Development of Chemistry Instructional Tools and Its Effect on Critical Thinking Skills, Metacognition, and Concept Mastery of Students

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Development of Chemistry Instructional Tools and Its Effect on Critical Thinking Skills, Metacognition, and Concept Mastery of Students

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Abstract: The aim of this research is to produce senior high school chemistry instructional tools based on investigations which is valid, practical, and effective and can empower critical thinking skills, metacognition, and mastery of buffer solution chemistry concepts for students. The method used are 1) the initial observation, 2) arranging the draft of instructional tool, 3) the development and verification of instructional tools, and try out and dissemination. The developmental phase in this research refers to the developmental model of 4-D (define, design, develop, and disseminate). Subject of the research are students class XI from state Senior High School (SHS) Bantaeng regency for limited try out test and chemistry teachers of SHS that amount 15 persons from Makassar city, Maros, Gowa, and Takalar regency for disseminate test phase. The research is 1st and 2nd year researches of plan 3 years. The first year is limited trial test and the second year is disseminated test of instructional tools. The results of the this research are obtained senior high school chemistry instructional tool based on investigations namely Investigation Lesson Plan (ILP), Investigation Model Book (IMB), and test and non-test instruments which are valid, practical, and effective based on the results of limited trial and disseminate test. The research result also shows the critical thinking skills and metacognitive of students generally are in the medium and begin to develop category, and concept mastery for buffer solution with high category. Furthermore, the teachers' responds toward ILP and IMB are positive and practice category.

1. Introduction

Among students of Senior High School (SHS), the subjects of Chemistry is not a favorite lesson, if not arguably less attractive as a lesson for students in general. Interview glance with some students in high school will be a place or school this research also reinforces the assumption above. They are generally quickly bored with a chemistry material by rote of concepts or laws of chemistry, formula and chemical structures, chemistry calculation and the similarities and the reaction mechanism. In addition, they generally have difficulty in integrating and applying chemical concepts into facts and everyday issues. For example in answering the questions: Explain the concept of chemistry, "why do the leaves of plants that have been plucked and stored in the open space or leaves that fall from the tree will be wither and dry?, And why the sugar dissolved in hot water more quickly dissolved

compared with dissolve in cold water? Why there are some substances such as water can conduct electricity?

For teachers coaching the chemistry lesson, the fact the problems above are also a burden, as well as students are less enthusiastic and impressed only after the value in the learning process, as well as learning outcomes are generally less satisfactory. We suspects the above problems caused by learning models that are less effective and do not train and empower student thinking skills. Although the lecture method, the 'one-way' and used over the years, has been equipped with a debriefing, to enable students to ask about the teaching materials are not conquered, but the opportunity debriefing is provided generally underused by the students , This is presumably at least for three reasons. First, students are generally reluctant to ask, perhaps because of shame if considered stupid by friends or altogether not understand so it does not know what to ask, or indeed because it is not interested in learning. Second, time to ask is usually not for long, because only at the end of the discussion. Third, students is not trained to empower their thinking skills through the use of questioning skills, information processing or through some learning model application. Because untrained then the chance of asking-answering provided does not use well.

Efforts to address learning problems chemistry, presumably based learning model of investigation (such as discovery learning) will more effectively be able to overcome these problems. The results of our research in college ([1]-[5]) showed that PBL and GI learning strategy are the two models that also investigative nuances can develop critical thinking skills, thinking metacognition, mastery of chemistry concepts, and received a positive response from students who've we taught with this model. Therefore, the research team will conduct research to further expand and deepen more, that is developing instructional tool based on investigative chemistry lesson of senior high school as an effort to foster critical thinking skills and mastery of chemistry concepts for students in senior high school.

2. Methodology

2.1. Research Subject

In generally, the method used are 1) the initial observation, 2) arranging the draft of instructional tools, 3) the development and verification of instructional tools, and try out and dissemination. Subject of instructional tool trial out test is 29 students of state Senior High School 1 Bantaeng regency in academic year 2015/2016 and 15 teachers of Chemistry of Senior High School from Makassar city, Maros, Gowa, and Takalar regency for disseminate test phase.

2.2. Design and Procedure of Development of Tool

In this research, development of design refers to 4-D model of [6]. Four phases of model development are the definition phase, design phase, develop phase, and disseminate phase. Development procedures are presented in Figure 1.

2.3. Research Instruments and Data Collection Techniques

The instrument is intended to measure the validity, effectiveness, practicality of instructional tools. The instrument used to measure the validity of the tool is review sheet or validation for expert/reviewer; to measure the practicality using managing learning observation sheet, observation sheet of instructional tools realization for chemistry teachers, and the response of teachers, and to measure the effectiveness of the tool using student response questionnaires, observation sheet of students learning activities, observation sheets of students critical thinking skills, metacognition, and mastery tests of chemistry concepts for students. The data collection is done by filling out the sheet review/validation [7], the observation sheet of management and learning realization [8], gives a test to measure mastery of chemistry concepts ([9], [10], [11]), critical thinking skills sheet and metacognition ([12], [13], and [14]), realization of ILP [15], the metacognition questionnaire [16], and the response questionnaires of the students and teachers toward the instructional tool [17].

