Developing an Observation Instrument to Measure Technological Pedagogical Knowledge (TPK) of Biology Teacher in Learning Process

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Abstract. Technological Pedagogical Knowledge (TPK) was a knowledge that must be mastered by the teacher for measuring a suitable technology for supporting the strategic application of teaching. TPK was important to be studied because it was the most influencing aspect for teacher’s TPACK. Basically, there was no observation instrument that discovers the TPK of biology teacher. The aim of this research was to develop an observation instrument for measuring TPK of biology teacher in learning process. The method used is design and development research (DDR) by Richey and Klein model. The instrument framework was developed based on educational standard for teacher in Indonesia, and then it was used to develop the items. Instrument will be tested for face validity by evaluation and education experts. Instruments that pass the face validity check were tried out on 11 teachers from six schools in DIY and Central Java region. The result showed that 11 items pass the empirical validity based on point biserial correlation and interater reliability was 0.968 based on intraclass correlation coefficient (ICC) – that means all items in the category were reliable. Thus, the observation instrument is qualified to measure the TPK of biology teacher in learning process.

1. Introduction

The 21st century is the era of fast development of technology. Technology has great effect in every aspect of life so that people must have technology awareness. Students in a school are part of people which means they must also have technology awareness. Technology awareness also means that the students actively use technological product in learning process. The school as a place of teaching-learning process needs to give idea about technology for the students [1]. Because of that, learning in 21st century must be integrated with the technology.

Technology implementation inside learning process must be done by teacher because based on Permendikbud No. 55 year 2017 about education standard for teacher in Indonesia, teacher must be able to apply IT in planning, conduct, evaluation and teaching maintenance, able to apply knowledge and skill of IT in the context of scientific development and implementation of skill field, master the integration of technology, pedagogy and scientific content [2]. This indicates that teacher doesn’t just need to master knowledge about pedagogy, content and technology. Instead, they must be able to apply that inside the learning process.
For integrating technology in a teaching, the teachers need to master the knowledge about pedagogy, technology, and content. The integration of knowledge about pedagogy, content and technology for realizing a teaching that implements IT is known as Technological Pedagogical and Content Knowledge (TPACK) [3]. The framework of TPACK consists of seven aspects, i.e. PK, TK, CK, PCK, TPK, TCK, and TPACK. Research related to the influence of those aspects toward TPACK has been studied. Research result suggests that although all aspects of technology knowledge (TK, TCK and TPK) are needed for the success technology integrated teaching, but TPK has the greatest influence in teacher’s TPACK [4, 5, 6, 7]. With the finding of TPK as the strongest aspect which influences TPACK, teacher’s mastery in TPK can be maximized before developing TPACK completely. Beside that, TPK is an important factor to help teacher and school to face the challenge in preparation of student by increasing important skill in 21st century [8]. Because of that, TPK becomes an aspect that must be regarded to develop teacher’s high TPACK.

TPK is an integration of basic knowledge between TK and PK. In the integration of technology and pedagogy, teacher not only must know the benefits of technology that can be used in teaching but also be able choose suitable technology to support teaching strategy be it is model, method, or teaching media in class [9]. The teacher must be able to decide why, when, where, and how IT can support the goal of the learning and also how to choose types of IT that fit for the purpose of student’s learning. So, the teacher needs knowledge about technology and pedagogy (TPK) to know and maximize the potential of technologies that support the application of pedagogy and teaching strategy.

Based on the research result, most of the TPK measuring uses attitude scale in the form of questionnaire. The instrument that specifically for measuring biology teacher’s application of TPK in learning process has not available. Several types of instruments can be used to measure the TPK of teacher in learning process, including classroom observation, teacher self-evaluation, teacher portfolio, teacher testing, and student result [10]. Instrument that is considered more appropriate to describe the events that occur in the learning process is classroom observation. Classroom observation can be used to explore the processes of teaching and learning in actions [11]. But, observation instrument to measure TPK of biology teacher in learning process is still not available. In accordance with the problem, it is a must to do a research of instrument development to create an observation instrument for biology teacher’s TPK. After that, the instrument can be used to measure TPK of biology teacher in learning process.

