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The Birth, Growth, and Development of Pedagogical Content Knowledge (Pck)

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Abstract.

Pedagogical Content Knowledge (PCK) is the basic skill that represents teacher professionalism and has proven useful for investigations in documenting knowledge that makes a good teacher. Teachers are one of the recognized intellectual actors having a knowledge base and set of skills developed during their teaching activities, to produce competent and highly competitive human resources in dealing with the currents of globalization, accompanied by increasingly sophisticated technological development. This research aims to see, historically, the birth of PCK and the growth and development of research on PCK. The method used is a documentary study by analyzing documents, both journals and books that discuss the results of PCK research. The analysis shows that when PCK research began to grow and develop, there were differences in the term PCK. There was a pattern of change in PCK research, a fundamental change in PCK knowledge by integrating technology into it (TPACK). It can be summarized that the future PCK research is directed to PCK improvement strategies for preservice and in-service teachers, as well as training teachers to be able to integrate technology in classroom learning (TPACK).

Keywords: birth, growth, development, pedagogical content knowledge (PCK)

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1. INTRODUCTION

Educational reform towards STEM (Science, Technology, Engineering, Mathematics) is needed to better prepare students to think critically about the challenges they will face in the 21st century [1]. Besides the curriculum and infrastructure, one of the factors that influence the success of student learning in the classroom is the teacher. The teacher has a role in managing the class well, with good pedagogical knowledge and mastery of concepts related to daily life that is expected to produce meaningful learning for students. Student-centered teaching strategies play an important role in improving student learning [2]. The growth of teacher awareness is the main key in giving students a strong foundation for further development of talent [3]. For example, science teachers are required to be able to create student-centered learning because it refers to the nature of science learning involving attitudes, processes, products and applications. In addition, as a teacher, they should not focus on the delivery of teaching materials (content centric), but instead focuses on the students (learner centric). National Science Education Standard states that social change affects students when they come to school and influences their need. The teacher must be involved in the process of developing and refining new approaches to teaching, assessment and curriculum [4].

Being a teacher is a profession and every profession has a body of knowledge that distinguishes from another. The basis for the birth of the idea of Pedagogical Content Knowledge (PCK) is the fact that there were no provisions regarding the basic knowledge needed to become a teacher. The paradigm at that time was that to be a teacher, one only needed to know a certain content. Thus, many think that knowledge/other skills outside of the content are not required to be a teacher. With the above paradigm, in the 1980s, Lee Shulman proposed a new idea of being a teacher by knowing not only the content but also knowledge about how the content was taught to students or called Pedagogical Content Knowledge (PCK) by Shulman, which is a special combination of knowledge that teachers must have to make a relevant content by teaching it (Shulman, 1986). The principles of PCK are about the basic knowledge to be possessed by a teacher [5]. After the emergence of this idea, many educational researchers also conducted the research, the results of which become the reference to provide modifications, complete and criticize the concept of PCK. For over three decades, PCK has been recognized as not only one of the most important components of teacher professional knowledge, but also one of the most complex to understand (Gess-Newsome, 2015).

The research aims to analyze the development of PCK from the beginning to the present and provide direction for further PCK research. This research discusses about the birth of the Pedagogical Content Knowledge (PCK) concept by Shulman and how the concept is grown and developed by researchers in the educational dimension. The research questions are: How was the Pedagogical Content Knowledge (PCK) concept born? how has this concept grown and developed to date? and What happened in the process?

