Media application in anchored instruction to support mathematics teachers' pedagogical content knowledge

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Abstract. A recent development in science and technology encourages teachers to apply technological information to deal with their duties and obligations of their professional development. The teachers are expected to apply the demands and responsibilities in their learning process. Learning by using interactive media is a solution to answer the recent challenges. This research aims to develop interactive media based on Anchored Instruction to support teacher learning. This study employed a 4-D research design consisting of 4 stages, namely: Define, Design, Develop, and Disseminate. Ten mathematics teachers selected with purposive sampling technique were involved in this study. Data collection comprises questionnaires and observation form. Data was analysed by using research and development procedures and triangulation techniques of data sourced from teacher contents on CoRe sheets, percentage data from student questionnaires, and percentage data from the school principal's supervision sheet. This development research produced valid learning tools related to Anchored Instruction as valid media to be used in public high schools in Central Aceh. This study also found that Anchored Instruction learning model could help mathematics teachers in improving PCK's in Geometry subject.

1. Introduction
A recent development in science and technology encourages government around the world to improve human resources competitive skills and to build practitioners' creativities. This development has a significant impact on the education sector. Education is an effort to help the natural ability of children so that they are able to grow and develop as human beings or as members of society who can achieve safety and happiness in their lives [1]. The impact of this development encourages teachers to utilize technological information in fulfilling their duties and obligations of their professional development. The Republic of Indonesia Law Number 14 Year 2005 states that professional teachers have the main tasks, namely educating, teaching, guiding, directing, training, and evaluating students in early childhood education, elementary education, and secondary education [2].

Using interactive media is one of the solutions to answer recent challenges in teaching and learning. Interactive media is multimedia that is equipped with a controller that can be operated by the user so that the user can select what is desired for the next process [3]. The use of interactive media makes learning resources more diverse. Previous learning which tended to only use media aids and teaching books can be expanded to the use of interactive media. The use of interactive learning multimedia is a systematic use of media as a learning resource [4]. Using media in the learning process is expected to motivate students and connect the education sector with current development in science
and technology. Moreover, multimedia learning is an integral part of students’ information system [5].

Using media in learning also has greatly supported the teaching and learning process so that the transfer of knowledge between teachers and students becomes faster and more effective [6]. The use of media in learning will help students to understand the subject taught contextually [7]. Students will experience problems directly from the subject discussed so that their understanding will be better. The use of media could clarify a problem because of animation and video capabilities [8].

The use of media in learning must be tailored to the needs of students and the subject being taught. In mathematics learning, for example, the ability of teachers in selecting the right media is an important principle for achieving the expected competencies. Another teacher's ability is to be able to synchronize media usage with the learning model used. The selection of the right learning model can accommodate the maximum use of instructional media [9].

The recommended learning model considered to be the choice of the teacher to use learning media is Anchored Instruction. Learning with Anchored Instruction requires students to be able to filter data, make mathematical models, and provide solutions to problems that have been given with the help of media [10]. Anchored Instructional Learning Environments enable students to improve their problem-solving skills and students' ownership of new knowledge [11].

The use of appropriate learning models and media must consider the teacher's ability to understand the content of the material. The teacher’s ability will build an active, creative and fun teaching and learning process. The ability of teachers in integrating media and learning models towards content knowledge at various levels of students' abilities is known as Pedagogical Content Knowledge (PCK) [12]. PCK also includes an understanding of what is contained in certain learning topics that are easy or difficult: conceptions and preconceptions brought by students of various ages and backgrounds to learn the topics and lessons most often taught [13]. PCK is a combination of teacher professional knowledge and teacher expertise. PCK is an academic idea that presents ideas that are based on the belief that teaching requires more than providing knowledge of the subject contents to students and learning is not merely absorbing information but focusing on its application [14]. Therefore, the quality of good learning can be determined by the quality of the teacher's PCK. This research aims to consider the interactive media used to develop and produce the learning instrument based on Anchored Instruction.

2. Method

This study used Research & Development (R&D). The 4-D design utilized to develop and validate educational product such as a lesson plan based on Anchored Instruction and interactive media [15].

Research participants were ten teachers who were selected through purposive sampling technique. The research design was chosen by considering the funding and the timing that was needed in presenting data [16]. The data was collected by using several techniques as follows.

- Questionnaire (CoRe form), which was filled by the ten teachers. The CoRe instrument which made scoring in eight components of assessment adapted from [14]. Scoring is carried out at intervals 1-4 for each item. By sum all items, it is obtained a minimum score is 8 and a maximum score is 32.

| Score | Criteria       |
|-------|----------------|
| 25-32 | Maturing PCK  |
| 16-24 | Growing PCK   |
| 8-15  | Pre PCK       |

- Observation form (principles’ supervising form to evaluate teachers’ performances). Supervision of the principal assesses the learning process carried out in accordance with the lesson plan and observes the achievement of indicators. The results of this supervision become a reference for the
ability of the teacher to manage the learning and pose the right material to achieve indicators. Good supervision results show good PCK of teachers.

