implement the inquiry approach in teaching cell division and Mendelian genetics improve science attitudes and skills of the students. Thus, teachers decide to implement the inquiry approach because of its useful effects on the teacher and students as well, despite the presence of some limitations.
3. Based on how they practice the inquiry approach in teaching cell division and Mendelian genetics, career stage 1/beginning teachers (with 0-5 years of teaching) followed the 4As completely compared with the career stage 2/proficient teachers (more than 5 years) who followed at least two (2) of the 4As only. Thus, after an in-depth analysis of the teachers

in terms of their PCK and inquiry instruction, it can be concluded that the number of years of teaching does not guarantee expertise. The development of PCK complements the use of the inquiry approach in teaching as part of the teacher's decision making. The development of PCK involves institution-initiated trainings, consultation with colleagues/peer consultation, self-reflection and self-study.

4. Results indicate that a relationship exists between PCK and decision making among the career stage 1/beginning teachers and career stage 2/proficient teachers. With the specific elements of PCK, there is a decision to implement the inquiry approach.
5. Results indicate that the individual differences in terms of educational background influenced the teachers' PCK level. On the other hand, educational background, number of years of teaching/teaching experience and professional development program attendance did not influence the decision making of the teachers.
6. Results indicate a relationship between PCK and the inquiry approach, and, PCK and decision making among the four (4) public high school teachers. Thus, it is not true that this relationship may only be observed among science teachers from the private sector.
7. The PCK category consisting of four (4) knowledge based on the combined Model of et.al. (2006), Cochran et al. (1991) and Sothayapetch et al. (2013) provided a useful reference for studying about the PCK of the teachers in relation to their decision making in using the inquiry approach for teaching cell division and Mendelian genetics.
8. There is a relationship between the teacher's mental construct and practice. How the teachers taught the topics influenced the formation of specific mental construct.

Recommendations

A recommendation for continuous professional development programs is suggested among beginning teachers. After about a year or two years of teaching, beginning teachers may apply for a master's degree. While a bachelor's degree is a notable achievement, it often is not enough to provide the optimal difference in students' lives. Being accomplished as an educator requires an advanced education degree, specifically designed to arm teachers with specialized skills. Moreover, a master's degree equips teachers with an advanced technical understanding of their subject matter of choice. However, the professional development program to be undertaken should exactly match with what the teacher is teaching so that content knowledge is completely taught to the students. As beginning teachers finish a master's degree, their expertise is enhanced as they are categorized as highly proficient teachers. Professional development programs may also involve short courses on teaching through the inquiry approach. This suggests that consistent school support through ongoing professional development programs is essential. Supporting the development of teachers' PCK for inquiry-based teaching is no simple task, but rather a complex activity. The professional development programs need to build on teachers' strengths and limitations, and should take into account the internal conflicts that teachers experience in their decision-making processes and classroom practices (Tuenter et al., 2013) regarding the use of the inquiry approach. Trainings on skills for teachers' subject matter knowledge are not enough (Weigel, Mulder & Collins, 2007). There is a need to go beyond lecturing teachers on how to teach science using the inquiry approach. Further obtaining of professional development program is taking a higher-degree where the teacher after he/she graduates may be involved in policy making, curriculum improvement, teaching improvement,

use of authentic activities, among others. In this case, the teachers are categorized as distinguished.

Results of this study contribute to the professional development of teachers and teacher educators on the individual, organizational, and national level. It is, thus, recommended that the findings be used to design assessment instruments to measure teachers' inquiry-based science teaching competencies. This will help in setting up professional development inquiry-based science teaching programs for teachers.

Instructional designers may use the results in revising the module in Grade 8 science in terms of content, illustrations and activities. Although all the teachers use the same module/textbook, they all resort to using other textbooks due to some important reasons. First, it has been found out that there is incomplete information in the module about the chromosome (only parts are shown but no discussion about its functions), about cell division (cytokinesis is not discussed; it should be discussed with an illustration) and about the discussion on Mendel's experiment (much better presentation is needed). Second, the experiment of Mendel, which is a basic concept in genetics, should be clearly illustrated for better student understanding. Third, illustrations are blurred (cell cycle, stages of meiosis) and there are only few activities on monohybrid and dihybrid crosses. Thus, it is imperative that revisions be made to provide the teachers as well as the students with complete mastery of content.

The study observed that one of the factors that contributes to teachers' decision to adopt IBA is peer consultation. Thus, it is recommended that collaboration among teachers should be strengthened in this time of pandemic. It is apparent that collaboration plays an important role in the adoption and implementation of the approach. Collaboration or peer consultation allows the sharing of practices between expert teachers and novice teachers. Thus, in the process the latter

may gain insights from the sharing which they can explore in their own teaching environment. Likewise, with the differences in the content knowledge and teaching experiences of the teachers, a strong collaboration or peer consultation may lead to the discovery and development of innovative ways on how to implement IBA amidst the pandemic. Though collaboration has already existed informally among teachers during the pre-pandemic period, it should be strengthened in this pandemic time. The schools should provide a space like synchronous interactions (like via zoom) among teachers where they can share their best practices in implementing IBA. An online inter-school synchronous conversation can likewise be facilitated by school administrators.

In addition, IBA activities can be integrated into the modules that are distributed to the students. Real-life questions such as “Whose trait did you inherit?” or “What is removed when you scrub your body?” as practiced by Teacher Des or Teacher Ace can be used in elucidating the concepts of Genetics or cell division, respectively, and maybe utilized to enhance collaboration among family members, which could simulate the collaborations among students in a face-to-face set-up. How the lesson is being presented inside the classroom may also be replicated in the modules. That is, the modules should be written in a conversational manner so that students may behave as if they are listening to an invisible teacher. The same approach could be done in an online learning environment although online learning activities could be added. For instance, the use of storytelling as practiced by Teacher Ces could be replicated in an online learning modality but this time, maybe, with the use of video recorded materials.

It is also recommended that a competence list of effective teaching using the inquiry approach be compiled based on the findings of the study. This competence profile might help teachers and school heads to reflect on the science curriculum for initial teacher training, to

implement competence guide, and to change the teaching approach for science courses (if inquiry approach is not yet implemented). A competency list might also cause more transparency of expectations. The competence list may also be used by administrators of non-IBT adopting schools as a guide for motivating teachers to use the inquiry approach.

