PEDAGOGICAL CONTENT KNOWLEDGE STUDIES IN THE CONTEXT OF CHEMISTRY EDUCATION IN THE PHILIPPINES: A META-ANALYSIS

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ABSTRACT. *By focusing primarily on students, existing research studies on education have tried to support reforms in the field. Aside from students, further research is needed to investigate teachers and/or both, particularly teachers' knowledge. Studies on PCK have become more popular recently. However, most educational research in the Philippines is empirical and needs to include a meta-analysis of data, especially in the field of chemistry, which has yet to be explored. As a result, this study uses meta-synthesis to analyze PCK studies in the context of chemistry education in the Philippines. Fifty research from 2016 to 2021 were reviewed in this analysis. A quantitative approach was employed to identify the trends of the studies and highlight the gaps and deficiencies therein. Results revealed that more qualified studies were undertaken in Luzon, while a nearly equal number of studies were collected from Visayas and Mindanao. The most common research designs utilized for PCK studies' methodological aspects are quasi-experimental and descriptive. PCKLS, PCK, and TPASK, as well as blended and distance learning approaches, were frequently studied methods/strategies. The most studied subjects in chemistry were naming compounds, balancing equations, writing formulas, chemical bonding, the mole concept, and the Periodic Table. Most qualified studies concentrated on the effectiveness of teaching strategies on students' academic performance. Knowledge of students and knowledge of teaching strategies and representations were the most often used PCK components.*

Keywords: Pedagogical content knowledge, chemistry education, meta-analysis.

1. INTRODUCTION

With its global recognition, chemistry has emerged as one of the most significant science subjects taught in higher education institutions and secondary schools. In the different fields of science, technology, engineering, and even business, chemistry is regarded as a fundamental subject [1]. Due to its foundation in our daily lives and the influence it has on the economy, environment, and society, chemistry plays a crucial role in the technological growth of developing countries [2]. One of the critical pillars of the country's economic change has been designated as chemistry education; therefore, it needs to receive the proper attention.

By focusing mainly on students, several studies on scientific education have attempted to advocate reforms in the subject [3-6],. However, there has always been a discussion about the quality of education in a growing and changing world, and teacher quality is still a popular issue [7]. According to Ayden and Boz [8] and King and Newman [9], one of the most crucial aspects of students' education is their teachers' comprehension and success, raising the significance of teacher knowledge and skill-enriching professional development activities. Because it provides relevant data for creating and adjusting professional development and teacher education programs, teacher knowledge is valuable in teacher education research. To look at teachers in the Philippines and other countries as well as students, more investigation is required, and it is especially necessary to look at teachers' knowledge base needs in teaching chemistry.

The idea of pedagogical content knowledge was first introduced and established by Shulman [10] in 1985. Accordingly, subject-specific, and general pedagogical knowledge are not connected, and there is a gap between them. He referred to this flaw as the "missing paradigm" between these two categories of knowledge. PCK was defined as the unique fusion of pedagogy and content knowledge [11]. To organize, convey, and change the topics being discussed, he separated his idea of PCK into two categories: (1) the knowledge of instructional strategies and representations; and (2) the knowledge of students' varied levels of topic comprehension. One special professional competency is the capacity of teachers to connect the dots between pedagogical and content knowledge. Thus, this framework was employed as a theoretical approach for analyzing teachers' knowledge.

Most educational research conducted in the Philippines is empirical, does not involve meta-analysis of findings, and has become a relatively unexplored area of study [12]. In the field of chemistry education, a critical review indicates a significant oversight in the empirical investigation of the distribution of the studies according to research variables investigated and, distribution of studies according to year, topics, and location. Thus, this study was designed to provide a broad perspective on earlier research by conducting a meta-analysis to satisfy the above-mentioned need.

2. RESEARCH QUESTION

This study sought to answer the following research questions:

(1) What is the distribution of PCK studies in the context of chemistry education according to publication year and research setting;

(2) What are the methodological features of PCK studies in the context of chemistry education in terms of:
   a. Research design;
   b. Variables investigated; and
   c. Chemistry topics

(3) What is the distribution of PCK components in the context of chemistry education studies?

3. RESEARCH METHODOLOGY

Research Design

This study is a meta-synthesis analysis that has thoroughly examined PCK studies concerning Philippine chemistry education. Simply, meta-analysis is done by grouping similar studies on the same ideas or topics under a certain criterion where quantitative findings will be interpreted. By combining the samplings of the studies, the number of samplings may be increased, and its impact will be measured **[13]**. Thus, it aims to systematically analyze articles and proceedings to identify the distribution and trends of the studies, as well as express the gaps and

deficiencies therein.

