Development of An Observation Sheet Instrument to Measure Biology Teachers’ Ability of Pedagogical Content Knowledge (PCK) Application

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Abstract. This research aims for making observation sheet instrument which is valid and reliable that is used to measure the ability in applying Pedagogical Content Knowledge (PCK) of biology teachers in learning process. This research categorized Design and Development Research (D & DR) by using 6 development steps according to Peffers, et al and Ellis & Levy. Steps in developing PCK observation instrument are: (1) Identify the problem; 2) Describe the objectives; 3) Design and develop the product; 4) product testing; 5) Evaluate the results of testing; and 6) Communicate the testing results. PCK observation instrument was tested on 11 biology teachers on July-August 2018, involving four raters. Face validity of the instrument involved two experts judgement. Empirical validity acquired by calculating Biserial Correlation value. Instrument reliability determined by calculating Intraclass Correlation Coefficient (ICC) value. Empirical Validity based on Biserial Correlation value shows that 18 items categorized as valid with R count > 0.602, while 10 items are not valid with R count < 0.602. Reliability of PCK observation instrument shows 0.951 for the ICC value which means the instrument has a high stability based on the agreement between raters (reliable).

1. Introduction

Education is an important aspect for Indonesian development. Nation’s development can be seen from its human resource quality. Efforts to raise the human resource quality can be done by raising the quality of education in Indonesia. Education system of Indonesia must be able to empower every education components which includes the learning programs, teachers, students, facilities, funds, societies, principal leadership and so on. The teachers is the main component in success of education system because they are the main actor in school. If we want to raise the quality of education, raising teacher’s professionality will become the priority.

A professional teacher must have competence in carrying out the teaching program. Teacher’s competence is one of the factors that affects the goal of the learning and education at school. As it is stated in Undang-Undang Number 14 of 2005 pasal 10 ayat 1 about Teacher and Lecturer [1], teacher’s competence consists of pedagogy, personality, social and professional that acquired from profession education. Based on the statement, in can be inferred that the mastery of those four competence must
be had by every teacher in order to become a professional educator. Nouvauli [2] explained that the teacher’s competence contributes in the raise of students’ learning achievement and the raise of school’s integrity – because teacher’s competence must present in themselves in order to realize the precise and effective performance.

A competent teacher must have understood and apply the Pedagogical Content Knowledge (PCK) in teaching process. Shulman [3] explained that PCK is a professional knowledge dimension which is important for teacher. Etkina [4] stated that there is a main foundation of basic knowledge for a teacher, especially biology teacher, i.e. Content Knowledge (CK), Pedagogical Knowledge (PK), and PCK. CK is a teacher’s knowledge in mastering the teaching material, while PK is a knowledge about how the students study – including the knowledge about cognitive psychology, about how the students’ memory work, the collaborative study through group and so the other. On the other hand, PCK is a knowledge about how a teacher combines CK and PK for maintaining the learning so that it can raise and gain the optimum academic ability of the student. Susilowati [5] explained that understanding the content of biology material is not enough for teaching biology. The teachers must also understand teaching technique. Biology teachers must have understanding about the student, curriculum, instructional strategy and evaluation, so they can do knowledge transformation.

The application of PCK in teaching process must be done by biology teachers because they are in level 7 in the standard of Kerangka Kualifikasi Nasional Indonesia (KKNI) [6]. One of the working competence of level 7 KKNI is the mastery of pedagogical content knowledge theory application – theory of study for its minimum, evaluation of study result process, curriculum, and principles of teaching educative studying field [7]. The application of teacher’s PCK can be viewed from two present components – PK and CK, but these components is more emphasized for pre-service teacher because it has orientation in knowledge or hasn’t reached implementation. Because of that, biology teacher must have been able to integrate PK and CK in their teaching process. But in reality, not all teacher apply PCK in their teaching. This condition matches with the research of Ramadhani, et.al. [8] in which it some teachers can not apply PCK well in their biology teaching because they forget the important value aspect, the goal and the benefit of the teaching of a concept.