2. METHOD

This research is a documentary study conducted by summarizing from journal and book sources. Documentary study is a data collection technique by studying documents to obtain data or information in the form of books, archives, documents, figures and images in the form of reports and information that can support and relate to problems researched. The documents analyzed consisted of 31 national and international journals and 2 international publication books. The documents analyzed were journals and books that discuss about the concept of Pedagogical Content Knowledge (PCK) and its usefulness. The researches that discuss the concept of Pedagogical Content Knowledge (PCK) are, such as. how PCK is carried out, new indicators in PCK, the subject of PCK and the factors that influence the implementation of PCK. Then, the researchers analyze the results and conclusions given, namely their views on Pedagogical Content Knowledge (PCK). The research procedure was undergone by documenting a general description of the notion of the Pedagogical Content Knowledge (PCK) concept in the form of descriptions and pictures. The researcher then searched for and downloaded sources of documents, both journals and books about the concept of Pedagogical Content Knowledge (PCK). The documents obtained were grouped based on the similarity of ideas, elaborated from the beginning to the present with an analysis blueprint containing the author, title, journal publisher/company (for books), year and important items/major concepts of the documents, about their views on the concept of Pedagogical Content Knowledge (PCK). Then, the researcher analyzed the content of the documents and breaks it down into a more complete description of the concept of Pedagogical Content Knowledge (PCK).

3. RESULTS AND DISCUSSIONS

3.1. The Birth of Pedagogical Content Knowledge (PCK) Term

Pedagogical Content Knowledge was initiated by Lee Shulman, who was born and grew up in Chicago, studying at the education department with Benjamin Bloom and Joseph Schwab. Shulman's first academic work was with the College of Education at Michigan State University. In 1982, he moved to the Stanford University's School of Education. In his early years at Stanford, Shulman took a part in the research that produced the concept about Pedagogical Content Knowledge which set out a new phase of research in teacher training and education. The concept began when in the summer of 1983, Shulman was invited to give a general course on teaching at a conference at the University of Texas. Shulman titled The Missing Paradigm. He explained that The Missing Paradigm was the study of a content and its interaction with pedagogy, which in that century many people defined as the achievement of knowledge of a content. Basically, Shulman showed the knowledge that distinguishes a teacher from a scientist.

In 1986, Shulman and Sykes released a book entitled *A National Board for teaching*? *In Search of a Bold Standard* also discusses eight categories of knowledge for teaching: (1) Education in general, including reading, writing, mathematics and reasoning; (2) Content knowledge (knowledge: the main concept and theory from a discipline and skill: how to use a microscope); (3) Content-specific pedagogical knowledge (for students, knowledge: specific concepts and misconceptions in topics given to students; skill: how to investigate the concept difficulties faced by students; for curriculum, knowledge: concept requirements to understand photosynthesis; skill: how to design learning in inquiry-based laboratories; for instruction, knowledge of learning in the laboratory consisting of 3 phases, pre-practicum discussion, practicum and post-practicum discussion, skill: how to teach students using a microscope; for evaluation, knowledge: the nature and composition of assessment processes; skill: how to evaluate students' skills to "manipulate" laboratory; (4) General knowledge about the principles and practices of pedagogy: students, knowledge: Piaget's development level; skill: how to deal with hyperactive students; curriculum, knowledge: Bloom Taxonomy; skill: how to prepare learning units; instruction, knowledge: various ways of assigning students to be involved in learning; skill: how to formulate a high level question; evaluation, knowledge: several types of tests; skill: how to make multiple-choice items; (5) Curriculum knowledge; (6) Knowledge of student diversity and individual differences; (7) Performance skills (how I see, hear, speak and move in class); and (8) Professional understanding (including

history and policy, philosophy and psychology, cultural and cross-cultural factors, and professional ethics).

At the beginning of 1986, there was no term Pedagogical Content Knowledge (PCK) disclosed by Shulman. At that time, it was still called Content-specific pedagogical knowledge. After releasing a book with Sykes in February 1986, Shulman came back to write for a journal entitled *Those who understand*: *Knowledge Growth in Teaching* is the beginning of the emergence of the term Pedagogical Content Knowledge (PCK), which Shulman explained as a special combination of relevant contents by teaching it so that it can be understood by others. In this paper, Shulman categorizes knowledge for teachers as the knowledge of the content itself, general pedagogical knowledge and pedagogical content knowledge (which is a special combination of knowledge so that a content is relevant to the way it is taught). The term PCK was launched by Shulman, which had no name before (Shulman, 1986). According to Shulman (1986b), knowledge content includes the knowledge of concepts, theories, ideas while pedagogical knowledge includes educational goals, teaching and learning methods.

