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Analysis of PCK Changes in Prospective Biology Teachers

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Abstract--

Objectives *- This study aims to analyze changes in PCK (Pedagogical Content Knowledge) prospective Biology teachers at one private university in Kuningan District, West Java Province, Indonesia.*

Methodology *- This research uses mixed methods through a concurrent embedded strategy. Quantitative methods are used to obtain a picture of the pattern of PCK changes in Biology students in the even semester of the 2018/2019 academic year. Qualitative methods are used to get more data around these change patterns. The sample in this study was Biology Education students at one of the private tertiary institutions in West Java who participated in the study and participated in all research instruments and had complete data, namely 22 second semester students, 18 fourth semester students, 18 semester six students and semester eight numbered 21 people so that the number of valid samples amounted to 80 (77.7%) of the population of 103 students. The sampling technique used was purposive sampling and saturated samples. The instruments used were knowledge tests, Content Representation (CoRe), concept maps, questionnaire and interviews.*

Findings *- The results of the study show that: 1) PCK is not only knowledge but also skill so it requires multiple assessments to uncover it; 2) PCK as knowledge has a pattern of change that is not linear with the number of semesters that have been taken by prospective teacher students, in contrast to PCK as a skill; 3) PCK prospective teachers begin to grow when prospective teachers have obtained all pedagogical courses, namely fourth semester; 4) PCK prospective teachers begin to develop clearly after prospective teachers take microteaching courses, namely the sixth semester; 5) PCK teacher candidates in the eighth semester already have an almost perfect form.*

Significance *- The findings of the research result are significant in the LPTK (educational institutions and education personnel) curriculum structure changes regarding the distribution and number of courses included in the proportion of content and pedagogy families, the pattern of course debriefing programs especially pedagogical families, and the patterns of planning, implementation and evaluation of microteaching and PPL (practice field experience). The research findings successfully detected the initial changes and development of PCK, and the form of PCK that was almost intact.*

Keywords*--Pedagogical Content Knowledge, Content Knowledge, Pedagogical Knowledge*

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- **INTRODUCTION**

Since Shulman (1987) conveyed the idea of PCK, PCK was considered a link that had been lost between CK (Content Knowledge) and PK (Pedagogical Knowledge) in the professional development of a teacher (Berry et al., 2008), namely knowledge of what must be taught, how to teach it, how to engage students and how to deal with student learning difficulties; then research on PCK is like mushrooms in the rainy season, growing and developing quickly. PCK inspired Grossman (1990), Cochran, KF, DeRuiter, JA. & King, RA (1993), and Magnusson, S., Krajcik, J, & Borko, H. (1999) by designing the PCK model. Magnusson et al. (1999) recommend a transformative model that considers PCK as knowledge gained through CK and PK. Whereas Cochran et al. (1993) proposed PCK as a model of integration of CK and PK (Gess-Newsome, J., 1999).

PCK research continues to grow to this day because it is well realized that PCK is needed as a teacher's professional expertise. Research on PCK is generally conducted on in-service teachers as a case study. Pre-service teachers are used as PCK case studies because pre-service teachers have limited or underdeveloped PCK, CK and PK (Aydin, 2012). In-service teacher PCK has a higher value than pre-service teacher (Schmelzing, S. et al., 2013). PCK research also generally involves PCK components and not as a whole (Aydin, S. & Boz, Y. 2012). As conducted by Karışan, D., Şenay, A. & Ubuz, B. (2013) using four components of PCK, there are also those who examine the influence of teacher orientation on teacher PCK and vice versa (Demirdöğen, B., 2016). In addition, some also offer two instruments to articulate, describe, and capture the knowledge of PCK science teachers namely CoRe (Content Representation) and PaP-eRs (Professional-experience Repertoires) (Nilsson, P. & Loughran, J., 2012). CoRe and PaP-eRs have been used as a reference for PCK research (Alvarado et al, 2015; Bertram & Loughran, 2012; Cansiz, N. & Cansiz, M. 2016). Other PCK studies exist through inquiry-based instruction (Nuangchalerm, P., 2012), through reflection in action (Park & Oliver, 2008); through concept maps (Dickerson, DL. Dawkins, KR. & Annetta, L., 2007); formative assessment (Falk, A., 2011); through the course method (Faikhamta, C. & Coll, RK. Roadrangka, V. 2009); through role playing (Rollnick, M., 2017); through lesson study (Juhler, MV., 2016); through an explicit-reflective approach (Krajewski, SJ. & Schwartz, R., 2014); through a web-based teaching model (Yesiltas, E., 2016); analyze PCK using instruments (Aksu, Z., Metin, M., & Konyalıoğlu, AC., 2014; Halim et al., 2012); through mentoring activities (Appleton, K., 2008); using models and languages (Strübe et al., 2014) and so on.