The constant comparative analysis includes that every part of data, i.e. emerging codes, categories, properties, and dimensions as well as different parts of the data, are constantly compared with all other parts of the data to explore variations, similarities and differences. It is a powerful tool that can be used for a large amount of data focusing on comparisons between interviews and observations conducted to answer the research questions. It is then recommended that other teachers use it other than the available qualitative and quantitative tools. When used, it is suggested that the researcher becomes creative and skillful as making the right choices in this process depends on the researcher's knowledge, support, talent and sensitivity. Sensitivity makes use of personal and professional experiences as well as methodological knowledge and thereby sees data in new ways in the process of developing theory. It is also suggested that a detailed memo-writing during the entire analysis process be used to write down ideas, assume associations, and make theoretical reflections related to each of the emerging categories.

Recommendations for future research should be in line with the K-12 implementation and should investigate PCK and decision making toward teaching using the inquiry approach among Grade 7, 9 and 10 science teachers.

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APPENDIX A
Letter for the Schools Division Superintendent

DR. JOSILYN SOLER SOLANA
Schools Division Superintendent
Division of Laguna

Dear Dr. Solana:

The undersigned is a PhD student of the UP Open University who is undergoing a study on "**BIOLOGY TEACHER'S PEDAGOGICAL CONTENT KNOWLEDGE AND DECISION MAKING IN IMPLEMENTING THE INQUIRY APPROACH**" where Grade 8 science teachers will be interviewed and observed in their respective classes.

In connection with this, I would like to ask permission that I be allowed to conduct this study to four (4) Grade 8 science teachers, two (beginning and experienced) each from Los Baños National High School and Pedro Guevara Memorial National High School from _____ . The choice of the schools from where the teachers were obtained, was based on the following:

1. The schools offer the DepEd's Engineering and Science Education Program (ESEP) which started in 2010 (STE Program) which hold a special science curriculum.
2. The schools involve the teaching of the making of an investigatory project, which is an inquiry-based activity.
3. The schools are consistent winners for the last five years in the DepEd's Regional and National Science Fairs where the students showcase their skills in investigatory project making.

The researcher's activities in the said schools will involve interviews and classroom observations on the indicated dates.

Rest assured that all information about the teachers will be treated with anonymity and confidentiality. Thank you very much.

Very truly yours,

Lea C. Garcia
PhD student

NOTED:

Ricardo T. Bagarinao, PhD.
Adviser

APPENDIX B

Letter for the DepEd's Division Science Supervisor

DR. REDELLA VISTA
Division Science Supervisor (High School)
Division of Laguna

Dear Dr. Vista:

The undersigned is a PhD student of the UP Open University who is undergoing a study on **"BIOLOGY TEACHER'S PEDAGOGICAL CONTENT KNOWLEDGE AND DECISION MAKING IN IMPLEMENTING THE INQUIRY APPROACH"**. Four grade 8 science teachers, where two (beginning and experienced) each from Los Baños National High School and Pedro Guevara Memorial National High School will be the teachers. In connection with this, I would like to ask permission that I be allowed to set a meeting with the principals of the said schools so that the principals may recommend the teachers and also to meet the teachers to arrange the schedule of interviews and classroom observations.

Rest assured that all the information about the teachers will be treated with anonymity and confidentiality.

Thank you very much.

Very truly yours,

Lea C. Garcia
PhD student

NOTED:

Ricardo T. Bagarinao, PhD.
Adviser

APPENDIX C
Letter for the Principal of School 1

MR. NELSON R UMALI.
Principal III, Los Banos National High School
Los Banos, Laguna

Dear MR. UMALI:

The undersigned is a PhD student of the UP Open University who is undergoing a study on **“BIOLOGY TEACHER’S PEDAGOGICAL CONTENT KNOWLEDGE AND DECISION MAKING IN IMPLEMENTING THE INQUIRY APPROACH”**. Attached is the Indorsement Letter from Dr. Josilyn S. Solana, CESO V, Schools Division Superintendent allowing me to conduct this study in your school. In connection with this, I would like to ask for your recommendation of two (2) grade 8 science teachers, (beginning- 0 to 5years of teaching experience, and experienced- more than 5 years of teaching) to become my teachers. The topics involved are cell division and Mendelian genetics. As per your recommendation of the teachers, I would like to meet them regarding the teaching of these topics. However, I am providing you with the tentative schedule which I will finalize with your recommended teachers upon meeting them.

Date	Activity
4 th week of February to 1 st week of March	<ul style="list-style-type: none"> ○ Meet teachers ○ Fill- out teacher’s profile ○ Orient teachers about the study ○ Pre-classroom observation interview
March 7 – 18, 2016	<ul style="list-style-type: none"> ○ Classroom Observations with video documentation
4 th to last week of March	<ul style="list-style-type: none"> ○ Post-classroom observation & interview

Rest assured that all information about the teachers will be treated with anonymity and confidentiality.

Thank you very much.

Very truly yours,

LEA C. GARCIA
PhD student
Division of Laguna

NOTED:

DR. JOSILYN SOLER SOLANA
Schools Division Superintendent

APPENDIX D
Letter for the Principal of School 2

Dr. Reynaldo D. Villaluz, Ed.D.
Principal, Pacita Complex National High School
Pacita Complex, San Pedro, Laguna

Dear DR. VILLALUZ:

The undersigned is a PhD student of the UP Open University who is undergoing a study on **“BIOLOGY TEACHER’S PEDAGOGICAL CONTENT KNOWLEDGE AND DECISION MAKING IN IMPLEMENTING THE INQUIRY APPROACH”**. Attached is the Indorsement Letter from Dr. Josilyn S. Solana, CESO V, Schools Division Superintendent allowing me to conduct this study in your school. In connection with this, I would like ask for your recommendation of two (2) grade 8 science teachers, (beginning- 0 to 5years of teaching experience, and experienced- more than 5 years of teaching) to become my teachers whom I am going to interview and observe as they discuss the topics on cell division and Mendelian genetics in the fourth quarter. As per your recommendation of the teachers, I would like to meet them regarding the schedule of the conduct of the study. However, I am providing you with a tentative schedule which I will finalize with your recommended teachers upon meeting them.