Data Collection

The terms "*pedagogical content knowledge*" and "*pedagogical content knowledge + chemistry education*" were used to search the literature for this study. The search engines used were limited to Google Scholar and case online. These databases were preferred since not only one specific type of journal will come out but a variety of related articles from different publishing companies [3]. Studies that were used in this research were discovered through this search process. Some of the references from these studies were also checked for any more pertinent studies that still needed to be incorporated into the investigation. Because only a few meta-analyses of research related to PCK and its effectiveness in chemistry education have been conducted previously, this study intends to meta-synthesize and analyze research findings from 2016- 2021.

Criteria for Data Inclusion

In line with the inclusion criteria used in these studies, the following were applied: (i) the study must be conducted in the area of chemistry education within the theoretical framework of PCK, (ii) it had to be completed between 2016 and 2021, (iii) it had to have been conducted in the Philippines, (iv) it had to have published its findings in the form of an article or journal, and (v) it had to be accessible. The study's inclusion criteria were all met by a total of 50 papers. The appendix is a list of the studies that were used in this article.

Analysis of Data

The research articles that formed a part of this study were originally given numbers between 1 and 50. Both the data analysis and the presentation made use of these figures. After that, each study was thoroughly read in light of the research questions. Data outcomes from each study were documented and verified based on the research problems. Categories were developed in the context of the study questions. The data analysis, for instance, led to the establishment of three categories in response to the research question, "What is the distribution of PCK studies in the context of chemistry education according to the study feature in terms of research setting?" The following three subcategories were created as the locale: Luzon, Visayas, and Mindanao. Similar analyses and classifications were performed on other data collected within the context of the study concerns. Additionally, categories were created using terms from related meta-synthesis research [14, 3]. For instance, the distribution of PCK studies and determination of PCK components were developed under the various themes of the examined research by altering the category of PCK components and study characteristics. Tables with the studied data and their frequencies are displayed. Later, each table was critically analyzed to highlight its differences, similarities, and deficiencies.

Validity and Reliability

The pertinent studies were carefully examined in line with the research problems during the data analysis process. In Microsoft Excel, the information was tallied, and categories were made under each problem. Two science researchers as experts (a master's degree and Ph.D. holder) were asked to independently code 13 randomly chosen research (25% of all studies) to ensure the validity of the codes. The Miles and Huberman [15] formula,

$$\text{reliability} = \frac{\text{number of agreements}}{\text{number of agreements} + \text{disagreements}}$$

which McAlister [16] stated, was used to calculate the experts' compromise percentage. The categories' evaluations resulted in a computation of the average reliability coefficient, which came out to be 0.81. According to Ayaz and Sekerci [17], the values obtained from 0.70 and higher are thought to be sufficient for the reliability requirements. By studying them collaboratively once more, the two research experts reached a consensus on coding which they had previously been unable to do [15]. For instance, Study 7 was classified by the first research expert as knowledge of students (KS). In contrast, Study 7 was classified by the second researcher as knowing teaching strategies and representations (KTSR). Later, after collaboratively analyzing the study, the two researchers concluded it should be classified as knowledge of teaching strategies and representations (KTSR). As a result, an effort was made to lessen the impact of individual biases brought on by extended contact with data sources. Such approaches strengthen the study's validity [18].

4. RESULTS AND DISCUSSION

The analysis's results are presented in three sections. The first section (3.1) indicates the level of distribution of PCK studies in the context of chemistry education in terms of (a) publication year and (b) the locale of the study. The second section (3.2) is divided into four parts that include the (a) research design, (b) dependent variables, (c) independent variables, and (d) chemistry topics. The level of distribution of PCK components in chemistry education is expressed in the third section (3.3).

PCK Studies According to Study Features

The distribution of PCK research according to study features has been screened to ascertain that they meet the inclusion criteria developed for the purpose. A total of 50 studies were subjected to a meta-analysis to determine the trend of PCK research from 2016 to 2021.

Table 1 lists the characteristics of each PCK study that matched the requirements for the meta-analysis. This descriptive analysis provides information on the studies' frequencies and characteristics based on the classified features, including publication year and research setting.