However, until now there are still many things that have not been revealed from PCK, including how the PCK growth profile, especially in prospective teachers. That is because PCK is a difficult concept to clearly describe (Aksu, Z., Metin, M. & KonyalÖoølu, AC., 2014). PCK can be described as a "wilderness" so that anyone who enters the forest when asked to describe the forest that he has entered, there will be so many variations of the picture obtained because each person will describe the experiences encountered while in the wilderness which is definitely different between one persons to another. This is nothing else because PCK is an intersection between CK and PK where CK and PK between individuals vary from one another to individual patterns (idiosyncrasies) (Loughran, JJ. Berry, A., & Muhlall, P., 2006). PCK when used by a teacher to transform teaching materials that are easily understood by students, requires specific expertise and varies from one teacher to another. Based on that, PCK is the

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professional expertise of a teacher who is amalgam so that the longer the PCK of a teacher grows and develops. Knowledge of how to grow and develop PCK is still minimal.

• RESEARCH OBJECTIVES

This study aims to analyze the changes in the PCK of Biology teacher candidates at one of the private tertiary institutions in Kuningan Regency, West Java Province, Indonesia.

• METHODOLOGY

This study uses mixed methods to combine quantitative research with qualitative research (Creswell, JW. & Clark, V.L.P., 2007). The research strategy used in this study is concurrent embedded to collect quantitative and qualitative data at the same time. Quantitative methods are used to obtain a pattern of changes in PCK Biology teacher candidates even semester 2018/2019 academic year. Qualitative methods are used to get deeper into changing patterns.

The population in this study were all students of Biology Education FKIP Kuningan academic year 2018/2019, as many as 103 with details of the number of students in the second semester being 25 people, semester four totaling 24 people, semester six totaling 28 and semester eight totaling 26 people. The sample used in this study were students who participated in the study and followed all research instruments and who had complete data, namely 22 second semester students, 18 semester four students, 19 semester six students and 21 semester 8 students so that the total sample taken was valid for 80 (77.7%) people.

The instruments used for PCK data are PCK knowledge tests, CoRe, concept maps, questionnaire and interviews. The instrument was previously tested for validity and reliability and was validated by biologists, pedagogists and instrument experts. Data from PCK test results were analyzed using quantitative ANOVA test analysis through SPSS for windows 21. Concept map data, CoRe, questionnaire and interviews were analyzed using qualitative descriptive analysis.

• FINDING AND DISCUSSIONS

The pattern of changes in the prospective teacher's PCK was obtained based on PCK test results, concept map tests, CoRe, questionnaires and interviews. The average score of the prospective teacher's PCK test results every semester as shown in Figure 1 is semester two < eight < four < six. This means that the average PCK test score does not run linearly with the number of semesters taken. There is an oddity: the average score of eighth semester student test scores is lower than the PCK test scores of fourth and sixth semester students. This is different from the results of Can, B., Erokten, S., & Bahtiyar, A. (2017) research that when the level of prospective teachers increases, the level of PCK also increases. The highest average PCK score is owned by sixth semester students. This is similar to the results of research Ozdemir et al. (2017) that third-level students have better understanding of

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student understanding (a component of PCK) than teachers and fourth-level students. Third-level students have the same knowledge about teaching strategies (one component of PCK) with fourth-level students even better than teachers. Research Şahin, Ö., Gökkurt, B., & Soylu, Y. (2016) shows that knowledge about student understanding develops directly proportional to the grade level and the teaching profession.

One other instrument used to measure PCK in this study is the concept map. The average score of the results of the concept map made by prospective teacher students as listed in Table 1, namely the average score of second semester students < six < four < eight. This means that the concept map score is not linear with the number of semesters taken by students. The order of students' ability to determine the number of proposition relationships is the average score of semester six students < two < four < eight. The ability of students to determine hierarchical order is the average score of semester two students < six < four < eight. The ability of students to determine examples is the average score of second semester students < six < four < eight.