The next step was data triangulation among data collected from CoRe form and percentage of principles’ supervising form. Triangulation is a combination of some techniques conducted to test data credibility of various sources. Triangulation does not intend to find the truth of a phenomenon, but to improve researchers’ understanding of what is found [17,18].

3. Result and discussion
The product of Research and Development (R&D) are Lesson plan and Cabri interactive media of Geometry. The following is the result of the research.

3.1. Define
The first step of the Define stage is Front-end Analysis, aiming to determine the principle problems faced in schools. This process was carried out by observing the sample school. The results of the observation indicated that the learning process tends to be monotonous by using the teacher-centred style of teaching. Based on these findings, there was a need to do a change in the teaching and learning process so that boring learning can be avoided.

The second step is Learner Analysis purposing to observe the development of students during learning. The results of the observations showed that students were able to learn well but only carry out routine activities, such as working on assignments/worksheets. Routine activities executed by students make some students just did their responsibilities and could not develop self-interest and motivation to understand other material outside the assignment given by the teacher. These findings showed that new activities were needed to engage student interest, such as the use of different learning media.

The third step is Task Analysis aiming to determine the learning content by detailing the contents of the teaching material according to the competencies of learning. The competency referred in this study was students who could determine position, calculate distance, and find angles involving points, lines, cubes and cuboids. The details of this competency were finally used as a base to develop a lesson plan by using interactive media.

The fourth step is Concept Analysis aiming to determine the problems of existing teaching materials in order to achieve learning competency. The problem found was that the design of instruments and media were difficult to develop the competencies. The results of the analysis were used to design teaching materials according to the media used.

The fifth step, Specifying Instructional Objectives, purposes to determine good media used to conduct the learning process in order to achieve the learning indicator.

3.2. Design
At this stage, the researchers designed learning materials that will be developed. The first step is Media Selection which aims to limit the development of a lesson plan that only uses interactive media. This study solely focused on the developments of a lesson plan using media Cabri Geometry and Microsoft PowerPoint. This media was chosen because the teachers had familiar with using Microsoft PowerPoint in their presentation activities. Development was carried out by introduces animation so that learning was more varied and imaginative. The use of Cabri Geometry was intended to introduce other geometric applications so that the choice of media usage during learning varies.

The second step is Format Selection which aims to determine the forms of activities in designing a lesson plan by using interactive media. This step helps to design the learning materials to be more efficient in utilizing time and determines targets to be achieved.

The third step is Initial Design aiming to design the prototype of a lesson plan based on interactive media. The prototype design was compiled, tested, and validated by colleagues. The pilot test was conducted in one meeting to gain students' responses and understanding of the lesson plan. Based on the results of the pilot test, it was found that students enthusiastically followed the learning and the
application of the lesson plan was very dynamic. Moreover, there was a need for improvements in time management when students solve problems posed by the teacher. The validation results showed that the lesson plan that was designed could be properly used with minor revision in terms of spending time for media use.

3.3. Develop
The Develop stage aims to modify and develop the design of the lesson plan that has been compiled and tested. The design was validated and tested for the second time. The Develop stage was carried out repeatedly three times. After obtaining the third modification of the designed lesson plan, the instrument would not undergo further changes, and it was suitable for use in Anchored Instruction with the use of interactive media.

3.4. Disseminate
The purpose of the Disseminate stage is to disseminate the designed lesson plan employing interactive media to 10 mathematics teachers. The dissemination was carried out to assess the use of lesson plan that had been developed so that teachers could use it as alternative in their teaching practice so that the teachers could improve their PCK.

The questionnaire was distributed to the ten teachers that use AI and interactive media in Geometric learning. The quantitative analysis of the questionnaires showed that seven mathematics teachers were in the Growing PCK level, two teachers were at the Pre PCK level, and one teacher was at Maturing PCK level.

The result of the CoRe instrument disseminating to the ten mathematics teachers using Anchored Instruction with interactive media of Geometry is presented in table 2.

| No | Objectives | Concept | Pedagogy | Evaluation | Total CoRe Score |
|----|------------|---------|----------|------------|------------------|
| G1 | 4          | 7       | 6        | 3          | 20               |
| G2 | 5          | 6       | 7        | 3          | 21               |
| G3 | 6          | 9       | 7        | 3          | 25               |
| G4 | 4          | 5       | 3        | 3          | 15               |
| G5 | 5          | 8       | 7        | 2          | 22               |
| G6 | 6          | 8       | 5        | 3          | 22               |
| G7 | 6          | 8       | 6        | 3          | 23               |
| G8 | 6          | 8       | 3        | 2          | 19               |
| G9 | 4          | 6       | 3        | 2          | 15               |
| G10| 5          | 7       | 5        | 3          | 20               |
| Mean| 5.1       | 7.2     | 5.2      | 2.7        | 20.2             |

The dissemination results of the CoRe instrument used by the same teachers in other mathematics learning conducted without using media is presented in table 3.

| No | Objectives | Concept | Pedagogy | Evaluation | Total CoRe Score |
|----|------------|---------|----------|------------|------------------|
| a  | b          | c       | d        | e          | f                |
| G1 | 4          | 7       | 6        | 2          | 19               |
| G2 | 3          | 6       | 5        | 3          | 17               |
The form of CoRe instruments filled in after two lessons showed that learning using media could improve mathematics teachers' PCK in each aspect. The difference in the CoRe score of mathematics teachers is in table 4.