Date	Activity
4 th week of February to 1 st week of March	<ul style="list-style-type: none"> ○ Meet teachers ○ Fill- out teacher’s profile ○ Orient teachers about the study ○ Pre-classroom observation interview
March 7 – 18	<ul style="list-style-type: none"> ○ Classroom Observations with video documentation
4 th to last week of March	<ul style="list-style-type: none"> ○ Post-classroom observation interview

Rest assured that all information about the teachers will be treated with anonymity and confidentiality.

Thank you very much.

Very truly yours,

LEA C. GARCIA
PhD student
Division of Laguna

NOTED:

DR. JOSILYN SOLER SOLANA
Schools Division Superintendent

APPENDIX F

PRE- CLASSROOM OBSERVATION INTERVIEW GUIDE

A. PCK Attributes Guide for teaching "Cell division" and "Mendelian genetics"

Tasks of the Researcher:

1. Tell the teachers that they can answer either in English or Filipino.
2. The interview will be audio taped.
3. Find a place (library or teacher's room or vacant room) where you will have the interview.

Questions to be Asked by the Researcher about Cell division and Mendelian genetics:

1. Please describe how you start teaching cell division and Mendelian genetics. Do you stimulate learning through an activity? Can you describe the activity?
2. Do you always follow the textbook to teach the students? What can you say about your textbook? Do all the contents in the textbook satisfy the curriculum of science? Do you use other materials?
3. How do you support student thinking through teaching about cell division and Mendelian genetics?
4. How do you teach them to learn about cell division and Mendelian genetics? In what way?
5. In your opinion, what is the purpose of learning about cell division and Mendelian genetics?
6. What instructional strategies do you employ to easily teach cell division and Mendelian genetics to the students? What do you think is the best method to teach these concepts?
7. From your point of view, what is the main reason for students to learn the content or concepts regarding cell division and Mendelian genetics? Or why is it important for students to learn about these topics?
8. How do you prevent student misconceptions? How do the different learning abilities of the students affect their learning of the content or concepts? How do you address these?
9. How do you know that students understand the idea or concepts you teach? In what way?
10. What kind/s of test do you give to measure student's learning of the concepts of cell division and Mendelian genetics? What do you do if the students fail in your test?
11. What other resources will you recommend to the students in order to learn about cell division and Mendelian genetics?
12. Do you keep a journal where you can describe your teaching or describe concepts which are difficult to teach? If yes, can you describe your journal.
13. Do you note/ask yourself which activities/strategies seem to work best in a specific group of learners? If yes, can you describe the strategies/activities?
14. Do you discuss/collaborate with other teachers in preparing your lessons? If yes, describe how you do it.
15. Do you engage in action research projects? Describe your engagement.

B. Implementation of INQUIRY APPROACH

Questions to be Asked by the Researcher:

1. For you, what is your perception of the inquiry approach ?
2. Can you tell me your idea of the inquiry approach in terms of its benefits/usefulness?
3. Do you find it easy? Difficult? If difficult, why do you decide to use it? Can you explain the reasons? If useful, can you explain how?
4. How do you decide to use it? Can you describe the process. For example, how do you do it, in terms of planning (your preparation), implementing (includes limitations, strategies to use) and assessing (type of test you do). Is it a good decision to use it? Explain why.

APPENDIX G

General Classroom Observation of the Inquiry Approach Practice Guide

Teacher: _____ Section: _____
Date: _____ Time started: _____ Time finished: _____

Unit/Chapter: _____ Lesson: _____

Tasks of the Researcher:

1. Make sure that the lesson plans are with the observer.
2. Set-up the video 10 minutes before the actual teaching.

Write all your observations regarding INQUIRY APPROACH implementation in the teaching of cell division/Mendelian genetics. Please write down everything that the teacher does in the classroom.

APPENDIX H

Post-Classroom Observation Interview Guide

Tasks of the Researcher:

1. Please bring the copy of the teacher's lesson plan or any graded student's work for comparison with the pre-classroom observation transcript and actual teaching performance observations.
2. Tell the teachers that in the interview, they may answer either in English or Filipino.
3. All the informal interview will be audio recorded.

A.PCK Attributes Guide for teaching "cell division" and "Mendelian genetics" Questions to be asked by the Researcher. (Note: It is possible that other observations may be documented during the actual teaching, and the following questions may be considered as tentative. Additional questions will be prepared after the actual teaching).

1. You mentioned about crossing over in cell division. Can you elaborate on these?
2. The concept of cytokinesis was mentioned but you did not discuss on this. Can you elaborate on this?
3. You mentioned about student's performance of an experiment. Why did you not use it in your class?
4. I observed you mentioned about the genetic disorders but you did not discuss on this completely. Can you elaborate on this?
5. You mentioned about teaching strategies, but not observed? Why?
6. I observed that only a few passed in this test. What is your reaction to this? What do you do to help slow learners?

B. Implementation of INQUIRY APPROACH

1. In terms of benefits/usefulness of inquiry approach use, were you able to experience this as you discussed the said topic? Can you expound on this.
2. You mentioned that it was difficult to use inquiry approach but you had a good discussion on the given topic. What made you decide to use the inquiry approach?
3. What made you decide to use it? Can you elaborate on this? Do you think it is a good decision to use the inquiry approach? Expound on this.
4. Do you have other inquiry-based activities that you would like to try in the class? Can you elaborate?