Evaluation of biology teacher during teaching, especially in applying PCK actually must be done routinely and periodically for sake of education quality improvement. Sudjana [9] stated that the target of evaluation is to educate the teachers in order they can be professional teachers. Through evaluation, the teachers can get recommendations and ways that can be taken to improve their teaching capability. Evaluation is so important to be conducted in order to contribute in the improvement of teacher’s competence and professionalism.

Evaluations of ability to apply PCK have been conducted many times, but mostly employing instruments like questionnaire and test for data discovery, but they have not observed biology teacher’s performance in teaching. This happened due to the lack of observation sheet instrument for measuring biology teacher’s PCK application ability. Yet, the observation sheet can represent the actual condition in the field so that it can produce more accurate and guaranteed data. Based on the previous explanation, a development of observation sheet instrument is needed to measure the ability of biology teacher in applying PCK during teaching process.

2. Materials and Methods
2.1. Materials

PCK (Pedagogical Content Knowledge) is a teachers’ ability in transferring their knowledge to their students so that their students know. This concept of PCK was developed for the first time by Shulman [3]. Shulman [3] discovered that PCK is an understanding about academic and pedagogic content specifically owned by teachers in order they can successfully transfer and make their students understand about knowledge concept inside the learning. Moreover, Imaduddin [10] explained that PCK is a special knowledge that is owned by teacher in mastering and teaching material about biology to the student in which it will lead toward an understanding.
PCK consists of the knowledge of pedagogy and knowledge of material, in other words, it is a knowledge about material and how to teach it. PCK consists of components that support teachers’ task of teaching. Dariyo [11] mentioned that PCK consists of two components that are connected *i.e.* Pedagogical Knowledge (PK) and Content Knowledge (CK). Chen [12] stated that PK is a method or teacher’s teaching process that includes knowledge about class management, learning planning and student’s learning. CK consists of some components that includes knowledge of concept, theory, idea, mindset, method, prove and proof [3]. Furthermore, Cochran [13] explained that PCK related with the way the teacher combines the material knowledge that is taught with the teaching method and the reason about combining the material knowledge as part of teaching process.

One of the factors that allows an improvement in teachers’ professionality is to strengthen their PCK [14]. Subanjii [15] explained that PCK is a systematic process that is designed by teacher to school the students so that they can: 1) construct new material knowledge through a connection with old knowledge, 2) understand the material more than just know, 3) can answer what, why, and how, 4) internalize the knowledge in which it forms behavior, and 5) turn the behavior to become self character.

2.2 Methods

2.2.1 Research Design

This research categorized as Design and Development Research (D & DR). Producing observation instrument that can be used to measure PCK application ability of biology teacher in the teaching process is the goal of this research. The development of PCK observation instrument using 6 development steps according to Peffers, *et al* [16] and Ellis & Levy [17]. Steps in developing PCK observation instrument are: (1) Identify the problem; 2) Describe the objectives; 3) Design and develop the product; 4) product testing; 5) Evaluate the results of testing; and 6) Communicate the testing results.

Product that will be developed is done by studying various theories that are relevant to form a PCK observation instrument framework. Permendiknas Number 16 of 2007 about Standard of Teacher’s Academic Qualification and Competence [18] and Permen Number 55 of 2017 about Education Standard for Teacher [19] become the base of the instrument framework. The forming of instrument framework is done by determining the aspects that will be measured. The aspects are (1) matching between material with Base Competency and allocated time; (2) matching between material and approach, model and teaching; (3) matching between material and teaching media; (4) matching between material and students’ character; (5) the quality of interaction between teacher and students in the teaching; and (6) correspondence of material and evaluation. The product that will be developed is an PCK measurement observation instrument of biology teacher with Guttman scale. PCK instrument validation is done to study the validity of the observation instrument.