Table 1. Frequency Distribution of Qualified Studies by Study Features (n=50 studies)

Study Feature	N	Percentage (%)
Publication Year		
2016	5	10
2017	11	22
2018	4	8
2019	5	10
2020	10	20
2021	15	30
Research Setting		
Luzon	28	56
Visayas	10	20
Mindanao	12	24

Results revealed that out of the 50 qualified studies, 15 (30%) were conducted in 2021, which is higher than the other years. From 2016 to 2018, there was a varying amount of research done in the Philippines. However, in 2019-2020, there has been an increasing trend.

The results show that compared to past years, there was an increase in the pursuit of research in chemistry education. As can be gleaned from the table, most of the research studies conducted all over the Philippines were up to date. It can be inferred that they addressed the present educational status, evidently describing the instructional scenario of the 21st century. Especially when the pandemic started in 2019, only a little research was conducted, maybe because of the adjustment to the sudden situation.

Eventually, when the pandemic was lifted in 2021, many issues and concerns concerning PCK studies in chemistry education were addressed, e.g., the transition from distance learning to face-to-face setup. This is a realization in one of the primary research agendas of the Commission of Higher Education – Higher Education Institutions (CHED-HEI), to enhance the research productivity of HEIs in distinctive competence areas. However, this does not limit the production of more research in relevant fields and priority disciplines, particularly in education. For the country to achieve greater productivity, growth, and overall global competitiveness, there is still work to be done to build robust research competence in HEIs [19].

In the meta-analytic review based on the source and locale of the study, it was found that a more significant number of the qualified studies were conducted in Luzon (n = 28, 56%). In contrast, an almost equal number of studies were gathered from Visayas (n = 10, 20%) and Mindanao (n = 12, 24%). The universities in Luzon are dominant compared to those in Visayas and Mindanao in terms of producing PCK studies in chemistry education research and offering graduate thesis degree programs [20]. Most of the institutions in Luzon, including state universities and colleges, private sectarian, and non-sectarian, offer the best practices for quality education [21]. Hence, it attracts more graduate students for admission because of quality and prestige. This accords with the Research and Development Survey Report in 2018 that NCR, Central Visayas, and Central Luzon have the highest number of publications among the regions [22]. Only Visayas does not accord with the results of this study, as can be gleaned in Table 1, is the least numbered among the qualified studies. Maybe because of the unreasonable searches as part of the inclusion criteria in this study. Meanwhile, universities in Luzon provide more significant opportunities, like facilities and specialized programs, for graduate students to be more equipped and exposed to research.

Methodological Features of PCK Studies

Qualified studies by research design

Out of 50 studies conducted in the meta-analysis, a total of 17 (34%) studies used quasi-experimental research utilizing the single group (pretest-posttest) and the two groups (pretest-posttest) design. The total number of studies (17, 34%) also used descriptive, while 8 (16%) of the qualified studies were mixed-method. Only 5 (10%) and 3 (6%) qualified studies made use of experimental utilizing single group (pretest-posttest) and descriptive-correlational, respectively. Results from research by Waxman et al. [23] and Schroeder et al. [24] support the study's conclusions; a more significant number of studies, relative to the other designs, were obtained for quasi-experimental that utilized a single pre-posttest design or a two-group pre-posttest design. At the same time, descriptive is the most used design as basic statistical information gathered for most quantitative studies. The difficulties of performing randomized experimental investigations with students and teachers in a school context may explain why quasi-experimental methods are used more frequently than experimental methods in most studies [24]. Additionally, according to a study by Gopalan, Rosinger, and Ahn [25], the usage of quasi-experimental design has been on the rise nationwide since 2009, with the Philippines included. The use of descriptive and quasi-experimental design, which is constantly changing and is an active area of research exploration, is the ladder of evidence in terms of the reliability of study findings, particularly in the context of education (U.S. Department of Education, 2017).

Table 2.1. Frequency Distribution of Qualified Studies by Design

Research Design	N	Percentage (%)
Descriptive	17	34
Descriptive Correlational	3	6
Quasi-experimental	17	34
experimental, single group (pre-post)	5	10
Mixed-method	8	16
Total Studies	50	100

The study's findings show that most studies were conducted short-term, and only a few were long-term. As mentioned by Simsek and Boz [3], some of the identified limitations in conducting experimental/quasi-experimental studies are probably the reason why short-term studies are more prevalent in chemistry education research. This includes cost, ethics, external validity, the feasibility of implementing an experiment, time, and timing. With these considerations, researchers usually conduct short-term rather than following the ideal duration of educational experiments, which covers three months or the equivalent semester excluding the writing of manuscripts.