Then, in 1987, Shulman wrote again about the reformation of the knowledge that teachers must have which had so far lost its paradigm, at which time scientists assumed that a professional teacher was only required to master content. According to Shulman, PCK is a special combination of content and pedagogy that is uniquely possessed by the teacher. In Harvard Educational Review, Vol. 57 No. February 1, 1987, Shulman gave his idea with the title *Knowledge and Teaching: Foundation of the new Reform*, in which he postulated his concept of 7 (seven) basic knowledges that must be possessed by teachers, namely: (1) content knowledge, (2) general pedagogical knowledge, (3) curriculum knowledge (4) PCK, (5) knowledge of students and their characteristics, (6) knowledge of the educational context, and (7) knowledge of educational goals, values, philosophy and history (Shulman, 1987).

Shulman introduced the concept of PCK as an element of what he called the knowledge base for teaching. The keyword in Shulman's conception for PCK is knowledge of content representation and teaching strategies with an understanding of student learning difficulties and conceptions. In the same article, he introduced about the processes of pedagogical reasoning and action. This reasoning process involves cycles through the activities of (1) understanding, (2) transformation (preparation, representation, adaptation of student characters, selection), (3) learning, (4) evaluation, (5) reflection, and 6) new understanding (Shulman, 1987).

3.2. The Growth of Pedagogical Content Knowledge (PCK)

In 1988, Tamir wrote in the Teaching and Teacher Education journal with the title *Subject Matter and Related Pedagogical Content Knowledge in Teacher Education*. His paper aimed to present initial ideas about the implications of the basic knowledge that must be possessed by teachers initiated by Shulman and Sykes in 1986. Tamir organized and explained more specifically about the basic knowledge categories of teachers. The concept conveyed by Tamir differ somewhat from the categories 3,4,5 and 6 in the paper of Shulman and Syke. *First*, there is a clearer difference between general pedagogical knowledge and the special pedagogical subject which consists of four categories, namely, student. curriculum, instruction and evaluation. According to Tamir, general material can be handled by general pedagogists while the special subject must be handled by instructors who are pedagogists who have prepared themselves in this discipline. *Second*, there must be a clearer difference in the framework presented by Shulman and Syke between knowledge and skills. The basis of Tamir's concept refers to Gilbert Ryle in 1952, who revealed the difference between propositional knowledge (knowing what) and procedural knowledge (knowing how) in accordance with the difference between "knowledge" and "skills" in the framework. Knowledge can be transmitted in a variety of ways and skills gained by direct experience (Olson, 1973; Tamir, 1988). *Third*, while Shulman and Sykes use the term "content knowledge", Tamir prefers to use the term "subject matter knowledge" because that knowledge actually includes the components (content) and syntax (process) of certain scientific disciplines (Schwab, 1964). In his journal in 1986, Tamir revealed the basic knowledge that must be possessed by teachers that was more or less similar to the concept of Shulman and Sykes but emphasized more on (1) general pedagogical knowledge, (2) pedagogical content knowledge, (3) curriculum knowledge, (4) student knowledge and (5) content knowledge (Tamir, 1988).

In 1990, Grossman actively opposes the assumption that anyone who has knowledge of a subject matter can teach well and that experience is the best teacher in the Journal of Teacher Education with the title *The Making of a Teacher: Teacher Knowledge and Teacher Education*. In creating a teacher, Grossman sought to answer the question that arises whether education for teachers makes a difference. Grosman's case study of six beginner teachers is centered on pedagogical understanding of the subject matter that distinguishes between subject matter experts (3 teachers) and experienced teachers (3 teachers). He defines Pedagogical Content Knowledge (PCK), which consists of four components of (1) knowledge of content (concept of purpose), (2) knowledge of student

understanding, (3) knowledge of curriculum, and (4) knowledge of learning strategies. These components serve as a framework for the analysis of teacher teaching practices and beliefs. Grossman has taken significant steps in pointing out the differences that may exist between subject matter experts and teachers who take special education and have confidence. He suggested that future research should examine the relationship between elements that influence beginner teacher's knowledge and beliefs, the development of Pedagogical Content Knowledge (PCK) and the interaction of these components [6].