Table 1 Average Scores per Semester of the Concept Map Test

No.	Semester	Number of Propositions	Number of Hierarchies	Number of Examples	Number of Cross-Link	Score
1.	2	4.64	10	0.18	0	14.82
2.	4	7	17	1.2	0	25.3
3.	6	3.76	11	0.95	0.5	15.95
4.	8	11.63	25	1.37	0	38

Based on Figure 2, it can be seen that the largest contribution of concept map scores comes from the number of hierarchies, followed by successive numbers of propositions, number of examples and cross-links. This means that in general teacher candidates understand the hierarchy in concept mapping. Hierarchy or levels of concepts. The hierarchy is arranged from the most general to the most specific. Determining which concepts are general and which ones are specific, requires an understanding of these concepts. Therefore, in the assessment of concept maps each answer to the hierarchy is given a weight of five. Among the four components of the concept map, cross-links are given the greatest weight, 10 because determining cross-links requires a deep understanding of the concept.

The ability to make concept maps mentioned above is strange, namely fourth semester students higher than sixth semester students. There are even two components of the concept map, which is determining the number of propositions and grades for sixth semester students who are defeated by second semester students. However, there are sixth semester students able to make cross-links. Eighth semester students have the highest score indicating that eighth semester students better understand the concept. This can break the PCK test results that eighth semester students have an average PCK score lower than the previous semester students, but the concept map results prove that eighth semester students actually have the best PCK. Learning outcomes using the concept map strategy are better than using conventional learning strategies (Ragisha. KK. & Gafoor, KA. 2014). Concept maps according to Romero, C., Cazorla, M. & Buzón, O. (2017) can be used as a strategy to measure student learning completeness. However, there is a fact that sixth semester students have higher PCK test scores than fourth and eighth semester

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students but have lower average grades than fourth and eighth semester students in terms of concept maps. This fact is difficult to explain why it happened. The possibility of sixth semester students lacking training in making concept maps while attending lectures.

Another instrument used in this study to capture PCK teacher candidates is the CoRe. Based on CoRe data, eighth semester students have PCK better than previous semester students. Eighth semester students know

The exact topics that need to be taught to students, topics that do not need to be taught to students, the essence of the learning topic, learning strategies that are appropriate to the material, things that can support and hinder the learning of the topic, and the instruments used . This is obtained based on their experience while carrying out learning in microteaching and PPL. The results of this CoRe analysis prove that CoRe can be used as an instrument for capturing PCK of prospective teachers or teachers (Hume & Berry, 2010; Cansiz & Cansiz, 2016; Nilsson & Karlsson, 2018). Thus, the results of PCK written tests are not able to describe the real PCK, that eighth semester students have poor average PCK scores compared to students from the previous semester, but through concept map and core eighth semester students have the best PCK compared to previous semester students. This reinforces the idea that PCK requires multi-instrument measurements (Shulman, 1987; Morrison, AD. & Luttenegger, KC., 2015).

Based on students' answers to the question "What other factors have you considered in teaching the concept?" is the second semester student does not understand the answers to these questions. Fourth semester students begin to understand, albeit on a limited scale, that other factors considered for learning this material concern teaching methods / models and instructional media. Sixth semester students understand these questions more and vary more in their answers, that other factors considered to teach this material concern learning resources, teaching models / methods and learning media. Eighth semester students consider the factors of infrastructure, models, motivation, available study time, varied learning resources and student abilities. Based on this, PCK began to grow when students sat in the fourth semester. This is reasonable because it is based on the distribution of biology education curriculum, fourth semester students have taken almost all pedagogy courses.

Based on the answer to the question "What kind of student conditions are you considering in teaching this concept?" in CoRe, students semester two and four do not understand the answers to this question, sixth semester students have the right answer, even though it is not as good as the eighth semester students. sixth and eighth semester students are the impact of learning from microteaching and PPL that has been taken, this shows that PCK is clearly visible when students have implemented teaching practices, that is sixth semester students have conducted microteaching and eighth semester students have done PPL. Kartal, Ozturk, & Ekici (2012) show that the implementation of microteaching and PPL learning can improve the PCK of prospective teachers. Through learning practices, students gain teaching experience so that the PCK of students grows and develops. The more experience, the better the PCK (Schmelzings et al., 2013; Evens, M., Elen, J., & Depaepe, F. 2015.).