Qualified studies by variables

In this meta-analysis, the variable presented is the output of chemistry education studies involving PCK. It refers to academic performance, mastery level, student conceptual understanding, competence, technological knowledge, content knowledge, and teacher effectiveness. Meanwhile, the rest of the variables that referred to students' different characteristics, such as attitude, learning styles, motivation, self-efficacy, etc., were scrutinized in empirical educational research.

Table 2.2 presents the study feature that is accounted as the variables investigated for this meta-analysis.

This includes Audio-visual Aided Instruction/Integrated Macro-Micro-Symbolic Approach (IMMSA)/ CSI Movies/ANIMATED VISUALS/Visual and Symbolic Conceptual Questionnaires (n=7, 14%), and the comparable result of PCK-guided Lesson study (PCKLS)/ PCK, TPACK, /Technological Pedagogical Science Knowledge (TPASK) (n-6, 12%), and Blended Learning Approach/ Distance Learning Approaches/flipped classroom/online – merge – offline (OMO) classroom model /Mobile Application (n=6, 12%) being evaluated from each of the qualified studies. It is then followed by Content learning needs/ learning analytics/ Integration of Creative Story Writing/ Reciprocal Teaching Approach with Self-Regulated Learning (RT-SRL) (n = 5, 10%), following are Resource-based course guide/Programmed Instruction (n = 4, 8%) and inquiry-based /7E lesson model / Process Oriented Guided Inquiry Learning (POGIL)//Science

Process Skills (n=4, 8%).

Table 2.2. Frequency Distribution of Qualified Studies by Variables

Variables	N	Percentage
PCK-guided Lesson study (PCKLS) / PCK, TPACK, /Technological Pedagogical Science Knowledge	6	12
Problem-Solving Strategies/Problem-based Learning (PBL)/Critical Thinking skills	2	4
Context-based approach	3	6
Resource-based course guide/Programmed Instruction	4	8
General Teaching Approach	2	4
Audio-visual Aided Instruction/Integrated Macro-Micro-Symbolic Approach (IMMSA)/ CSI Movies/Animated Visuals/Visual and Symbolic Conceptual Questionnaires	7	14
Outcomes-Based Teaching and Learning Computer-Assisted Instructional Material	1	2
Content learning needs/ learning analytics/ Integration of Creative Story Writing/ Reciprocal Teaching Approach with Self-Regulated Learning (RT-SRL)	5	10
Constructivist Approach	1	2
inquiry-based /7E lesson model / Process Oriented Guided Inquiry Learning (POGIL)//Science Process Skills	4	8
Blended Learning Approach/ Distance Learning Approaches/flipped classroom/online – merge – offline (OMO) classroom model /Mobile Application	6	12
Spiral Progression Approach	3	6
PEER-LED TEAM LEARNING (PLTL)/ TEAM Teaching	2	4
Metacognitive activities/ Science Learning Motivation	3	6
Green Chemistry Education	1	2
Total Qualified Studies	50	100

The other 6% qualified studies were classified under the Context-based approach (n=3) and Spiral Progression Approach (n=3), and very few studies fell under Problem-Solving Strategies/Problem-based Learning (PBL) and General Teaching Approach (n=2, 4%). Only 1% fall under Outcomes-Based Teaching and Learning Computer Assisted Instructional Material (OBTL-CAIM) and constructivist approach.

The result of this meta-analytic review indicates that since the last decade, studies on PCK have focused on its components in connection to various variables in diverse circumstances. One example is the various teaching pedagogies evaluated and implemented in chemistry classrooms. The findings in Table 2.2 prove that the integration of technology, e.g., IMMSA)/ CSI Movies/ANIMATED VISUALS, in classroom instruction, have always retained their appeal to the Filipino scientific community. This may be due to the difficulties currently being handled with the rapid technological advancement among students and society today. As stated in Aksoy's research [26], visual elements, including PowerPoint (PPT) animations, animated images, and multimedia applications, are essential in technology-assisted instruction. It aids in information encoding, long-term memory storage, and recovery [27]. As a result, information is communicated more effectively, and students can study comfortably [28].

PCKLS, PCK, TPASK, and blended and distance learning approaches were commonly studied methods/strategies used as an intervention in forging the other development of students in general. Aside from the fact that PCK research in chemistry education has sparked a global conversation about how to improve teacher qualifications [29], these methods were the most general area of research and practice in science education because of their relevant application in the current situation caused by the pandemic. It was followed by content learning and inquiry-based approaches where the pedagogical trends in chemistry education can be inferred to align and support the framework and goals of 21st-century teaching.