2. Method
2.1. Research Design
The type of this research is Design and Development Research (DDR). Development of this instrument based on Richey and Klein model. Research instrument that is developed consists of framework, observation sheet, and evaluation guide.

The evaluation was started on February to August, 2018. Early development of the observation instrument such as framework, observation sheet, and evaluation guide was done on February to April, 2018. Face validity check by evaluation and education experts was done on May 2018. The test was held on July to August, 2018 in six high schools in the DIY and Central Java Region.

The subjects of the research were 11 biology teachers from six high schools in DIY and Central Java. The choice of research subjects was based on the location of the school.

2.2. Research Development
The instrument that is developed is observation instrument for measuring TPK for biology teacher. The development of the instrument based on Richey and Klein model [12]. The following are the development steps of observation instrument of biology teacher’s TPK.

2.2.1. Analysis. Information gathering and research are an analysis of need of TPK observation instrument that will be developed and a study of research reference related to the development of TPK instrument. The development of instrument is started with gathering information related to the concept
of TPK. This early information is used for determining early planning of TPK instrument product. Beside that, there is a study about the availability of instrument for measuring teacher’s TPK.

2.2.2. Design. The design step is in the form of determining aspects of TPK that will be developed in the instrument. The concept of TPK aspects are based on permendikbud No. 55 year 2017 about Teacher’s Education Standard. These aspects will be used to arrange the framework of observation instrument of biology teacher’s TPK.

2.2.3. Development. The next step is the development of instrument in the form of observation sheet of TPK and scoring guide based on the framework that has been developed in the previous step.

2.2.4. Evaluation. Instrument that has been made will be checked it’s internal and external validation. Internal validation will be checked by evaluation and education experts. Based on the suggestions from the experts, a revision will be done to make a proper instrument for real test in the field. Field testing is used to acquire the proof of external validation. The external validation will be check its empirical validity and interrater reliability of the instrument. In the final step, a final product finishing will be done in which instrument item that is not valid will be discarded.

2.3. Data Analysis

Data analysis of this research consists of face validity, empirical validity, and interrater reliability of the instrument testing result. The following is the data analysis technique which is employed in this research.

2.3.1. Analysis of face validity. Face validity can be calculated by using this formula.

\[
\text{Validity}(V) = \frac{\text{total validation score from experts}}{\text{total maximum score}} \times 100\%
\]

Result of calculation that has been acquired will be matched with the following validity criteria [13]:

| No  | Score                | Validity Criteria       |
|-----|----------------------|-------------------------|
| 1.  | 85.01 – 100.00 %     | Quite Valid             |
| 2.  | 70.01 – 85.00 %      | Valid                   |
| 3.  | 50.01 – 70.00 %      | Less Valid              |
| 4.  | 01.00 – 50.00 %      | Not Valid               |

2.3.2. Analysis of empirical validity. Empirical validity is acquired from analysis of observation instrument testing result by using biserial correlation point because the type of instrument’s answer is categorized as true or false. The correlation result that is acquired will be compared to r value table. Coefficient of biserial correlation point calculated using this formula [14].

\[
r_{pbis} = \left[ \frac{(M_i - M_x)}{S_x} \right] \sqrt{p/(1-p)}
\]

Explanation:

- \( M_i \) = Mean of instrument’s score (x) from all subject that gets 1 point in related item
- \( M_x \) = Mean of instrument’s score from all subjects
- \( S_x \) = Standard deviation of instrument’s score
- \( P \) = Proportion of subject that gets 1 point in related item
2.3.3. Analysis of interrater reliability. The reliability of observation instrument is using the interrater reliability in the form of Intraclass Correlation Coefficient (ICC) because 4 raters are used in the testing of this instrument. The calculation result that has been acquired will be matched with reliability criteria as follows [15].

| No | Score     | Reliability Criteria |
|----|-----------|----------------------|
| 1  | > 0.90    | Excellent            |
| 2  | 0.75 – 0.90 | Good               |
| 3  | 0.50 – 0.75 | Moderate           |
| 4  | < 0.50    | Poor                 |

3. Result and Discussion

The product that is developed in this research is an observation instrument of biology teacher’s Technological Pedagogical Knowledge (TPK) from senior high school. This instrument hopefully can be used to discover the TPK of biology teacher in learning process that hasn’t known because the unavailability of suitable instrument.