The fulfillment of face validation toward PCK observation instrument that is developed is passed through experts judgements with the help of two expert lecturers. They give evaluation and suggestion upon the developed instrument. The field testing is done to acquire empirical data and instrument’s reliability. The instrument’s testing was conducted on July-August, 2018. The instrument that is developed was tested on 11 biology teachers from six SMA in DIY and Central Java. Those six SMA are SMA Negeri 1 Depok, SMA Negeri 1 Ngaglik, SMA Negeri 1 Minggir, SMA Negeri 2 Surakarta, SMA Negeri 5 Surakarta, dan SMA Negeri 6 Surakarta. The testing involved four post-graduate students as raters (observers).

2.2.2 Research Instrument

The fulfillment of face validity by experts judgement was done by making questionnaire instrument. Questionnaire was used by the experts to evaluate and give suggestions toward the developed instrument. The questionnaire consists of two evaluation aspects, *i.e.* construction and language aspects. The evaluation from the experts was measured with Likert scale 1-4. Evaluation and suggestion from experts become improvement and upgrade for the instrument.
2.2.3. Data Analysis

This research gathers two types of data, the quantitative and the qualitative. Quantitative data is acquired from expert’s evaluation and result of testing. While the qualitative data was taken from the expert’s suggestion toward the developed instrument. These two data is used as a guide to determine whether the developed PCK observation instrument is reasonable or not.

Data that is collected will be analyzed descriptively and inferentially. Descriptive analysis is used to know the logical validity of the developed instrument based on the evaluation and suggestion from experts. Evaluation result from experts for every observation item is divided into criteria based on its validity which follows Akbar [20].

Instrument validity criteria is determined from calculation result using the following formula:

\[ V = \frac{\text{Total validation score experts}}{\text{Total maximum score}} \times 100 \% \]

After that, the calculation result will be matched with the validity criteria as in the following table 1.

| Percentage       | Validity Criteria |
|------------------|-------------------|
| 85,01 % - 100,00 % | Quite Valid       |
| 70,01 % - 85,00 % | Valid             |
| 50,01 % - 70,00 % | Less Valid        |
| 01,00 % - 50,00 % | Not Valid         |

Inferential analysis is used to see empirical validity and reliability of the PCK observation instrument. Empirical validity data acquired by calculating Biserial Correlation using *Microsoft Excel* program, on the basis analysis model from Widiarso [21]. Biserial correlation to identify total item correlation of dichotomy data with scores 1 and 0. Observation item categorized valid if \( R \) count > \( R \) table (0.602). While the instrument’s reliability is determined by calculating the Intraclass Correlation Coefficient (ICC). ICC is used to determine the reliability between two or more observers (inter-rater reliability). ICC value is analyzed using SPSS program.

3. Result and Discussion

3.1. Result

3.1.1. Result of Logical Validity from Expert’s Judgement

Data about suggestions from experts related to the appropriateness of the instrument is in table 2 as follows.

| No | Suggestions | Expert I | Expert II |
|----|-------------|----------|-----------|
| 1. | In the 11th statement, separate it to become two different statement, based on creativity and innovation. | PCK observation component is still lack in components, *i.e.* the components of interaction with student and evaluation. |
| 2  | The way in writing the statement must be matched with the aim of the observation in the teaching process. | | |
Criteria of item validity from the PCK observation based on judgement from experts is served in table 3 as follows.