APPENDIX I

Checklist for the Teacher's Documents

(based on clues of the 9 principles of Grotzer (1996) in output demonstrating the inquiry approach)

School: _____ Date when document was given: _____

1. Description of the document

- a. Type: _____
- b. Purpose: _____

2. Does the document demonstrate inquiry-based learning?

- a. Indicates experiential activity

- b. Indicates question-asking

- c. Indicates use of collaborative learning

- d. Indicates use of open-ended questions

- e. incorporates discovery/students build a model to answer questions in a sequential order)

- f. theorizes and considers evidence

- g. indicates use of measurement

- h. indicates use of specific instruments/materials

- i. incorporates hands-on activities

APPENDIX J
Summary of Reflective Journal Entries

Teacher: _____ Section: _____ Date: _____
 Unit/Chapter: _____ Lesson: _____

Part 1

Entry No.	Summary

Part 2

Pre-classroom Observation	Researcher's Task	Data Collection Procedures	Data analysis Procedures
Classroom Observation	Researcher's Task	Data Collection Procedures	Data analysis Procedures
Post-classroom Observation	Researcher's Task	Data Collection Procedures	Data analysis Procedures

APPENDIX K
DepEd's Topics for Fourth Grading Period

Grade 8 FOURTH Grading Period	Learning Competency	No. of days
Topic		
Biodiversity	Explains the concept of species as a reproductively distinct group of organisms	2
Species diversity	Classifies organisms using the hierarchical taxonomic system (domain, kingdom, phylum, class, order, family, genus, species) based on structure and function	3
Hierarchical taxonomic system of species	Explains the advantage of high biodiversity in maintaining the stability of an ecosystem	3
Protection and conservation of endangered and economically important species		
Ecosystems	Describes the transfer of energy through the trophic levels	2
Transfer of energy in trophic levels	Analyzes the roles of organisms in the cycling of materials	2
Cycling of materials in the Ecosystems	Explains how materials cycle in an ecosystem	4
water cycle	Suggests ways to minimize human impact on the environment	2
oxygen-carbon cycle	Describes changes caused by organisms in their environment	2
nitrogen cycle		
Impact of human activities in an ecosystems		
Structures and Functions: Focus on the Digestive System	Describes the coordinated functions of the organs of the digestive system	2
Organs of the digestive system and their interaction with organs of the respiratory and circulatory systems	Traces the path of food as it is being digested	1
Changes in food as it undergoes physical and chemical digestion	Explains how enzymes help in digesting food	1
Diseases resulting from nutrient deficiency and ingestion of harmful substances	Explains how digested food is absorbed through the villi and is carried through the bloodstream to the liver	2
Prevention, detection, and treatment of diseases of the digestive system	Explains how dissolved wastes and solid wastes are eliminated through the excretory system	1
Contemporary health issues that promote proper nutrition and overall wellness	Illustrates how diseases of the digestive system are detected, prevented or treated	1
Heredity: Inheritance and Variation of Traits	Identifies healthful npractices that affect the digestive system	1
Organelles of the cell involved in cell division	Discusses contemporary health issues that promote proper nutrition and overall wellness	1
Stages of mitosis		
Stages of meiosis	Identifies organelles that are involved in cell division	1
Mendelian Genetics	Describes and compares the processes of mitosis and meiosis and their role in the cell division cycle	3
	Compares the number of chromosomes of the daughter cells resulting from mitosis and meiosis	2
	Differentiates oogenesis from spermatogenesis	2
	Explains the significance of meiosis in maintaining the chromosome number	1
	Describes how the union of egg and sperm cells results in variation	1
	Identifies phenotypes as the expression of inherited characteristics	2
		42
GARCAT		

APPENDIX L

Sample Institutional Plan (Modified Lesson Plan)

LEARNING OBJECTIVES	KNOWLEDGE	Identify and explain mitosis and meiosis division.
	SKILLS	Illustrate the stages of mitosis and meiosis division.
	ATTITUDES	Understand why there are different physical traits among each other.
RESOURCES NEEDED	REFERENCE USED	Learners Manual page 320-327; Teachers Guide
	TEACHER'S MATERIALS.	projector, video clip on mitosis and meiosis
	LEARNER'S MATERIALS.	manila paper/cartolina, pentel pen
ELEMENTS OF THE PLAN	TEACHER'S ACTION	LEARNER'S RESPONSE
MOTIVATION / INTRODUCTORY ACTIVITY	Orally asked students the stages in cell cycle. Hand sign exercise in stages of mitosis.	Students enthusiastically complied.
ACTIVITY	Video viewing on mitosis and meiosis. Follow up activity in illustrating and explaining mitosis and meiosis division.	Students watch the video. Some are not focus and called upon. Students are cooperative during activity proper.
ANALYSIS	The following questions to be delivered: (1) What are the phases/ stages involve in mitosis? (2) What are the phases / stages involved in meiosis?	Students have answered the questions adequately.
ABSTRACTION	Emphasis on mitosis division is for somatic cells (body cells) and meiosis division is for sex cell (sperm cell and egg cell).	Students are now aware from where their physical traits came from based on the family portrait on the previous lesson.
APPLICATION	The following statement to be delivered: (1) The cell division in body cells help us grow. (2) The division of sex cells let us know what we inherited from our parents.	
ASSESSMENT	TEACHER'S ACTION	LEARNER'S RESPONSE
KNOWLEDGE	The stages of mitosis and meiosis division.	Students express their opinion on mitosis and meiosis division.
PROCESS OR SKILLS	Illustration of the mitosis and meiosis division.	Students adequately illustrated the mitosis and meiosis division.
UNDERSTANDING	Explain the stages of mitosis and meiosis division.	Students adequately explains the mitosis division but had a hard time in completing the explanation on meiosis division.
PRODUCT / PERFORMANCE	Evaluation of group work (posted on the board).	Using rubrics, the students evaluate their classmates group work.
ASSIGNMENT		REMARKS
Reinforcement	(1) Bring onion roots and fish eggs.	Out of 5 groups, one group fairly explained their work but have not illustrated properly. Other groups presented adequately.
Enriching		
Enhancing		
Preparing for now lesson		

PREPARED BY:

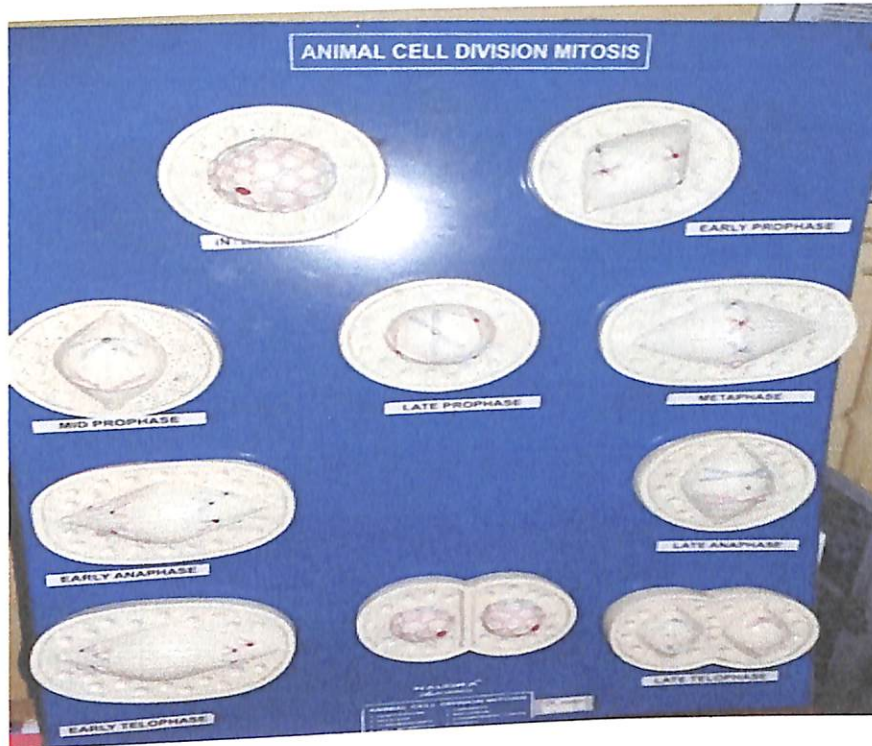
MARY ANN T.
ENRIQUEZ

CHECKED BY:

BARBARA BELVINO

CORROBORATED BY:

APPENDIX M
Instructional Materials for Module 5



APPENDIX N

Two Long tests of School A

I. Modified true or false. Write T if the following statement is true, and F if the statement is false. Circle the underlined word to make it correct.

1. Mendel's pea plants were self-fertilized for several generations before he began his experiments. **T**

2. The phenotype is the physical expression of the genotype. **T**

3. The genotype is the genetic makeup of an organism. **T**

4. The phenotype is determined by the genotype and the environment. **T**

5. The genotype is determined by the phenotype and the environment. **F**

6. The phenotype is determined by the genotype and the environment. **T**

7. The genotype is determined by the phenotype and the environment. **F**

8. The phenotype is determined by the genotype and the environment. **T**

9. The genotype is determined by the phenotype and the environment. **F**

10. The phenotype is determined by the genotype and the environment. **T**

II. Identify the stage or phase exhibited in the following situations. Choose your answer in the box provided.

1. The chromosomes are visible as distinct structures. **Metaphase**

2. The nuclear envelope is breaking down. **Prophase**

3. The chromosomes are moving toward the poles. **Anaphase**

4. The chromosomes are condensing. **Prophase**

5. The chromosomes are decondensing. **Telophase**

6. The chromosomes are moving toward the poles. **Anaphase**

7. The chromosomes are condensing. **Prophase**

8. The chromosomes are decondensing. **Telophase**

9. The chromosomes are moving toward the poles. **Anaphase**

10. The chromosomes are condensing. **Prophase**

III. Match the description with the correct stage of mitosis.

1. The chromosomes are visible as distinct structures. **Metaphase**

2. The nuclear envelope is breaking down. **Prophase**

3. The chromosomes are moving toward the poles. **Anaphase**

4. The chromosomes are condensing. **Prophase**

5. The chromosomes are decondensing. **Telophase**

6. The chromosomes are moving toward the poles. **Anaphase**

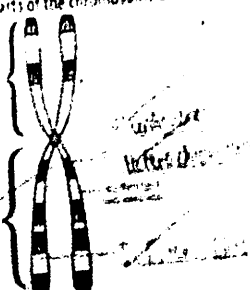
7. The chromosomes are condensing. **Prophase**

8. The chromosomes are decondensing. **Telophase**

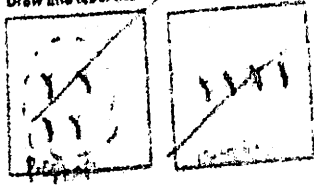
9. The chromosomes are moving toward the poles. **Anaphase**

10. The chromosomes are condensing. **Prophase**

IV. Label the parts of the chromosome below.



V. Draw and label the four stages of mitosis.



Long test 1

Write the letter of the best answer. For numbers 12-15, show your solution using a Punnett square.

1. He is an Augustinian monk that was interested in investigating how individual traits were passed on.
 - A. Gregor Mendel
 - B. Landon Down
 - C. Hugo De Vries
 - D. Carl Linnaeus
2. Constitutes the offspring of the parental cross.
 - A. P1 generation
 - B. F2 generation
 - C. Parental
 - D. Gametes
3. The dominant trait dominates or prevents the expression of the recessive trait.
 - A. Law of Segregation
 - B. Law of Independent Assortment
 - C. Principle of Codominance
 - D. Principle of Dominance
4. How many gametes will be formed in the genotype RrYy?
 - A. 2
 - B. 3
 - C. 4
 - D. 16
5. Which of the following genotypes is homozygous dominant?
 - A. Rr
 - B. RR
 - C. Rr
 - D. rR
6. Which of the following genotypes are all heterozygous?
 - A. RrAa
 - B. RRaa
 - C. rRAA
 - D. RRAA
7. It is a cross between individuals that involve two heterozygous pairs of genes.
 - A. Hybrid cross
 - B. Monohybrid cross
 - C. Dihybrid cross
 - D. Polyhybrid cross
8. When a white flower is crossed with a red flower, all of the offspring exhibited pink flowers. Which Non-Mendelian principle of inheritance best explains this occurrence?
 - A. Codominance
 - B. Incomplete dominance
 - C. Multiple alleles
 - D. Sex linked trait
9. Which of the following statements is FALSE about sex determination?
 - A. Human body cells show 23 pairs of chromosomes: 22 pairs are somatic chromosomes and 1 pair sex chromosome.
 - B. Human males have non-identical sex chromosomes.
 - C. All individuals with Y chromosomes are all males.
 - D. All individuals with X chromosomes are all females.
10. Which of the following traits is NOT a sex linked trait?
 - A. Hemophilia
 - B. Color blindness
 - C. Hypertrichosis
 - D. Polydactyly
11. Leo is a carrier of the trait hypertrichosis pinnae auris, a genetic disorder that causes hair on the ear. Leo's trait is said to be Y-linked. If he marries Jessa and had 4 children- 2 boys and 2 girls, how many of their children will have hypertrichosis?
 - A. All the boys only.
 - B. All the girls only.
 - C. All of the children.
 - D. None of them.
12. What could be the blood type of a father if his wife has a blood type A and his daughter has a blood type AB?
 - A. A
 - B. AB
 - C. B
 - D. O
13. When a normal female but a carrier of color blindness marries a normal male, what is the probability of having a colorblind male offspring?
 - A. 25%
 - B. 50%
 - C. 75%
 - D. 100%
14. Edzel has a blood type of AB, if he marries Caren who has a blood type of B, which of the following will not be the blood type of their child in the future?
 - A. A
 - B. AB
 - C. B
 - D. O
15. Vincent and Coelin wants to identify their real daughter who was missing for two years. The following data were presented to the couple:

Name	Blood Type
Vincent	AB
Coelin	O
Child X	A
Child Y	B
Child Z	O

If you are the investigator, who among the children will you eliminate first?

- A. Child X
- B. Child Y
- C. Child Z
- D. All of the children

For numbers 12-15, scoring will be based on the following rubrics:
 Punnett square: 5 points
 genotypic ratio: 2 points
 phenotypic ratio: 2 points
 correctness: 1 point

Long test 2

APPENDIX O

Two Long tests of School B

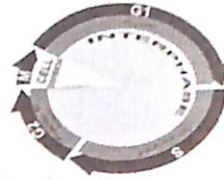
GRADE 8 QUARTER 4 Module 5 Cellular Reproduction and Genetics (PART A)

- It is the study of heredity and variation.
- All living things contain the genetic material that serves as the set of instructions that direct the activities and functions of the cells.
 - cell membrane
 - Deoxyribonucleic acid
 - nucleus
 - Ribonucleic acid
- The number of chromosomes in a Homo sapien (man) is _____ while the number of chromosomes of a Caenorhabditis elegans (roundworm) is _____.
 - 24, 8
 - 42, 10
 - 46, 12
 - 52, 20
- The picture at the left is a DNA that are bound with proteins and are organized as beads and strings.
 - cell membrane
 - chromosome
 - microtubules
 - nucleus



For item numbers 5 to 7, refer to figure 1 (the cell cycle)

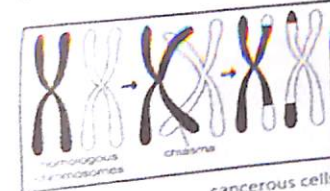
- The period of DNA synthesis or replication in preparation for the next cell division.
- It represents a period of rapid cell growth to prepare for cell division.
- This stage is characterized by protein and ribonucleic acid (RNA) synthesis.
- Mitosis and meiosis are applied in _____ cells.
 - egg
 - eukaryotic
 - prokaryotic
 - sperm



For numbers 9-12, complete the table below.

	Mitosis	Meiosis
9. Number of daughter cells produced		
10. Number of chromosomes is halved. (Yes/No)		
11. Pairing of homologous chromosomes take place. (Yes/No)		
12. The daughter cells produced are always identical in terms of genetic material. (Yes/No)		
13. The crossing over of homologous chromosomes happens during _____.		

- Meiosis I Anaphase II
- Meiosis I Prophase I
- Meiosis II Prophase II
- Meiosis II Telophase I



14. Gametes cells are sex cells while somatic cells are _____.
- also sex cell
 - not sex cells but other type of cells
 - both other type of cells and sex cells
 - not other type of cells but

15. The following are examples of drugs that are know to cause breaks or abnormalities in chromosomes EXCEPT _____.
- Chlorphenamine
 - Chlorpromazine
 - Diphenhydramine
 - Lysergic acid diethylamide

16. Gregor Mendel was an Augustinian monk in a monastery was interested in investigating how individual traits are inherited. Which of the following sequence Mendel conducted on the garden pea?

- He cross pollinates the hybrid plants.
 - The offspring of the parental cross produces hybrids.
 - He produces pure breed round and wrinkled plants.
 - He cross pollinates peas with round and wrinkled traits.
 - The round traits are three times as many as the wrinkled.
- 1 3 4 2 5
 - 1 2 3 4 5
 - 3 4 2 1 5
 - 3-2-1-4-5

For item numbers 17-20, match column A to column B.

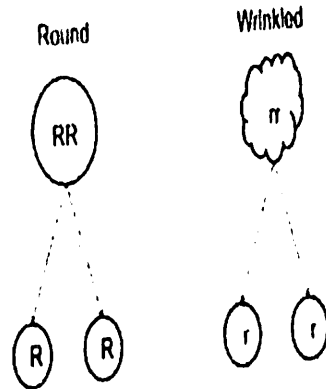
COLUMN A	COLUMN B
17. genes	A. prime or showy trait
18. alleles	B. the pair factors which controls the appearance of a particular trait
19. dominant trait	C. hidden traits
20. recessive trait	D. controls the appearance of traits

Long test 1

GRADE 8 CHAPTER 4
Module 5 Cellular Reproduction and Genetics
(PART B)

1. A gene is a pair of particular traits. Which of the following statements is NOT true about a gene?
- It can only have a pair of recessive traits.
 - It can only have a pair of dominant traits.
 - It can both have a dominant trait and recessive trait.
 - It cannot have either a dominant trait or a recessive trait.
- For item number 2 to 6, refer to the illustration below.
2. What does genotype RR represents?
- Hybrid round pea plant
 - Hybrid wrinkled pea plant
 - Pure-breed round pea plant
 - Pure-breed wrinkled pea plant
3. What is the dominant trait?
- Green colored pea plant
 - Round seeded pea plant
 - Wrinkled seeded pea plant
 - Yellow colored pea plant
4. The genotype rr separates into how many gametes?
- 2
 - 4
 - 6
 - None
5. The separation of genes during gamete formation is known as _____.
- Law of Segregation
 - Mendelian Genetics
 - Law of Independent Assortment
 - Non-Mendelian Patterns of Inheritance
6. Which of the following have a homozygous genotype?
- Green colored pea plant
 - Round seeded pea plant
 - Wrinkled seeded pea plant
 - Yellow colored pea plant
7. Which is NOT true about phenotype and genotype?
- Phenotype can be observed directly by physical appearance.
 - Genotype cannot be observed directly by physical appearance.
 - Phenotype is the expression of the genotype of an individual for a particular character.
 - Genotype cannot tell if an individual is homozygous or heterozygous for a given character.
8. The result of crossing pure-breeding round and wrinkled seeds is _____.
- rr
 - Rr
 - RR
 - RRrr
9. Using test cross technique,