Marks, in the Journal of Teacher Education with the title *Pedagogical Content Knowledge: From a Mathematical Case to a Modified Conception* in 1990 by interviewing 8 (five) fifth-grade teachers about their teaching in class, revealed the concept/idea of Pedagogical Content Knowledge (PCK) consisting of 4 (four) components of (1) knowledge of subject matter for teaching purposes, (2) knowledge of students' understanding of the subject matter, (3) knowledge of the media used in the subject matter, and (4) knowledge of the teaching process for the subject matter. In his paper, Marks suggested that there need to be a revision in the practice of teacher education designed to integrate content and pedagogy [7].

In 1999, Gess-Newsome & Loderman issued a book entitled *Examining Pedagogical Content Knowledge*, as in chapter 2 by Morine-Dhersimer and Kent with the title *The Complex Nature and Resources of Teachers' Pedagogical Knowledge*. In this chapter, Morine-Dhersimer and Kent explain about the integrated knowledge that contributes to PCK, namely: (1) curriculum knowledge, (2) content knowledge, (3) general and specific context knowledge, (4) knowledge about students and learning, and (5) pedagogical knowledge. The sub-categories of curriculum and pedagogy knowledge consist of knowledge about assessment, evaluation and the purpose of education. In addition to the 5 (five) basic knowledges, Morine-Dhersimer and Kent elaborate the concept from pedagogical knowledge, which, according to them, has other integrated components. These components are: (1) general pedagogical knowledge, (2) teaching models and strategies, (3) communication in the classroom, (4) classroom management, and (5) reflection. The reflection component is also described in several components such as specific pedagogical knowledge according to context, personal pedagogical knowledge (teacher's beliefs and experiences) [8].

Another chapter in the Gess-Newsome & Loderman's book in 1999 which discusses PCK is chapter 4. Magnusson, Krajcik and Borko. Based on the previous concept of Tamir (1988) and Grossman (1990), they developed the concept of PCK, which is oriented to teaching science, which consists of 5 (five) components of: (1) orientation towards science, (2) knowledge and beliefs about the science curriculum, (3) knowledge and

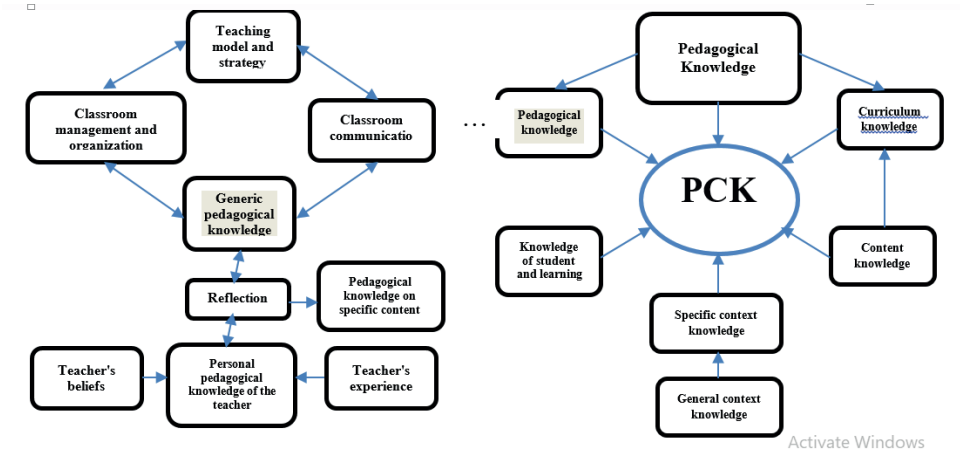

Figure 1: Morine-Dhersimer and Kent's PCK Model, 1999.

beliefs about students' understanding of certain science topics, (4) knowledge and beliefs about assessment in science, and (5) knowledge and beliefs about teaching strategies for teaching science [9].

