USEFULNESS OF CONSTANT COMPARATIVE ANALYSIS AS A TOOL IN ASSESSING THE PEDAGOGICAL CONTENT KNOWLEDGE (PCK) OF FOUR (4) FILIPINO GRADE 8 TEACHERS AS THE INQUIRY-BASED APPROACH (IBA) IS USED

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ABSTRACT

Using constant comparative analysis, this study determined the PCK of four (4) Grade 8 science teachers. Supported by interviews and classroom observations, results identified emergent themes of the teachers' 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. While most of the components were commonly observed among the teachers, there was variation observed for the teachers' knowledge of content. The two beginning teachers consistently had a high level of PCK indicating a complete discussion of content while the experienced teachers had different PCK levels - Teacher Ces had a moderate level where few components of the content are missing in the discussion while Teacher Bes had a low level of PCK where many components of the content are missing. Based on this result, it can be concluded that the number of years of teaching/teaching experience does not guarantee expertise. A continuous professional development program is suggested that should focus on content. Recommendation is suggested that other teachers use constant comparative analysis as a powerful qualitative tool in comparing large amount of data. Future research on PCK level among Grade 7, 9 and 10 is also suggested.

Keywords: Constant Comparative Analysis, Emergent Themes, Inquiry-Based Approach, PCK level, PCK component, Powerful tool.

INTRODUCTION

The *why* and *how* of PCK on the inquiry approach use and implementation, not just the *what*, *where*, *when*, or "who" may always be investigated through the qualitative case study method in order to gather an in-depth understanding of human behavior and the reasons that govern such behavior. The strategies in this kind of method include structured and semi-structured interviews, case studies, narrative study, classroom observations, informal conversations, focus groups, open-ended survey questions, journal entries etc. Among the mentioned methods, the case study method appeared to be the most useful but with some disadvantages. 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. In the light of such observations, this study was conducted to show the usefulness of constant comparative analysis as a tool in the case study of grade 8 science teachers in terms of assessing their pedagogical content knowledge in teaching cell division and Mendelian genetics using the inquiry-based approach.

LITERATURE REVIEW

The Concept of PCK

PCK was introduced by Shulman (1987) as the blending of content and pedagogy into an understanding of how particular topics, and problems are organized, represented, and adapted to the learners' diverse interests and abilities. 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 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). 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). This research 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.

PCK and the Inquiry Approach

Some authors have indicated that the use of the inquiry approach can help develop a teacher's PCK. 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 approach is important 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. 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 one biology teacher's PCK. 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). 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; Loughran, Milroy, Berry, Gunstone, & Mulhall, 2001).

Constant Comparative Analysis as a Qualitative Methodology

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. Mercan (2015) used the same tool in the study of secondary Physics, Chemistry, and Biology 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.

METHODOLOGY

Design of the Study and Case Selection

It is a qualitative study in which four (4) teachers were selected for an empirical investigation on their PCK through interviews and classroom observations. Cross-case comparison (comparing one case to another case) was done to come up with conclusions and develop theories based on the observed cases. Each teacher was selected based on the length of teaching. In particular, there were two (2) two groups - one was from the group of teachers with 0-5 years of teaching (beginning teachers) while the other one was from the group of teachers with more than 5 years of teaching (experienced teachers).

Data Collection and Analysis Procedures

Using an interview guide on knowledge of cell division and Mendelian genetics, the teachers were interviewed separately. In the second meeting/interview, the information collected during the first meeting was validated. Classroom observation was done to observe how the teachers teach the content. Observations were done for 10 days and class sessions were video-recorded. The data was collected prior to the pandemic lockdown in 2019. Constant Comparative Analysis was used to identify underlying themes in the data. This analysis involved transcribing the interviews, chunking of each teacher's data, coding of each chunked data, subcategorizing of the coded chunked data, comparing of data, grouping of data and documenting the coded information.

Data Validation

Member checking was employed to validate the data. The findings were also subjected to peer examination, in which the findings were given to a second reader for comments.

RESULTS AND DISCUSSION

Using constant comparative analysis, the following PCK themes were identified as preceded by each Knowledge Base.

Knowledge of Instructional Strategies

Theme 1: Start a lesson with motivational activities. As indicated in their responses, Teachers Ace, Ces and Des 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 believed 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. On the other hand, Teacher Bes reported that she starts a lesson with the lecture style method. 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."* 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.

Theme 2: Use of Models and Multimedia Materials

Models. Specifically, all the teachers use models of mitosis and meiosis provided by the Department of Education (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) who said that models are a useful resource for teaching. The author added that models 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).

Forms of representations. Gilbert (2004) supports those representations are important tools in science investigations. These are valuable means of expressing and understanding a process and constructing knowledge. As indicated in their responses and consistent in their actual teaching, all the teachers use different forms of representation to facilitate students' learning of content. As observed, 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 evidence 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. Students given illustrative diagrams likely engage in deeper levels of processing while listening to the lecture (Brenneman, 2015).

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. 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 and 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. Teacher Ces did not mention about using multimedia material in the interview which was not also observed in her actual teaching.

Theme 3: Use Cooperative Learning

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.

Theme 4: 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 which Teacher Ace asked her students to do. 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. "Pneumonics" is a hand-activity about the stages of mitosis while role playing is about Gregor Mendel and his experiment. The acquired reading material was the story-telling activity implemented by Teacher Ces.

Theme 5: 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. 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

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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

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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

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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.

Knowledge Of Content
Theme 6: 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. 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 the sharing of traits inherited in the family or why a trait runs in the family and explaining why there is resemblance with parents. 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. On the other hand, Teachers Bes and Ces showed limited 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. 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.

Knowledge of Students' Understanding of Science
Theme 7: Develop or Stimulate Students' Critical Thinking by Asking Questions

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. 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. 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. Cuccio-Schirripa and Steiner (2000) also reported that 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. 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.

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. 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.

Theme 8: 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.

Using a textbook. The teachers reported that they make a summary of concepts with correct definitions/descriptions based on the textbook after their discussion. 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.

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. 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. 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.

Theme 9: Use of Multi-Assessment Tools

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, participation, assignment and other activities such as quiz, exam, group presentation, seatwork and boardwork. Such tools can be used by every educator to increase student engagement. 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*." 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. 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).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. 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.

Knowledge Of Assessment
Theme10: 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. 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 fails, 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."* As observed in their actual teaching, the teachers had remedial classes. 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.

CONCLUSIONS

Based on the use of constant comparative analysis as a tool in this qualitative research, 10 emergent themes were identified. Likewise, the analysis of teachers' interviews as confirmed in their actual teaching determined the level of the teachers' PCK. Teachers Ace and Des consistently had a high level of PCK indicating a complete discussion of content. Teacher Ces had a moderate level where few components of the content are missing in the discussion while Teacher Bes had a low level of PCK where many components of the content are missing. As indicated in the study, Teachers Ace and Des are beginning teachers while Teachers Bes and Ces are experienced teachers, but after an in-depth analysis of their PCK level, it can be concluded that the number of years of teaching/teaching experience does not guarantee expertise. A recommendation for continuous professional development programs is suggested for both beginning and experienced teachers with focus on content and inquiry-based approach use. The constant comparative analysis, as a powerful qualitative tool, may be used by other teachers for large amount of data focusing on comparisons between interviews and observations. Recommendations for future research should investigate on PCK toward teaching using the inquiry approach among Grade 7, 9 and 10 sciences.

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