Based on the results of the CoRe analysis for the question "what do you want students to learn from this topic?" in CoRe, it can be concluded that the more the number of semesters taken leads to the right material structure. Second semester students do not know to answer that question. Fourth semester students begin to lead to

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the topic. Sixth semester students are increasing the material that leads but non-urgent material appears for the topic. Eighth semester students already know important materials that are important to convey to high school students. Eighth semester students are more complete, focused and focused in answering this question.

The average score of the PCK knowledge test results is based on the ANOVA test as seen in Table 2 p value from the Sig. for PCK obtained 0.016, so the value of p <0.05 which means Ho is rejected or there is a difference in the average PCK test results between students in each semester. This means that the average PCK knowledge test obtained by students is correct, that is, the average PCK knowledge of semester two students < eight < four < six.

PCK based on the description above, between PCK as a knowledge and PCK as a competence of special teaching skills show different characteristics. PCK test results show PCK as knowledge, but PCK test results for concept maps and CoRe show PCK as skills. PCK as a knowledge has non-linear growth characteristics with the number of semesters taken by prospective teacher students, while PCK as a teaching skill / expertise has a linear growth pattern with the number of semesters taken by prospective teacher students.

Table 2 ANOVA Test Average PCK Score

		Sum of Squares	df	Mean Square	F	Sig.
PCK	Between Groups	2978.227	3	992.742	3.672	0.016
	Within Groups	20007.991	74	270.378		
	Total	22986.218	77			

Based on this, caution is needed when mentioning PCK, whether PCK is knowledge or PCK as skill / expertise. PCK as knowledge is sufficiently measured using a knowledge test instrument, whereas PCK as a skill / expertise is not enough to use a knowledge test instrument but uses several kinds of test instruments (for example classroom learning observations and interviews) where the results are triangulated. In this connection, the right term for expertise in gathering teaching material and applying it in learning in such a way that is easily understood by students not PCK but PCS (Pedagogical Content Skill) to refer to PCK in the sense of words as teaching skills. As noted by Widodo, A. (2017) that although PCK may not be directly related to teaching practice, PCK shapes teacher practices. Teacher practice is about skills. Likewise, the opinion of Loughran, JJ. Berry, A., & Muhlall, P. (2006) that PCK is a practical skill with individual patterns (idiosyncrasies) and differences are influenced by the teaching context, teaching content and experience. PCK may be the same or similar for some teachers, but it may also be different for others, which is definitely a teacher's expertise and professional knowledge.

Knowledge is information obtained through sensory input: reading, watching, listening, touching, and so on. The concept of knowledge refers to linkages with factual information and theoretical concepts. Knowledge can be transferred from one person to another or can be obtained alone through observation and learning. However, skills refer to the ability to apply knowledge to certain situations. Skills are developed through practice, through a

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combination of sensory input and output. For example, social skills are developed through interactions with people by observing, listening to and talking with them. Trial and error is perhaps the best way to achieve mastery of skills. Simply put, knowledge is theoretical while skills are practical (Boulet, G., 2015). Based on this definition, PCK as knowledge can be obtained from various sources which can be input through sensory. In this study, PCK prospective Biology teacher candidates for the fourth and sixth semester are better than eighth semester students, which is not strange because fourth and sixth semester students get more PCK knowledge from various sources compared to eighth semester students. This is not the case with PCK as a skill or PCS developed through practice so that it is natural that eighth semester students have better PCK skills than fourth and sixth semester students because eighth semester students have taken almost all courses and have taken microteaching and PPL.

Consequently PCK as a skill or PCS, the development of PCK (PCS) prospective teachers is done with as many prospective teachers as possible given the opportunity to do teaching exercises. Through practice prospective teachers gain experience so that they are increasingly maturing their PCK (PCS). It is also through training that teacher candidates gain new knowledge which further enriches the prospective teacher's PCK. As a skill, PCK also means talent. A prospective teacher who has talent as a teacher has a whole PCK faster than prospective teachers who do not have talent as a teacher.PCK as a skill can explain why a prospective teacher has high knowledge (including CK or PK) but has a low PCK.The results of the study of Çalik, M. & Aytar, A. (2013) can strengthen researchers' belief that PCK is not only knowledge but also a teaching skill. According to them prospective teachers do not have enough description of PCK sub-components, especially curriculum knowledge, and knowledge of student learning difficulties. However, prospective teachers have adequate PK ideas in the context of PCK. Although they have sufficient theoretical knowledge about instructional methods, techniques, strategies, measurements and assessments, they have encountered several problems in transferring theoretical knowledge into practice. Given the results, it is recommended that prospective teachers be given more opportunities to practice teaching techniques. In this regard, the development of teaching practices for prospective teachers is very urgent and essential because PCK develops through classroom teaching practices (van Driel, J. H., Verloop, N., & de Vos, W., 1998). Moreover, for most teachers, theory does not always help solve everyday problems that involve education. Therefore, they do not have much interest in articulating the relationship of their practice with academic knowledge (Loughran et al., 2001; Loughran, J., Mulhall, P., & Berry, A. 2004).