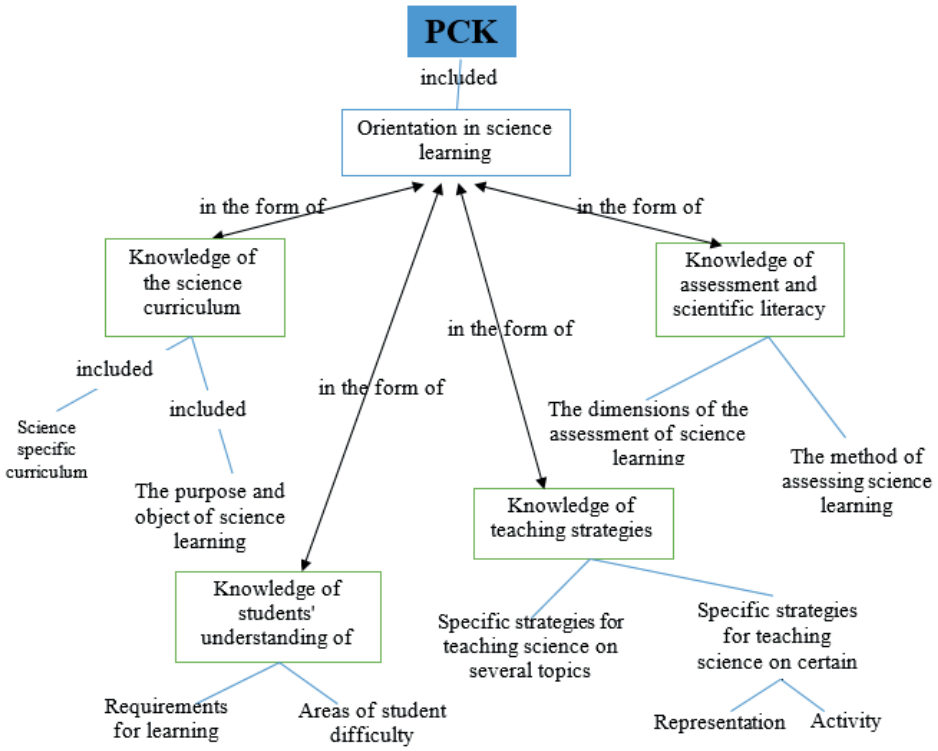

Figure 2: PCK components for teaching science according to Magnusson, Krajcik & Borko, 1999.

At the end of the second millennium of 2000, the concept of PCK was expressed by Loughran *et al*. The concept of PCK was revealed in 2000 and 2001 in a row. In April 2000, Loughran, Gunstone, Amanda Berry, Milroy & Mulhall from Monash University, Australia at the Faculty of Education presented a paper at the annual meeting, the

National Association for Research in Science Teaching, in New Orleans. The paper presented by Loughran *et al.* is entitled *Science Cases in Action: Developing an understanding of science teachers' pedagogical content knowledge*. Loughran *et al.* revealed that although PCK is actually possessed by an experienced science teacher, there needs to be a more complex process to recognize or articulate PCK itself. The bases of this statement are (1) PCK is not only related to the development and transformation of learning materials certain; (2) PCK is a complex idea that can only be recognized for a long period of time, and (3) experienced science teachers do not usually talk about PCK when they discuss teaching. Teachers focus on learning problems (teaching procedures, activities, and strategies). According to them, PCK is not 'part' of their profession; (4) even though experienced science teachers may have a lot of knowledge about content and pedagogy compatible with science teaching and learning, it is difficult for individual teachers to recognize and express; (5) PCK develops by understanding the concept/content differently as a result of trying to teach the concept/content and recognizing the discrepancies inherent in knowledge and developing understanding in practice; (6) It is difficult for teachers to reconstruct developments and changes in their teaching over time. Therefore, it is very difficult to know the understanding of the concepts that the teachers have and how they have changed; and (7) In seeing the ability of PCK to involve the use of a complex set of 'instruments', some researchers involve interviews, classroom observations, curriculum discussions, collaboration with other teachers, and teacher testing between belief and practice [10].