0. 1111

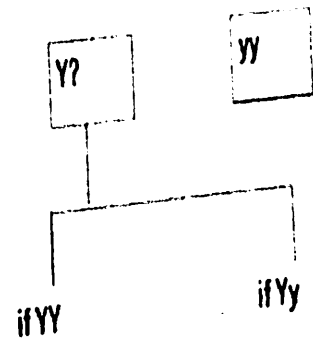


9. Using test cross technique, Y (dominant yellow) and y (recessive green), what would be the result of the genotype seed color of pea from figure 1?

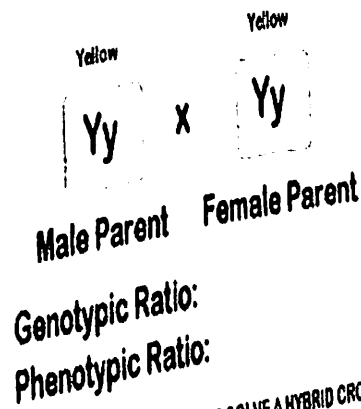
- All yellow, all green
- All yellow, ½ green
- ½ yellow, ½ green
- ½ yellow, ¾ green

10. It helps us to predict the outcome of a given cross.

- Probability
- Punnett square
- Testcross technique
- Toss coin



For item number 11-15. Show complete solution.



PUNNETT SQUARE METHOD TO SOLVE A HYBRID CROSS

APPENDIX P

SAMPLE CODES EXTRACTED FROM INTERVIEWS VIA ATLASTI SOFTWARE

Codes-quotations list

Code-Filter: All

HU THESIS :
File [C:\Users\Admin1\Documents\atlasti\THESIS 1 hpr7]
Edited by Super
Date/Time 2016-09-13 14:47:34

Code: Action research as part of curriculum in the futuro (2-0)

P 1: INTERVIEW WITH T.ACE.pdf - 1:26 (I am not engaged but I know, t.) (7:1594-7:1800) (Super)
Codes [Action research as part of curriculum in the futuro]
No memos

I am not engaged but I know, this
action research project making will
be implemented next year. I think it
will be in the 3
rd
quarter of grade 8. I
hope this will push through, hopefully
(sighs)

P 3: INTERVIEW WITH T.CES.pdf - 3:29 (Two years ago, I have tried to..) (9:608-9:1350) (Super)
Codes [Action research as part of curriculum in the futuro]
No memos

Two years ago, I
have tried to pass a topic to the
Superintendent's office through
the Science Supervisor
However, until now there is no
response from the office. I do
not know the reason why I did
not receive any response.
Anyway, if in the future, the
teachers will have a chance to
be engaged in action research
projects, I suggest that DepEd
will hold a seminar on action
research first. I remember,
DepEd offered a seminar for
elementary action research so I
hope there is going to be one
for high school. I am involved
in curriculum improvement,
school improvement. I am the
president of the faculty 2 years
ago and I go for the particulars
of action research such as its

1

APPENDIX Q

SAMPLE CODES EXTRACTED FROM ACTUAL OBSERVATIONS VIA ATLASTI SOFTWARE

Observations on the Actual Teaching of Teacher Ace

Day 1. Teacher Ace was very energetic as she greeted her students. Her voice was loud enough to motivate the students to be awake and alive. She started the class with questions for motivation. She asked the students, "do you always take a bath?" "do you scrub your body when you take a bath?", "what is it that you remove from your body as you use a scrubbing pad?" In chorus, all the students answered, "we take a bath everyday, Ma'am". One student raised his hand and said, "when I use panglelod or scrubbing pad, some dead skin cells are removed." She asked "can you explain what this removal of dead cells means? Anybody?" One student raised his hand and answered, "Ma'am it indicates that cells do divide." The teacher said, "very good, now, class, are you familiar with the stages of mitosis?" The students said "Yes" but some said that "we are not sure of the correct order, Ma'am." Teacher Ace said, "we will discuss about the stages later but before we discuss that, we start with the cell cycle first." But before discussing about the cell cycle, she first asked, "among the cell parts that you know, which do you think is involved in mitosis?" The students took turns in answering "cell membrane, nucleus, mitochondria, Golgi body." The teacher said "it's the nucleus." "Why do you think so?" One

☒ Teacher's positive personality to motivate students

☒ Motivational activity of sharing personal experiences

☒ Critical thinking during discussion

Figure 7. The Parts of the Chromosome based on the LM

Teacher Ace pointed to the chromatid and centromere. She described the chromatid "as one of the paired strands of the duplicated chromosome while the centromere is the region where the spindle attaches during cell division." She added that "the euchromatin is the lightly staining region of the chromosome while heterochromatin is the darkly staining region." She asked, "what do you think is the importance of the chromosome?" One student answered that "the chromosome is for the transfer of traits." The teacher said "no because it is the DNA that does that role." She said that "the number of chromosomes in a cell is characteristic of the species where it belongs." She added, "there are some examples-humans have 46 chromosomes; dogs have 52; corn has 20." "For us humans, we are diploid(2n) while sex chromosomes are haploid (n)," she explained. She added that "the male chromosomes are XY while the female chromosomes are XX." After discussing about the chromosome, she showed a picture posted on a Manila paper an illustration of the cell cycle.

