A Development of IPA (Natural Sciences) Learning Tools Based on Investigative Approach in Empowering Students’ Higher-Order Thinking Skills and Concept Mastery in Junior High School

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Abstract. The major objectives of this research were to produce valid, practical, and effective learning tools of IPA subject which are able to empower higher-order thinking skills (HOTS) and students’ concept mastery in junior high school. There are several specific aims such as: 1) obtaining IPA learning tools for seventh grade students of junior high school in terms of investigative, potential and effective ‘acid-base’ materials to be implemented in the subject learning process for empowering students’ higher-order thinking skills and the concept mastery and 2) obtaining IPA learning tools in the form of investigative lesson plans (RPP), Student Worksheet, and Student’s Book for junior high school. This research applies research and development design, where development is carried out with reference to the 4-D model in particular define, design, develop, and disseminate. As for the research subjects, it involved 64 students and four IPA teachers which was conducted at a junior high school in Makassar that is SMPN 36 Makassar. In connection with it, the stages of the research are defining, designing, developing, and disseminating which focus to obtain valid, effective and practical learning tools. As as result, this research: (1) produces investigative IPA learning tools which are valid, practical, and effective for junior high school; (2) obtains the learning tools’ validity level as 3.84 which is classified as strongly valid, the practicality level of teachers’ responses aspect as 91.28 with positive response category, the implementation level as 1.83 with implemented category, and the ability to manage learning as 3.63 with excellent category; and (3) the level of effectiveness for critical thinking skills as 85.17 with high category, problem-solving ability as 74.50 with high category, and concept mastery as 82.78 with high category, and the percentage of learning completeness as 85.41% with very high category. Thus, this research produces a valid, practical, and effective IPA learning tools in empowering students’ higher-order thinking skills and the concept mastery of ‘acid-base’ materials for junior high school.

1. Introduction
Several interviews have been conducted with a number of Natural Sciences (which further abbreviated as ‘IPA’ as its Indonesian term) teachers for junior high school who happened to be master students of chemistry education at postgraduate program of Universitas Negeri Makassar, Academic Year 2018/2019. It also involves some students at SMP Negeri 36 Makassar as the research site in which the school considers that IPA subject is highly related to memorized concepts and requires a high level of thinking. In addition, they are commonly dealt by difficulties in integrating and applying the subject
concept into reality and everyday problems. As an example when answering the following questions, ‘Explain with the concept of IPA on why do the leaves of plants that have been picked off and stored in an open space or the leaves that fall from the tree will wither and die? Why does sugar dissolved faster in hot water than in cold water? Or, why are there some substances for example water which able to conduct electricity?’

For IPA educators or teachers, the aforementioned facts also become burdens besides students who are less enthusiastic and attractive, unwilling in the learning process and whose learning outcomes are commonly less satisfying. We assume that those issues are caused by learning models or strategies that are less effective and do not train to stimulate and empower students’ thinking abilities. Although a learning model with lecture method as a ‘one-way’ teaching that is still commonly used has been provided with exercises and questioning session to allow them to ask questions about teaching material that they are difficult to comprehend, but in fact, those opportunities are often ignored by them. This is allegedly due to at least three main reasons. First, most students are reluctant to ask, whether because they are ashamed to be considered stupid by others if asking, having no idea so they do not know what to ask, or merely because they are not interested in learning. Second, less duration for questioning session which is often available at the end of a discussion. Third, students are not trained to empower their thinking skills through the provision of exercises, the use of questioning skills, information processing and some application of learning models. Because they are less trained, the opportunity to empower their potential of thinking and questioning is not optimally utilized.