| Item | Score | (%) | Information | Item | Score | (%) | Information |
|------|-------|-----|-------------|------|-------|-----|-------------|
| 1    | 40    | 100 | Quite Valid | 1    | 40    | 100 | Quite Valid |
| 2    | 40    | 100 | Quite Valid | 2    | 40    | 100 | Quite Valid |
| 3    | 40    | 100 | Quite Valid | 3    | 40    | 100 | Quite Valid |
| 4    | 30    | 75  | Valid       | 4    | 40    | 100 | Quite Valid |
| 5    | 40    | 100 | Quite Valid | 5    | 40    | 100 | Quite Valid |
| 6    | 40    | 100 | Quite Valid | 6    | 40    | 100 | Quite Valid |
| 7    | 40    | 100 | Quite Valid | 7    | 40    | 100 | Quite Valid |
| 8    | 40    | 100 | Quite Valid | 8    | 30    | 75  | Valid       |
| 9    | 40    | 100 | Quite Valid | 9    | 40    | 100 | Quite Valid |
| 10   | 40    | 100 | Quite Valid | 10   | 40    | 100 | Quite Valid |
| 11   | 30    | 75  | Valid       | 11   | 40    | 100 | Quite Valid |
| 12   | 30    | 75  | Valid       | 12   | 40    | 100 | Quite Valid |
| 13   | 40    | 100 | Quite Valid | 13   | 40    | 100 | Quite Valid |
| 14   | 40    | 100 | Quite Valid | 14   | 40    | 100 | Quite Valid |
| 15   | 40    | 100 | Quite Valid | 15   | 40    | 100 | Quite Valid |
| 16   | 40    | 100 | Quite Valid | 16   | 40    | 100 | Quite Valid |
| 17   | 40    | 100 | Quite Valid | 17   | 40    | 100 | Quite Valid |
| 18   | 40    | 100 | Quite Valid | 18   | 40    | 100 | Quite Valid |
| 19   | 40    | 100 | Quite Valid | 19   | 30    | 75  | Valid       |
| 20   | 40    | 100 | Quite Valid | 20   | 40    | 100 | Quite Valid |
| 21   | 40    | 100 | Quite Valid | 21   | 40    | 100 | Quite Valid |
| 22   | 40    | 100 | Quite Valid | 22   | 30    | 75  | Valid       |
| 23   | 40    | 100 | Quite Valid | 23   | 40    | 100 | Quite Valid |
| 24   | 40    | 100 | Quite Valid | 24   | 40    | 100 | Quite Valid |
| 25   | 40    | 100 | Quite Valid | 25   | 40    | 100 | Quite Valid |
| 26   | 40    | 100 | Quite Valid | 26   | 40    | 100 | Quite Valid |
| 27   | 40    | 100 | Quite Valid | 27   | 40    | 100 | Quite Valid |
| 28   | 40    | 100 | Quite Valid | 28   | 40    | 100 | Quite Valid |

Empirical validity data is served in the following table 4.
Table 4. Empirical Validity as Result of Biserial Correlation Calculation

| Number of Observation Item | Biserial Correlation Value | Information | Validity Criteria |
|----------------------------|----------------------------|-------------|------------------|
| 1                          | #DIV/0!                    | < R table (0.602) | Not Valid        |
| 2                          | 0.49                       | < R table (0.602) | Not Valid        |
| 3                          | 0.49                       | < R table (0.602) | Not Valid        |
| 4                          | 0.57                       | < R table (0.602) | Not Valid        |
| 5                          | 0.73                       | > R table (0.602) | Valid            |
| 6                          | 0.73                       | > R table (0.602) | Valid            |
| 7                          | 0.67                       | > R table (0.602) | Valid            |
| 8                          | #DIV/0!                    | < R table (0.602) | Not Valid        |
| 9                          | 0.89                       | > R table (0.602) | Valid            |
| 10                         | 0.84                       | > R table (0.602) | Valid            |
| 11                         | 0.66                       | > R table (0.602) | Valid            |
| 12                         | 0.84                       | > R table (0.602) | Valid            |
| 13                         | 0.57                       | > R table (0.602) | Not Valid        |
| 14                         | 0.84                       | > R table (0.602) | Valid            |
| 15                         | 0.49                       | < R table (0.602) | Not Valid        |
| 16                         | -0.02                      | < R table (0.602) | Not Valid        |
| 17                         | 0.94                       | > R table (0.602) | Valid            |
| 18                         | 0.94                       | > R table (0.602) | Valid            |
| 19                         | 0.78                       | > R table (0.602) | Valid            |
| 20                         | 0.73                       | > R table (0.602) | Valid            |
| 21                         | 0.79                       | > R table (0.602) | Valid            |
| 22                         | 0.79                       | > R table (0.602) | Valid            |
| 23                         | 0.40                       | < R table (0.602) | Not Valid        |
| 24                         | 0.94                       | > R table (0.602) | Valid            |
| 25                         | -0.02                      | < R table (0.602) | Not Valid        |
| 26                         | 0.89                       | > R table (0.602) | Valid            |
| 27                         | 0.94                       | > R table (0.602) | Valid            |
| 28                         | 0.79                       | > R table (0.602) | Valid            |