3.3. The Development of Pedagogical Content Knowledge (PCK)

In the 2000's paper, there was no expression on how to measure and recognize PCK abilities by a teacher. This raises the question of how the teacher's PCK can be revealed, articulated and illustrated to others. In 2001, Loughran, Milroy, Berry, Gunstone & Mulhall re-examined and wrote about the concept of PCK in the Research in Science Education journal under the title *Documenting Science Teachers' Pedagogical Content Knowledge Through PaP-eRs*. In this research, Loughran *et al.* collected the data by conducting interviews with experienced science teachers to find out the explicit nature of the teacher's teaching practices. This research was initially a way to document the PCK of teachers. Over time, from the knowledge and information collected by Loughran *et al.*, they developed the PCK articulation and illustration approach, called CoRe (Core Representation), which represents certain content/topics from science teaching and PaP-eRs (Pedagogical and Professional experience Repertoire), which helps explain

specific aspects of CoRe, which offers insight into the pedagogical content knowledge itself. The CoRe and PaP-eRs instrument developed by Loughran and colleagues has until now been used by researchers in the educational dimension to determine the PCK ability of a teacher (Loughran et al, 2001).

Then, in 2001, Pierson wrote again in the Journal of Research on Computing in Education with the title *Technology Integration Practice as a Function of Pedagogical Expertise* and revealed new ideas in the PCK knowledge for teachers. Pierson conducted the research by comparing teachers who taught using technology with those teaching without using technology. The evidence presented in Pierson's research shows that variations in the use of technology are closely related to the level of teacher's teaching skills. He suggested that future developments in the educational dimension can also use technology together or meaningfully to enhance learning activities for students such as planning, classroom management and assessment. This refers to the concept of PCK presented by Shulman in 1986 that expert teachers had the integration of content knowledge and pedagogical knowledge, and based on his research, Pierson proposed a new component in PCK, namely technological knowledge. According to Pierson, a teacher who effectively integrates technology will be able to utilize content knowledge and extensive pedagogical knowledge in combination with technological knowledge [11].

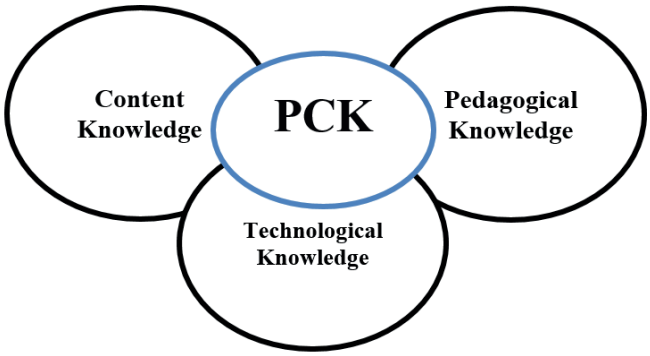

Figure 3: TPCK Model by Pierson, 2001.