With respect to several efforts to overcome these problems found in chemistry subject learning, it is likely that the investigative learning model such as guided inquiry (GI), problem-based learning (PBL), group investigation, and discovery learning will be proper and effective solutions. A previous analysis result found in higher education [1] show that PBL and GI learning strategies, which are included as two investigative learning models, can develop higher-order thinking skills or critical thinking, metacognitive thinking, chemistry concept mastery, and obtain positive responses from students. Likewise, another previous findings in high schools [2] show that investigative chemistry subject affects and empowers their critical skills, metacognition and specific concept mastery of buffer solution. Therefore, the current researchers as a team will conduct a more extensive and deeper research, that is developing investigative IPA learning tools in an effort to grow higher-order thinking skills or often called as HOTS (involves critical thinking, creativity, and problem solving) and concept mastery for junior high school students.

Operationally, the aim of this research is to produce investigative, potential and effective IPA learning tools to be implemented in learning process to improve students’ HOTS and concept mastery in junior high school.

2. Methodology
The type of this research is R & D design which is oriented in process and product. The development process is described as carefully as possible until a potential, valid, practical, and effective learning tool product is obtained.

Referring to the needs in developing the learning tools, an object for this research is acid-base materials presented in seventh grade students in odd semester. In addition, the research subjects for the application of these learning tools are seventh grade students at SMP Negeri 36 Makassar in South Sulawesi, Academic Year 2018/2019 as many as two classes with a total of 64 students. Then, the subjects of the learning tools dissemination involve four teachers at SMP Negeri 36 Makassar who are also members of IPA Teachers Working Group (MGMP).

The design of this research is R & D where the development refers to the procedures of developing learning models which are arranged based on the pattern [3] with 4-D model. This model consists of four developmental stages namely define, design, develop, and disseminate.

2.1 Developing Instrument
Several developed learning tools for the students are lesson plans (RPP), Student Worksheet (LKPD), Student's Book (BPD), and Evaluation test and non-test instruments (IT-NT). There are also some
steps taken in this development such as learning tools drafting, validation and revision, and trial tests. As for the validation of the learning tools, it includes a step based on experts’ reviews as well as inputs for revision. The data of reviews were descriptively analyzed to measure the validity of the learning tools. Then validity criteria of the learning tools are identified if average score of each measured aspect or indicator achieves ‘good’ as the minimum category. Equally important, the result analysis of the reviews is also intended to observe what aspects of the learning tools that need immediate responses to be improved or revised.

Regarding the learning tools validity, it is linked with the standard index of tools validity testing by using Gregory Index. The next step is to conduct trial tests of the learning tools in classrooms by involving two classes. It was conducted to test the practicality and effectiveness of the learning products.

In the event of validity assessment of the products, it is carried out by two experts where practicality assessment is carried out by a teacher and effectiveness assessment is based on the results of students’ HOTS and specific concept mastery of IPA subject. Furthermore, the trial tests of HOTS consist of critical thinking skills test and problem-solving ability test related to IPA.

On the part of the instruments used to measure the learning tools validity, it is in the form of a review sheet or validation for experts or reviewers. While measuring the practicality, an observational sheet is used to observe learning management and implementation for IPA teachers[4] as well as teachers’ responses questionnaire. Moreover, to measure the effectiveness of the learning tools, several tests are implemented such as critical thinking skills test, problem-solving ability test [5] and concept mastery test related to IPA.

Data for this research were retrospectively collected by filling out a review or validation sheet [6], an observational sheet concerning learning tools’ management and the implementation [7], providing tests to measure the the concept mastery of IPA[8], an observational sheet and test instruments regarding to HOTS[9], and teachers’ responses questionnaire towards the learning tools [10].

In line with that, the data were descriptively processed and analyzed [11] including the result data of the validation or reviews, IPA learning tools’ management, implementation and the concept mastery [12]. HOTS which comprise critical thinking skills and problem-solving ability, and the teachers’ responses questionnaire towards the learning tools. Data processing and analysis were also carried out with the assistance of SPSS 20.0 application program for Windows.

In relation to the validity criteria of the learning tools, they are referred to the standards of Gregory index [11] with a coefficient $x > 0.75$, whereas the practicality criteria adopt [11] as well. For the effectiveness criteria, they refer to the reliability coefficient according to Boris [13], that is $x \geq 0.75$. Moreover, the categorization of students’ HOTS and the concept mastery of IPA refer to the categorization by Center for Educational Assessment, National Institute for Research and Development of the Ministry of Education and Culture [14].