### Table 4. The mean difference of CoRe score between learning with AI and other learning

| Aspect                  | AI | Objectives | Concept | Pedagogy | Evaluation |
|-------------------------|----|------------|---------|----------|------------|
|                         |    |            | 0.7     | 0.8      | 0.3        |
| Other                   | Other | 0.7 | 1 | 0.8 | 0.3 |

Table 4 shows that there was a high increase of CoRe score in the aspect of concept, pedagogy, objective and evaluation with mean differences of 1.0, 0.8, 0.7 and 0.3 respectively. The result showed that instruction with using media would increase the CoRe score of mathematics teachers' PCK.

In order to triangulate the comparative data of mathematics teachers’ CoRe scores in Anchored Instruction with the use of media, school principals supervised the teachers during learning. The results of the principal supervision are displayed in table 5.

### Table 5. Principal’s supervision

| No | Sample | Principal’s Supervision | CoRe |
|----|--------|-------------------------|------|
| 1  | G1     | 85                      | 86   |
| 2  | G2     | 98                      | 83   | 21   | 17   |
| 3  | G3     | 100                     | 88   | 25   | 21   |
| 4  | G4     | 87                      | 88   | 15   | 14   |
| 5  | G5     | 100                     | 92   | 22   | 20   |
| 6  | G6     | 95                      | 93   | 22   | 19   |
| 7  | G7     | 98                      | 90   | 23   | 18   |
| 8  | G8     | 86                      | 82   | 19   | 17   |
| 9  | G9     | 85                      | 80   | 15   | 13   |
| 10 | G10    | 95                      | 92   | 20   | 16   |

The supervision results showed that the principal tends to appreciate the use of media in Anchored Instruction compared to other instruction. The following is t-test performed to determine the mean differences of CoRe score in both instructions.
Table 6. Independent sample test

|                  | t-test for Equality of Means |
|------------------|-----------------------------|
|                  | T   | df  | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |
| Joined           |     |     |                |                |                     |                                           |
| Equal variances assumed | 2.155 | 18   | 0.045          | 2.800           | 1.300               | 0.070 to 5.530                            |
| Equal variances not assumed | 2.155 | 17.084 | 0.046          | 2.800           | 1.300               | 0.059 to 5.541                            |

According to the t-test, there was a significant difference $t(18) = 2.16$, $p < 0.05$. It showed that there was a significant difference of CoRe score gained by mathematics teachers using Anchored Instruction. It summarises that PCK of teachers using Anchored Instruction was better than using other instruction. The contribution of Anchored Instruction towards mathematics teachers’ PCK is shown in table 7.

Table 7. Coefficient of determination

| Model | R       | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|---------|----------|-------------------|----------------------------|
| 1     | 0.909$^a$ | 0.826    | .804              | 1.127                      |

$^a$Predictors: (Constant), AI

Table 7 showed that $R^2$ is 0.826. The score of coefficient determination range $0 \leq R^2 \leq 1$. It means that if $R^2$ close to 1, then there is a significant influence between variables. In order to know how the variables influence each other, the Adjusted R Squared was calculated as $0.826 \times 100% = 82.6\%$. The calculation showed that the influence of the using media in Anchored Instruction in Geometry learning is 82.6%.

Another factor which enhances mathematics teachers’ PCK is teachers’ ability in applying different learning models that are uncommonly used in their teaching. One of the obstacles faced by teachers during teaching and learning is a limitation of the media used. A study conducted by Purwaningsih [19] found that learning experiences and method used by teachers were less varied. Those problems become profiles of teachers’ PCK [19]. Another factor influencing mathematics teachers’ PCK could be their teaching experiences. Teachers who have longer teaching experience have better PCK. Teachers’ experience is one of the factors influencing teachers’ PCK [20].

4. Conclusion and recommendation

Based on the results of data collection and analysis in this study, it can be concluded that this development research produced valid learning tools related to Anchored Instruction as valid media to be used in public high schools in Central Aceh. This study also found that Anchored Instruction learning model could help mathematics teachers to improve their PCK in Geometry subject.

It is suggested that the educational policy regarding the improvement of teachers’ competency should be made comprehensively based on the finding of this study. It was found that the CoRe score of both objective and evaluation aspects have the lowest difference mean score. It is expected that the educational policy should find a solution to increase the CoRe score.

Furthermore, it is expected that further research should be conducted thoroughly regarding the development of learning instruments to improve mathematics teachers’ PCK.

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