Mishra & Koehler in their journal entitled *Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge* also explains the importance of adding technological knowledge as must-have knowledge by the teachers now. In this journal, Mishra & Koehler propose that the term TPACK, instead of TPCK, to be more easily called and remembered. Until now, in Indonesia, the concept of TPACK itself is widely used in the educational research, in line with the rapid technological advances in Indonesia (disruption era). The concept of TPACK is also used as a core material in

the teacher professional development program in Indonesia, such as PPG. The teacher professional development program using TPACK enables teachers to reflect on how they can start using technology in the classroom and think about student involvement in the use of technology and learning (Dalal *et al.*, 2017). The research by Chen & Jang in 2018 explained that in the in-service teacher program, it is necessary to incorporate TPACK's basic knowledge into the teacher's self-regulation to improve the teacher's professionalism sustainably [12].

Due to many opinions about the concept of Pedagogical Content Knowledge (PCK), some revealed that PCK is an integration of the basic knowledge of teachers while others reveal that PCK is a separate part, which is one of the basic knowledge of teachers. Finally, in October 2012, a meeting/conference called "PCK Summit" was conducted, which brought together 22 international research groups (Shulman, one of the participants) via Skype working on the field of PCK in science. The groups met for five days in Colorado Springs, the state of Colorado, United States. The purpose of this meeting was to reach a consensus to make the definition of PCK adopted by several models and groups to be mutually agreed upon. The latest model of PCK, which is the result of the agreement of the meeting/conference held, is that PCK consists of 5 (five) components of knowledge, namely: (1) knowledge of assessment, (2) knowledge of pedagogy, (3) knowledge of content, (4) knowledge of students' understanding, and (5) knowledge of curriculum. The results of this meeting/conference were written by Helms and Stokes in 2013 in a paper entitled *A Metting of Minds Around Pedagogical Content Knowledge: Designing an International PCK Summit for Professional, Community and Field Development* [13].

At first, PCK was only a concept of a basic knowledge that must be possessed by the teacher. After starting to grow and develop, researchers explained that PCK, which is one of the basic knowledge that must be possessed by the teacher, is a combination of interconnected components of knowledge while others explained that PCK is separate knowledge from other knowledge and is one of the basic knowledge of the teacher. Based on the results of the research by analyzing journals that discuss PCK starting from its birth, growth and development, researchers reveal that there is a pattern of change from the concept of PCK over time. The first pattern of change occurred in the term/naming of PCK itself. When Cochran *et al.* proposed a new term in 1993, namely Pedagogical Content Knowing (PCKg) to be more consistent with the view of constructivism and its application in teacher teaching and preparation. The term PCKg only lasted for 2 (two) years, 1993-1995, because after that, researchers use the term PCK again until now.