3. Results and Discussion
On average, this research resulted in a valid, practical and effective IPA learning tools with investigative approach for junior high school. Data on the validity, practicality, and effectiveness of the learning tools are further described.

3.1 Data of validity
With reference to descriptive data on the learning tools validity based on expert assessment, it is presented in Table 1 which shows that the products are categorized as strongly valid. Those experts clarify that the components specifically RPP, LKPD, and BPD have fulfilled the required aspects of complete form, material accuracy with competencies to be achieved, complete construction, and language structure precision which is in accordance with proper grammar of Indonesian language and easily understood by students, appropriate time allocation in accordance with the learning model applied, as well as the benefits of the tools in learning process.

Likewise for evaluation test and non-test instruments (IT-NT) where they have also fulfilled the required aspects as valid test instruments. This can be seen from related material’s questions which
adjust to indicators of competency achievement, clear and readable construction of questions, non-ambiguous interpretation, clear command sentences, and good and correct Indonesian language use.

Additionally, the experts provide input on certain parts of RPP that need to add more clear examples of the material’s benefits of acids, bases, and salts in daily life along with detailed descriptions of cognitive and affective assessments. They also suggest that for BPD, it needs to include steps on how to identify acidic and alkaline solutions. Furthermore, LKPD is also suggested to be sharpened in terms of activities inclusion that enhance students’ critical thinking skills and problem-solving ability. As for evaluation test and non-test intruments, the experts also recommend that the cognitive level of the material’s questions need to be adjusted to the learning objectives and not only to one cognitive level. Bloom proposed several cognitive levels, that is knowledge (C1) until evaluation (C6). In the case of HOTS cognitive levels, the used levels are analysis (C4), synthesis (C5), and evaluation (C6) [15].

Table 1. Descriptive Data on IPA Learning Tools based on Investigative Approach for Junior High School

| No | Learning Tools’ Components | Assessment Score | Category       |
|----|---------------------------|-----------------|----------------|
| 1  | RPP                       | 3.79            | Strongly Valid |
| 2  | LKPD                      | 3.83            | Strongly Valid |
| 3  | BPD                       | 3.86            | Strongly Valid |
| 4  | IT-NT                     | 3.88            | Strongly Valid |
|    | Average Score             | 3.84            | Strongly Valid |

3.2 Data of Practicality
Here is the following descriptive data on the practicality of the learning tools based on teachers’ responses presented in Table 2.

Table 2. Data of Teachers’ Responses on IPA Learning Tools

| No | Aspects of Assessment | Assessment Score | Category       |
|----|-----------------------|-----------------|----------------|
| 1  | RPP                   | 93.13           | Strongly Positive |
| 2  | LKPD                  | 93.75           | Strongly Positive |
| 3  | BPD                   | 87.50           | Strongly Positive |
| 4  | IT-NT                 | 93.75           | Strongly Positive |
|    | Average Score         | 91.28           | Strongly Positive |

Here is the following descriptive data on the practicality of the learning tools based on the implementation presented in Table 3.

Table 3. Data of Implementation on IPA Learning Tools

| No | Aspects of Assessment   | Assessment Score | Category    |
|----|-------------------------|-----------------|-------------|
| 1  | Syntax                  | 1.88            | Implemented |
| 2  | Social Interaction      | 1.76            | Implemented |
| 3  | Reaction Principle      | 1.83            | Implemented |
| 4  | Supporting System       | 1.85            | Implemented |
|    | Average Score           | 1.83            | Implemented |

Here is the following descriptive data on the practicality of the learning tools based on the teachers’ ability in managing learning process presented in Table 4.
Table 4. Data of Teachers’ Ability on Learning Management

| No | Aspects of Assessment     | Assessment Score | Category   |
|----|---------------------------|------------------|------------|
| 1  | Preliminary Activity     | 3.63             | Excellent  |
| 2  | Core Activities          | 3.68             | Excellent  |
| 3  | Closing Activity         | 3.41             | Good       |
| 4  | Class Environment        | 3.81             | Excellent  |
|    | Average Score            | 3.63             | Excellent  |