3.1.2. Reliability Result
PCK observation instrument reliability data is served in table 5 as follows.

Table 5. Instrument Reliability Based in ICC Value

| Intraclass Correlation | 95% Confidence Interval | F Test with True Value 0 |
|------------------------|-------------------------|-------------------------|
|                        | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures        | .951b        | .883        | .985  | 78.378 | 10 | 30 | .000 |
| Average Measures       | .987c        | .968        | .996  | 78.378 | 10 | 30 | .000 |

3.2. Discussion
Early product of this development research is in the form of PCK application observation sheet that contains 20 observation items using Guttman Scale with two options (Yes-No). After finishing the early product, the next step is instrument validation. The PCK instrument validation was done to check the instrument’s validity in the form of observation items. Sugiyono [22] stated that a valid instrument means that the instrument that is used can measure what must be measured. Face validity result with experts judgement help resulting in some suggestions to improve the developed instrument. The
improvement is done based on the suggestions in order to archive better result. There were statement items addition after the improvement, from 20 to become 28 items. After adding some items, it would be evaluated by the experts. Evaluation from them gave information about observation items that were valid and were not. The result of the evaluation showed that 28 items categorized as valid and quite valid. All items are retained and won’t be discarded because there is no item that is not valid. This result suggest that the instrument was ready for testing.

PCK observation sheet instrument was tested on 11 biology teachers to see its empirical validity and reliability. Empirical validity result shows that 18 items of PCK observation items categorized as valid with $R$ count $> 0.602$. While 10 items categorized as not valid with $R$ count $< 0.602$, i.e. items 1, 2, 3, 4, 8, 13, 15, 16, 23, and 25. Items that were not valid after that were discarded. Instrument’s reliability was calculated by inter-rater reliability consistence test. Inter-rater reliability is used to determine consistency of measurement between observers.

Reliability is a coefficient that shows rate of persistence or consistency in measuring result. Measurement which has high reliability is called as reliable measurement. In the reliability test using Intraclass Correlation Coefficient (ICC) the result was 0.951. The ICC value shows that the result nearing 1 which means the instrument has very high stability based on the agreement between raters (reliable). Azwar [23] stated that reliability is showed by reliability coefficient in which the value is in the range between 0 to 1.00. The more it nears 1.00, the higher the reliability. On the other hand, coefficient which goes down toward 0 means that the it is less reliable. Result of reliability value shows that observation instrument sheet is reliable to be used to measure the ability of biology teacher in applying PCK. Triyono [24] stated that reliable instrument means that the instrument can be used to measure same object for some times and measurement results are consistent.

4. Conclusion
Based on the aim and explanation of the research result, it can be concluded that observation instrument sheet that is developed to measure the ability of PCK application by biology teacher is valid and reliable. This is proved by the empirical validity result by using biserial correlation, in which 18 items of statement categorized as valid with $R$ count $> 0.602$. While 10 items categorized as not valid with $R$ count $< 0.602$. PCK observation instrument reliability shows ICC value 0.951 which means the instrument has very high stability based on agreement between raters (reliable).

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