3.1. Result of TPK Observation Instrument Development

The early development of TPK observation instrument started from early information gathering about important aspects of teacher’s TPK. This early information is used to formulate the framework, item of statement in observation sheet, and teacher’s TPK evaluation guide. Moreover, a study of research about availability of instrument for measuring teacher’s TPK is conducted. Based on the research result, most of the TPK measuring uses attitude scale in the form of questionnaire. The usage of observation instrument that specifically for measuring biology teacher’s TPK in teaching has not available.

TPK observation instrument consists of the framework, observation sheet, and evaluation guide. This instrument will be checked for the face validity by two evaluation and education experts. The suggestions from them are: 1) fixing the sentences in the question item that is not clear and fixing ambiguous or can make different interpretation between raters, 2) the statement that has been made must be suited with the aim of the observation in the learning process, and 3) there must be addition for question items related to data analysis, making concrete of abstract concept, concluding and so on. The sample item of TPK instrument is as follows.

| No | Statement                                                                 |
|----|---------------------------------------------------------------------------|
| 1  | Teacher can apply ICT for support the application of teaching model in learning process |
| 2  | Teacher can apply ICT for support the application of teaching method in learning process |
| 3  | Teacher can apply ICT for support the application of teaching approach in learning process |
| 4  | Teacher can operate ICT based media in learning process                   |
| 5  | Teacher can choose the suitable ICT based on student characteristic        |
| 6  | Teacher can use ICT for lesson evaluation                                 |
| 7  | Teacher can explain how to use ICT for learning to student                |
| 8  | Teacher can make teaching media use ICT                                   |
Instrument that has been revised will be evaluated by experts to get face validity proof. Face validity is a validity proof that is based on evaluation of instrument’s appearance format and the matching of item context with the goal of instrument measuring. If the item in the instrument context matches with goal of the measuring; by viewing from appearance side it makes sure and gives impression that it can discover something that will be measured, it can be said that face validity of the instrument has met the requirements [14]. This validity is needed because before doing the estimation toward reliability and validity of the instrument, item analysis procedure is done previously by testing the characteristic of each item that will become part of the related instrument [14]. Based on the instrument evaluation by experts, analysis result of face validity is as follows.

Table 4. Face Validity Analysis Result

| Number of statement | Aspect of construct (%) | Criteria | Aspect of language (%) | Criteria |
|---------------------|-------------------------|----------|------------------------|----------|
|                     | Validator I  | Validator II |     | Validator I  | Validator II |     |
| 1                   | 75          | 75         | valid                  | 75       | 75         | valid |
| 2                   | 75          | 75         | valid                  | 75       | 75         | valid |
| 3                   | 75          | 75         | valid                  | 75       | 75         | valid |
| 4                   | 75          | 100        | quite valid            | 75       | 100        | quite valid |
| 5                   | 100         | 100        | quite valid            | 100      | 100        | quite valid |
| 6                   | 100         | 100        | quite valid            | 100      | 100        | quite valid |
| 7                   | 100         | 100        | quite valid            | 100      | 100        | quite valid |
| 8                   | 100         | 100        | quite valid            | 100      | 100        | quite valid |
| 9                   | 100         | 100        | quite valid            | 100      | 100        | quite valid |
| 10                  | 100         | 100        | quite valid            | 100      | 100        | quite valid |
| 11                  | 100         | 100        | quite valid            | 100      | 100        | quite valid |
| 12                  | 100         | 100        | quite valid            | 100      | 100        | quite valid |
| 13                  | 100         | 100        | quite valid            | 100      | 100        | quite valid |

Based on Table 4, calculation result of the TPK observation instrument face validity is > 75% for the validity score in which all statements in the TPK observation instrument categorized as valid and quite valid. This validation result indicates that the instrument met the requirement of face validity proof and reasonable to be tested specifically for biology teachers in DIY and Central Java.