☒ Instruction of concept

APPENDIX R

SMART WORKERS OF THE CELL COMPANY

One day, while the nucleus got tired of his job, he decided to take a short nap. But as he closed his eyes, he heard noises of quarreling members of his cell company. The cytoplasmic organelles such as mitochondria, lysosomes, ribosomes, Golgi bodies, and endoplasmic reticulum were complaining of their very tiring and routinary work. They felt that the administration headed by the nucleus have given light duties for the cell membrane, cell wall and chloroplast. He stood up and called an emergency meeting and let each organelle cite their sentiments. Cytoplasm acts as a mediator since all organelles are embedded to him. Each of them was given a chance to defend themselves. Mitochondria: I change chemical energy stored in food into compounds that are more convenient for the cell to use. Lysosomes: I am a clean up crew. I have chemicals and enzymes necessary for digesting certain materials in cells that have outlined their usefulness.

Golgi bodies: Without me, lysosomes will not be here. I'm responsible also to modify, collect, package and distribute molecules at one location of the cell and used at another.

Ribosomes: Even I'm just 25 nanometer in diameter, I'm very active in making proteins.

Endoplasmic reticulum: Without me, each of us will not receive any important materials.

Proteins that are released or exported from the cell are synthesized by me.

The nucleus carefully analyzed the explanations of each organelle and gave the chance to the second group.

Cell membrane: I act like a door. Since you are working in this company, I make sure that I know what enters and leaves the company for your protection.

Cell wall: I go with the cell membrane in supporting and protecting the company.

Chloroplast: I agree with you, Mitochondria, but I'm the only one that can trap the energy of sunlight and convert it into chemical energy.

Cytoplasm: Now that we are all enlightened by your beliefs, as mediator, I believe that all of you played an important role for the company. But the decision still depends on our director and manager, the Nucleus.

The Nucleus said, "Do you still want to be a part of our company? Are you still willing to perform your job satisfactorily and faithfully? Can you live without each other? The answers are all yours..."

The first group of organelles shamefully approach the second group of organelles, hug each other and humbly accept their faults.

From then on, Cell's Company's organelles worked harmoniously.

APPENDIX S

PHILIPPINE PROFESSIONAL STANDARDS FOR TEACHERS

CAREER STAGES

<p>Career Stage 1 Beginning Teachers</p>	<p>Career Stage 2 Proficient Teachers</p>	<p>Career Stage 3 Highly Proficient Teachers</p>	<p>Career Stage 4 Distinguished Teachers</p>
<p>Beginning Teachers have gained the qualifications recognized for entry into the teaching profession.</p>	<p>Proficient Teachers are professionally independent in the application of skills vital to the teaching and learning process.</p>	<p>Highly Proficient Teachers consistently display a high level of performance in their teaching practice.</p>	<p>Distinguished Teachers embody the highest standard for teaching grounded in global best practices.</p>
<p>They have a strong understanding of the subjects/areas in which they are trained in terms of content knowledge and pedagogy.</p>	<p>They provide focused teaching programs that meet curriculum and assessment requirements.</p>	<p>They manifest an in-depth and sophisticated understanding of the teaching and learning process.</p>	<p>They exhibit exceptional capacity to improve their own teaching practice and that of others.</p>
<p>They possess the requisite knowledge, skills and values that support the teaching and learning process.</p>	<p>They display skills in planning, implementing and managing learning programs.</p>	<p>They have high education-focused situation cognition, are more adept in problem solving and optimize opportunities gained from experience.</p>	<p>They are recognized as leaders in education, contributors to the profession and initiators of collaborations and partnerships.</p>
<p>They manage learning programs and use strategies that promote learning based on the learning needs of their students.</p>	<p>They actively engage in collaborative learning with the professional community and other stakeholders for mutual growth and advancement.</p>	<p>They provide support and mentoring to colleagues in their professional development, as well as work collaboratively with them to enhance the learning and practice potential of their colleagues.</p>	<p>They create lifelong impact in the lives of colleagues, students and others.</p>
<p>They seek advice from experienced colleagues to consolidate their teaching practice.</p>	<p>They are reflective practitioners who continually consolidate the knowledge, skills and practices of Career Stage 1 teachers.</p>	<p>They continually seek to develop their professional knowledge and practice by reflecting on their own needs, and those of their colleagues and students.</p>	<p>They consistently seek professional advancement and relevance in pursuit of teaching quality and excellence.</p>
			<p>They exhibit commitment to inspire the education community and stakeholders for the improvement of education provision in the Philippines.</p>

APPENDIX T
Sample Counting of Integration of PCK Components
Teacher Des

Ck and IS – 19
 CK and US – 4

IS and US - 21
 Assessment - 2

	Instructional Strategies	Content Knowledge	Instructional Strategies	Students' understanding of Science Assessment
	Video clip	DNA	Video clip	Commended the students
			Discussion (Q and A) on the kind of cell	Commended as she said very good
			Discussion of past lesson	Commended the students' sharing
T. Des	Picture and visual aid in textual form	Chromosome		
	Visual aid	Cell cycle	Discussion	Commended as students answered G1, S and G2
	Picture	Cell cycle substages		
	Visual aid, picture and model	Mitosis		
	Video	Mitosis	Cooperative learning	Discussion of what was seen in the video oral recitation of answers via q and a
	Model	Mitosis		Quiz- draw each stage of mitosis
	Personal illustration	Cytokinesis		
	Pneumonics	Mitosis	Discussion	Very good for differentiating mitosis with meiosis
	Visual aid in textual form	Meiosis	Discussion on crossing-over	Very good for analysis of the concept
	Picture	Homologous chromosomes	Use of multi-assessment tools	Quiz – activity 2
			Discussion of past lesson	Asking questions in a Q and A conversation
	Discussion	Role of meiosis	Discussion on role of mitosis and meiosis	Very good for the students' sharing
	Family picture	Intro to genetics		
	Visual aid	Basic Genetics terms	Discussion	Discussion on role of mitosis and meiosis
	Illustration	Mendel's experiment	Discussion on Mendel's experiment	Very good for that analysis
			Discussion on how Recessive trait is expressed	Very good sharing
	Visual aid	Principle of dominance	Drill/exercise/board work	Understanding homozygous and homozygous traits
	Illustration	Distribution of gametes	Assignment	Conduct of Act 3
	Illustration	Law of Segregation	Assignment on Act 3	Commended the students
			Cooperative learning	Activity 4
			Discussion of Act 4	Commended the students
			Assignment	Act 5
	Visual aid	Law of Independent Assortment	Problem-based method	Extra problem-solving in genetics Remedial-modelling meiosis