Referring to Tables 2, 3, an 4, it is stated that the practicality of IPA learning tools is averagely categorized as strongly practical. This is indicated by strongly positive responses from the teachers, the implementation of IPA learning tools with the overall implemented category as well as learning management with excellent category. In support of the results, the teachers consider that IPA learning tools which include RPP, LKPD, BPD, and IT-NT based on investigative approach are excellent. It is due to a high degree of compatibility among these tools. For instance, the composition of the material presented in BPD is in accordance with the order of the indicators in the RPP. Moreover, the use of LKPD is listed in the RPP, and to work on it, students can use BPD. The teachers also responded positively to IT-NT tool where the evaluation test is comprised in RPP and arranged based on learning objectives and experiences to students through the use of LKPD.

In view of teachers’ observations during learning process specifically at the trial test stage, the whole learning syntax (discovery learning) is completely carried out. Along the learning process we can detect an intense interaction between teacher and students, among students, or students and learning environment. What is more, high responses were obtained from the students when each teacher gave an assignment in the form of LKPD where they complete it seriously. The tools and materials include litmus paper, table vinegar, citrus fruits, detergents, table salt, and Aqua mineral water.

Regarding learning management, the teachers as the subjects assess the high ability shown by the researchers who also act as teachers in managing class starting from the preliminary activity, core activity, and closing activity. The stimulus in the form of displaying some natural ingredients that contain compounds of acids, bases, and salts truly intrigues the students to be engaged in the learning process. The same way happened when the students work on exercises or tasks in LKPD during the class. They seem to enjoy the learning process which makes class atmosphere in to an intense and a conducive state to run well until the end of the class.

3.3 Data of Effectiveness

Regarding descriptive data on the effectiveness of IPA learning tools based on HOTS or critical thinking skills, problem-solving ability, and the concept mastery for junior high school, they are presented in Table 5.

Table 5. Data of Effectiveness on IPA Learning Tools

| No | Aspects of Assessment     | Assessment Score | Category  | Percentage of Completeness | Description   |
|----|---------------------------|------------------|-----------|----------------------------|---------------|
| 1  | Critical Thinking Skills (KBK) | 85.17            | High      |                            |               |
| 2  | Problem-Solving Ability (KPM)  | 74.50            | High      |                            |               |
| 3  | Concept Mastery (PK)        | 82.78            | High      | 85.41%                     | Very High     |
|    | Average Score              | 77.48            | High      |                            |               |
As regards, it is shown in Table 5 that the effectiveness of IPA learning tools in developing students’ KBK, KMP, and PK is classified as high. This illustrates that the investigative-based learning tools of IPA subject is able to develop students’ KBK and KPM in particular. With the development of both aspects of assessment through investigative learning activities, it impacts the increasing concept mastery (PK) and the percentage of students’ learning completeness. Then, it is also relevant to the previous findings that the developed IPA learning tools which are in the form of modules are appropriate to be used to improve the seventh grade students’ learning outcomes in junior high school[16].

IPA learning based on investigative approach is a strong foundation in education. Students will experience a meaningful session of learning when they are confronted with the steps of scientific inquiry, which assist them on how to learn [17]. In preparing a presentation’s material on the results of an investigation, it is closely related to concept mastery, critical analysis, synthesizing information, and efforts to solve problems [18]. Furthermore, inquiry-based learning has the potential to develop critical thinking skills [19]. In other studies, found that discovery learning as one of inquiry-based learning types can improve students’ problem-solving ability [20]. Students who have good critical thinking skills also have a good understanding of concepts [21], because critical thinking emphasizes decision making about what to believe and what to do [22].

4. Conclusion
This research has found that generally IPA learning tools based on investigative approach are stated as valid, practical, and effective for seventh grade students in junior high school to empower their higher-order thinking skills (HOTS) and concept mastery specifically acid-base materials.

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