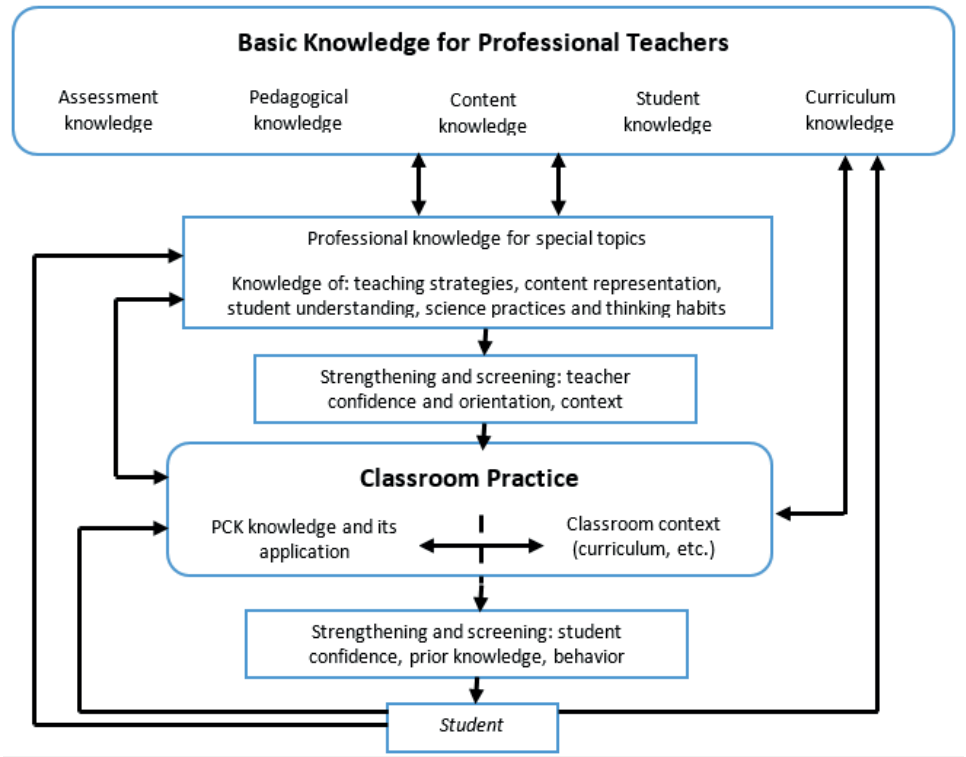

Figure 4: PCK Consensus.

Initially, PCK was a static concept to measure the knowledge of a teacher. Then, PCK was also used to measure the knowledge of preservice teachers (educational students), such as a study conducted by [14] involving 12 prospective chemistry teachers following a program to measure participants' PCK knowledge. The knowledge of teachers is also finally separated into 2 (two) categories, namely beginner and experienced teachers. [15] conducted a study to measure the Pedagogical Content Knowledge (PCK) abilities of experienced and inexperienced biology teachers resulting that there were some differences between senior and junior teachers in making CoRe and PaP-eRs documents. These differences were related to the translation and grouping of materials. The results of the study of [16] also show that beginner teachers are required to have basic knowledge from PCK. They added that the concept of PCK was also used to measure the knowledge of a professor at the university and to improve students' understanding of the concept that leads to their achievements in class. Based on this analysis, it was found that in the development of PCK research, there were patterns of change in the subject. The subject of PCK, which was initially only directed at the basic knowledge of the teacher, developed into the basic knowledge of prospective teachers, beginner teachers, professional teachers, professors at universities and students in class.

The patterns of change in the concept of PCK subsequently occurred when PCK, which had previously only been used as a static thing about teacher knowledge, was

transformed into a training that taught methods/strategies to improve teacher's PCK knowledge that had an impact on changing teaching strategies in the classroom with students. The patterns of change of PCK originated from the time PCK developed, starting from Loughran's concept providing CoRe and PaP-eRs instruments to measure and improve the PCK knowledge of teachers. PCK, which was originally only a picture of the teacher's knowledge, has now developed into a way to train to improve the basic skill of teachers. The concept of PCK also subsequently turned into TPCK proposed by Pierson (TPACK by Mirsha & Koesher) which separated technological knowledge into new basic knowledge that teachers must also have. A teacher in this century is deemed to be professional if he/she has integrated technology in the learning design that can assist him/her in transforming the knowledge to students. A teacher must have a positive attitude towards the importance of integrating technology in learning activities because technological competence has a positive relationship and further significant effects on science teachers [17]. PCK, which used to be a special combination of pedagogy and content, has changed into a special combination of pedagogy, content and technology over time and the development of technology. There is a fundamental change in which previous technological knowledge, part of the pedagogical knowledge, has turned into the knowledge required by the teacher. It is expected that the future PCK research can use PCK from the consensus as a way to make a professional teacher because the relationship between the knowledge bases in PCK from the consensus, knowledge of assessment, pedagogy, content, students and curriculum, is believed to have a positive impact on student outcomes.

4. CONCLUSION

This research aims to analyze the development of PCK from the beginning to the present and provide direction for further PCK research. Based on the results, we can sum up that there is a pattern of change from the concept of PCK, initially revealed by Shulman. The pattern of change occurred in the term/naming, the subject of PCK, from basic knowledge into a way to train teachers and the addition of technology in the concept of PCK. The future research of PCK is directed at how to develop strategies to improve teacher's PCK and train them in integrating technology (TPACK) into classroom learning.

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