The results of interviews with prospective teacher students about the role of lectures, microteaching and PPL on the development of PCK students are as follows: 1) in terms of mastering the curriculum of a scientific discipline, lectures are of little help because students are provided through CK and PK family courses; 2) in terms of recognizing learning styles and student learning difficulties, the contribution of lectures is almost non-existent because they are not taught and students must learn independently from other sources of information such as seeing the teacher's learning process via YouTube; 3) in terms of assessing students 'preconceptions and students' misconceptions as well the lecture process does not contribute because it is not taught, the lecturer should provide more understanding to students directly related to teaching practice. So that when in the field students are not surprised by a variety of learning styles and student learning difficulties; 4) in having learning strategies according to the topic of student conditions, the lecture process contributes a little because there are some lecturers who

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explain various learning strategies but are not so detailed as explained by the lecturer; 5) In assessing student learning outcomes, students must understand each student's characteristics and this contributes little to the lecture process. Likewise in learning in microteaching and PPL, supervisors and tutor teachers in high school have very little equipped students to develop PCK components. There are even PPL participants who have never been mentored by supervisors and are never cuddled by tutors but generally teacher candidates think that microteaching and PPL lectures contribute a lot in the development of PCK for prospective teacher students.

Based on the answers of these students, it can be concluded that the debriefing program during being a student there are two components of PCK that are not touched, namely the component recognizes learning styles and learning difficulties of students and the components of assessing students' preconceptions and misconceptions. This is different from the results of research by Çalik & Aytar (2013) who found weaknesses of prospective teachers regarding the PCK component, especially in curriculum knowledge and knowledge about student learning difficulties. Similarly Adadan, E. & Oner, D. (2014) found the PCK component of prospective teachers did not develop at the same level and each PCK component showed relatively different features between individuals. Bektas, O. (2015) in a study of prospective teacher students in Turkey found that some prospective teachers did not have enough information about instructional strategies and assessment knowledge in a topic. Many prospective teachers state that to overcome misconceptions about a topic traditional instructions and open questions can be used.

The answers through interviews with prospective teacher students differed from the answers of prospective teacher students through questionnaires about the PCK debriefing program through lectures, microteaching and PPL. Based on the questionnaire answers to the development of the five components of PCK are as follows: 1) 61.8% agree and 18.4% strongly agree that the lecture program is useful in recognizing student learning styles during microteaching / PLP; 2) 59.2% agreed and 13.2% strongly agreed that the lecture program was useful in dealing with student learning difficulties when microteaching / PLP; 3) 61.8% agreed and 18.4% strongly agreed that the lecture program was useful in assessing students' conceptions (preconceptions and misconceptions) during microteaching / PLP; 4) 53.9% agreed and 27.6% strongly agreed that the lecture program was useful in developing learning strategies during microteaching / PLP; and 5) 45.3% agree and 21.3% strongly agree that the lecture program is useful in assessing student learning outcomes when microteaching / PLP. This difference is likely when students fill out a questionnaire just to please stakeholders of Biology education study programs where students gain knowledge. When interviewing they delivered improvised, nothing was covered up because it was emphasized really during the interview.

• CONCLUSION

The pattern of changes in PCK for prospective teachers has the following characteristics: 1) PCK is not only as knowledge but also a skill that requires multiple assessments to uncover it; 2) PCK as knowledge has a pattern of change that is not linear with the number of semesters that have been taken by prospective teacher students, in contrast to PCK as a skill; 3) PCK prospective teachers begin to grow when prospective teachers have obtained all pedagogical courses, namely fourth semester; 4) PCK prospective teachers begin to develop clearly

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after prospective teachers take learning in microteaching, namely the sixth semester; 5) PCK teacher candidates in the eighth semester already have an almost perfect form.

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