Meanwhile, OBTL, constructivism, and green chemistry education were among the pedagogies that call for further investigation and implementation. The inclusion criteria set forth have an impact on the small number of research included in this meta-analysis.

Qualified studies by Chemistry Topics

The PCK studies were split into two categories as a result of the analysis within the context of chemistry courses. The first was conducted as part of a specific chemistry course for schools K–12. The second covered study was conducted as a component of the K–16 curriculum for a specific chemical course, such as general chemistry. In the first group, 29 studies were included, while 21 were in the second.

As shown in Table 2.3, the grade 9 scientific topics Naming Compounds, Writing Formulas, Balancing Equations, Chem Bonding, Mole Concepts, and Periodic Table received the most attention in the first category of the PCK-related studies (n=13, 26%). The subjects in grade 10 that came after it included Gas Laws, Chemical Reactions, and Biomolecules (n=7, 14%). These are in line with the findings of research by Mongcal et al. [30] which found that chemical bonding, the mole concept, gas laws, and chemical reactions are among the least understood chemistry topics.

Table 2.3. Frequency Distribution of Chemistry Topics

Chemistry Topics	Frequency	Percentage
Category 1		
Laboratory apparatus, scientific investigation, solutions, the concentration of solutions, substances, mixtures, elements, compounds, acids and bases, and metals and nonmetals	5	10
Naming Compounds, Writing Formulas, Balancing Equations, Chem Bonding, Mole Concepts, Periodic Table	13	26
Gas Laws, Chemical Reactions, Biomolecules	7	14
Stoichiometry	4	8
Category 2		
General / Inorganic	20	40
Analytical and Physical	1	2
Total Studies	50	100

Thus, teachers and researchers have always been given the highest priority as the focus of integration for every

intervention. This is because teachers must show students both their breadth and depth of knowledge of the aforementioned specific topics and how they can apply the information to various contexts. Content knowledge is regarded as a critical component of instruction [11]. The least preferred chemistry subject area in the PCK studies is stoichiometry (n=4, 8%). General or Inorganic chemistry is the most preferred topic for the second category. In this study, 82% of qualified studies focused on K-12 curriculum implementation (n=41), while only 18% focused on K-16. Since stoichiometry is not specifically covered under the spiral progression of K-12, it also follows that the said topic is not given more attention to be integrated with the intervention of most researchers. The same with those topics not considered as the least mastered.

PCK components in the context of chemistry education

The PCK components examined in the PCK studies were adapted from the generated themes of the study of Simsek and Boz [3].

Table 3.1. PCK Components Examined in the Analyzed Studies

PCK Component	f
Knowledge of teachers (KT)	18
Knowledge of students (KS)	39
Knowledge of teaching strategies and representations (KTSR)	26
Knowledge of curriculum (KC)	4
Knowledge of measurement and evaluation (KME)	2
Contextual knowledge (CK)	3
Knowledge of misconceptions (KM)	2
Beliefs	4

Table 3.1 shows how researchers focused more on students' knowledge and instructional strategies and representations. Four studies that looked at curriculum and beliefs were the next emphasis after eighteen studies that looked at teachers' knowledge. Only studies 29, 33, 41, 10, 13, 16, and 38 looked at the elements of contextual knowledge, knowledge of misunderstandings, and knowledge of measurement and evaluation. *(See Appendix)*

As shown in Table 3.2, only six of the PCK research focused on a single PCK component, while 44 studies discussed multiple PCK components.

The knowledge of students and the knowledge of teaching strategies and representations emerged as the most frequently used PCK components in the context of chemistry education in the Philippines when the PCK components used in the research were examined. This supports the research by Aydin and Boz [8] that teachers struggle with classroom management, student motivation, student communication, and student development. The results were found to be consistent with Saeleset & Friedrichsen's [31] and Chan & Hume's [32] findings that the most significant and frequent integrations among the PCK components and crucial to the development of teacher knowledge were knowledge of students and knowledge of teaching strategies and representations.

In the Philippines, the components of PCK that received the least research attention included knowledge of context, understanding of misconceptions, and knowledge of measurement and evaluation. Likewise, this is consistent with global literature [33].