3.2. Result of TPK Observation Instrument Testing

The data of testing result is used for calculating the empirical validity and inter-rater reliability of the TPK observation instrument. Empirical validity is analyzed with biserial correlation point while the inter-rater with Intraclass Correlation Coefficient (ICC).

3.2.1. Empirical validity. The set of empirical validity of every statement item is done on the base of biserial correlation point ($r_{pbis}$). Total item correlation coefficient that is calculated with biserial point formula shows that the parallel of item function and instrument function in catching individual difference. Statement item of TPK observation sheet will be considered valid if the value of $r_{count}$ > $r_{table}$ with false degree 5%. Testing result analysis of 11 biology teachers with $r_{table}$ 0.602 shows the empirical validity as follows.
Table 5. Empirical Validity Analysis Result

| Number of Statement | $R_{pbis}$ | R Table | Criteria |
|---------------------|------------|---------|----------|
| 1                   | 0.81       | 0.602   | valid    |
| 2                   | 0.95       | 0.602   | valid    |
| 3                   | 0.95       | 0.602   | valid    |
| 4                   | 0.90       | 0.602   | valid    |
| 5                   | 0.66       | 0.602   | valid    |
| 6                   | 0.85       | 0.602   | valid    |
| 7                   | 0.77       | 0.602   | valid    |
| 8                   | 0.85       | 0.602   | valid    |
| 9                   | 0.81       | 0.602   | valid    |
| 10                  | 0.53       | 0.602   | not valid|
| 11                  | 0.81       | 0.602   | valid    |
| 12                  | 0.95       | 0.602   | valid    |
| 13                  | 0          | 0.602   | not valid|

Based on Table 5, from 13 items of statement, 11 of them are valid while the rest are not. Statement items that are not valid have coefficient of biserial correlation point ($r_{pbis}$) < 0.602 i.e. number 10 and 13. Statement items that are not valid will be discarded so that the final product of TPK observation instrument consists of 11 items of valid statements. Thus, biology teacher’s TPK observation instrument that is developed is valid to measure the TPK of biology teacher in class.

3.2.2. Interrater reliability. The data of testing result is also used to calculate interrater reliability of observation instrument. If in the research there is only single observer, the researcher doesn’t need to decide the observation reliability. But a research with single observer can possibly make a subjective result – result as the researcher desires. Commonly, to minimize the subjectivity in the scoring, evaluation procedure through rating is done by more than two raters [14]. When a research involves many observers, difference in argumentation, perception, and result interpretation is possible. Because of these differences, interrater reliability is needed [16]. In the testing of the research, four raters are involved so the reliability that is used is ICC. Reliability test between raters uses ICC is employed if the raters are more than two persons [17]. Result analysis of reliability as follows.

Table 6. Reliability Criteria

| Intraclass Correlation Coefficient (ICC) | Reliability Criteria |
|-----------------------------------------|----------------------|
| 0.968                                   | Excellent            |

Based on Table 6, result of ICC analysis shows that interrater reliability is 0.968. Reliability of TPK observation instrument categorized as high which emphasizes that measuring result with this instrument is reliable. Reliability coefficient which is 0.90 for its lowest bound shows that the instrument can be used for making a decision about an individual [18]. Based on the result, the TPK observation instrument can be guaranteed for its reliability so that it can be used to measure biology teacher’s TPK in learning process.
4. Conclusion
Based on the result of the research about the development of biology teacher’s TPK observation instrument, it can be concluded that: 1) the instrument consists of 11 statement items, 2) the instrument has met the requirement of face validity through experts’ evaluation, 3) the instrument has also passed the empirical validity check based on the test result by discarding two statement items that are not valid, 4) the reliability of instrument’s interrater has accomplished a high reliability. Thus, the TPK observation instrument is appropriate and can be used to measure biology teacher’s TPK in learning process.

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