Table 3.2. The Condition of Including PCK Components Together in the Analyzed Studies

Type	PCK Component	f
The study focused on one PCK component	KT	2
	KS	4
The study focused on two PCK components	KS+KT	1
	KS+KTSR	22
	KT+KTSR	1
	KS+B	1
	KT+B	1
	KT+CK	2
	KS+KME	1
The study focused on three PCK components	KT+KS+KTSR	4
	KS+KT+KC	1
	KT+KTSR+CK	1
	KT+KC+B	1
	KT+KS+B	1
	KS+KTSR+KM	1
	KS+KTSR+KME	3
	KT+KTSR+KC	1
The study focused on four PCK components	KS+KT+KC+KTSR	1
	KT+KS+KTSR+KM	1

Therefore, these elements should be used more frequently in future investigations. However, just six (6) PCK research had focused on only one PCK component in the context of chemistry education in the Philippines, while 44 PCK studies focused on multiple PCK components. However, no study that had looked at all eight parts of the PCK simultaneously or questioned how they related could be discovered.

5. CONCLUSION

The meta-analytic investigation concludes that there was an increase in the pursuit of research in chemistry education as compared to the earlier years. Most of the research studies conducted all over the Philippines were up-to-date. They believed that they addressed the present educational status, evidently describing the instructional scenario of the 21st century. Based on the source and research settings of the study, results revealed that a more significant number of the qualified studies were conducted in Luzon. In contrast, an almost equal number of studies were gathered from Visayas and Mindanao. Most of the institutions in Luzon belong to the top-performing universities in the Philippines, thus more significant opportunities to conduct and publish research.

For methodological features of PCK studies, the following were revealed: (a) most dominant research design used in the context of chemistry education is quasi-experimental research utilizing the single group (pretest-posttest) and the two groups (pretest-posttest) design, as well as descriptive research design; (b) the majority of the relevant research examined the impact of instructional strategies on students' academic achievements, followed by studies that dealt on teachers' effectiveness based on competence, content and

knowledge; (c) PCKLS, PCK, TPASK, as well as blended and distance learning approaches were commonly studied methods/strategies followed by content learning and inquiry-based approaches where the pedagogical trends in chemistry education can be inferred to clearly align and support the framework and goals of 21st century teaching; and (d) Grade 9 science themes like Naming Compounds, Writing Formulas, Balancing Equations, Chemical Bonding, Mole Concept, and Periodic Table were the most studied chemistry topics, followed by grade 10 topics like Gas Laws, Chemical Reaction, and Biomolecules.

Knowledge of students and knowledge of teaching strategies and representations were the PCK components most frequently applied in the context of chemistry education in the Philippines. Contextual knowledge, knowledge of misconceptions, and knowledge of measurement and evaluation were the PCK subcomponents in the Philippines that had received the least amount of research.

6. RECOMMENDATION

Findings of numerous studies have provided insights and background needed to undertake this study that further clarifies the effect of PCK studies in the chemistry education context by meta-analyzing the results of all appropriate and available studies under the inclusion criteria.

With the conclusions drawn by this study, it can be inferred from the data presented the necessity for the establishment of more local studies centers in the southern Philippines to help universities and colleges develop their programs to strengthen research capabilities. Thus, there is a need to strengthen graduate programs in chemistry education not only in all promising higher education institutions of the Philippines but also in the Department of Education to enhance research productivity concerning chemistry education, particularly in the Visayas and Mindanao.

A conscious effort from different educational stakeholders can be attained to conduct further training and introduce and train teachers on the proper use of different pedagogical approaches. This study can serve as a reference point for future meta-analysis studies looking at the effects of PCK studies applied in teaching chemistry further in the same year trend, 2016-2021, which will focus on other inclusion criteria aside from the ones stated in this study, specifically the comparison using effect sizes.

In this study, only quantitative studies were reviewed. Therefore, a future meta-analysis may include qualitative studies. Another limitation of this study is that it involved studies conducted only in the Philippines. Further research may be pursued by reviewing studies that are carried out in other countries (ASEAN countries). Such interest would provide an opportunity to make comparisons on a larger scale. All subjects and skills showed significant differences when grouped according to the school division. This means that the performance of students in these subjects and specific skills differs as a function of the school division. The amount of fiscal and administrative resources, types of teachers, available teacher support, location, stakeholder support, and other nontangible variables that differ among these school division offices explain this difference. This suggests that the school division from which students come can also impact their performance.

Therefore, it is recommended that a follow-up study be made for this paper as an assessment to come up with a modified PCK model and develop an action plan or prototype out of it. This action plan is still in the context of chemistry education, which will present and include the fundamental concepts and processes of how the proposed instruction through an eclectic approach can be done and be applied in the actual classroom setting. A future research study may also be conducted to assess the applicability and effectiveness of the teaching approach that is anchored on the proposed model. Through this, verification, and validation of the proposed PCK model may be realized.

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APPENDIX

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