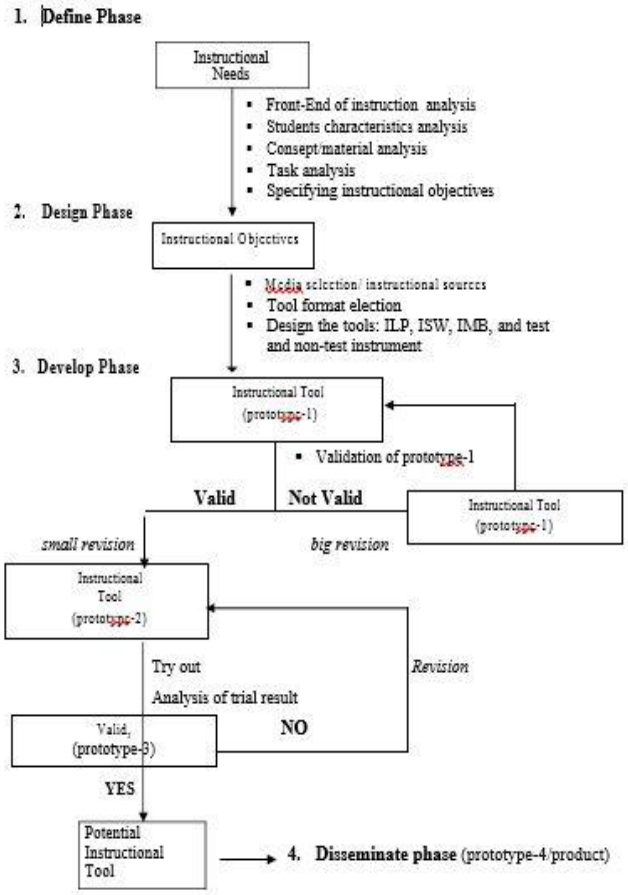

Figure 1. Procedure of Senior High School Chemistry Instructional Tool Development Based on Investigation

2.4. Processing and Data Analysis Techniques

This research data is processed and analyzed descriptively ([18], [19]) includes validation or review results data, the management of learning, activity of students, data analysis of test result of chemistry concepts mastery [20], the data of critical thinking skills, metacognition (questionnaire MAI), realization of instructional tool, and the response questionnaires of students and educators/teachers toward instructional tool.

Criterion of tool validity refers to Gregory standard index [18], the practicality of the tool refers to [18] with the level of realization of to the tool 50% of at least 70% of aspects observed, and the effectiveness of the tool refers to coefficient reliability by Boris in Trianto [21].

3. Results and Discussion

3.1. Process of instructional tool development

The process of senior high school chemistry instructional tool development based on investigation refers to 4-D model of [6]. This model includes four phases namely define, design, develop (conducted on 1st year), and disseminate (conducted on 2nd year). Based on the validation results of the instructional tools stated that the senior high school chemistry instructional tool that has been designed it classified as valid category with average of validity of the instructional tool is 3.47 with valid category (Table 1).

Table 1. Validation results of the instructional tools

Tool	Indicator	Appraisal	Categories of validity
Investigation Lesson Plan (ILP)	1. Specifying of learning objectives	3.50	Very Valid
	2. Learning material	3.80	Very Valid
	3. Language and sentences	3.50	Very Valid
	4. Facilitation and teaching aids	3.50	Very Valid
	5. Methods and learning activities related to CTS and metacognition	3.37	Valid
	6. Time allocation	3.50	Very Valid
	7. Assessment/bill	4.00	Very Valid
Average		3.59	Very Valid
Investigation Model Book (IMB)	1. Transition of concept	3.50	Very Valid
	2. Language and Writing	3.65	Very Valid
	3. Construction	3.50	Very Valid
	4. Characteristic of sub concepts	3.50	Very Valid
Average		3.54	Very Valid
Investigation Student Worksheet (ISW)	1. Presentation of Problems	3.00	Valid
	2. Language and writing	3.60	Very Valid
	3. Scope of research	3.50	Very Valid
	4. Presentation of activities	3.50	Very Valid
Average		3.40	Valid
Critical Thinking Skills	1. Objectives	3.50	Very Valid
	2. Construction and problem instructions	3.12	Valid
	3. Language	3.33	Valid
	4. Time	3.00	Valid
	5. Scope of research	3.50	Very Valid
Average		3.29	Valid
Concept Mastery Test	1. Objectives	3.50	Very Valid
	2. Construction	3.00	Valid
	3. Language	3.33	Valid
	4. Time	3.00	Valid
	5. Scope of research	3.50	Very Valid
Average		3.27	Valid
Student Response Questionnaires	1. Objectives	3.25	Valid
	2. Construction of statement	3.00	Valid
	3. Language	3.50	Very Valid
	4. Scope of Components	3.50	Very Valid
Average		3.31	Valid
Observation Sheet of	1. Objectives	3.50	Very Valid
	2. Construction	3.50	Very Valid

Tool	Indicator	Appraisal	Categories of validity
Lesson Plan Realization	3. Language	3.50	Very Valid
	4. Time	3.50	Very Valid
	5. Scope of Components	3.50	Very Valid
Average		3.50	Very Valid
Observation Sheet of Learning Management	1. Initial activity	4.00	Very Valid
	2. Core activity	3.95	Very Valid
	3. End activity	4.00	Very Valid
	4.Time management	3.75	Very Valid
	5. Asking technique	3.62	Very Valid
	6. Class condition	4.00	Very Valid
	7. Use of Media	4.00	Very Valid
Average		3.90	Very Valid
Teacher Response Questionnaire	1. Objectives	3.50	Very Valid
	2. Construction	3.50	Very Valid
	3. Language	3.50	Very Valid
	4. Scope of Components	3.50	Very Valid
Average		3.50	Very Valid
	Average	3.47	Valid

3.2. Try Out of Instructional Tool Validation Results

The revised instructional tool was tried out to students of state Senior High School Tompobulu Regency of Bantaeng of academic year 2015/2016. Limited try out of the tool includes aspects of the use of the tool in the learning process, giving a test to measure the student critical thinking skills and concepts mastery, filling the realization observation sheet of ILP and management of learning by the observer, and giving the students and teachers response questionnaires. The data obtained in this trial was processed and analyzed to use in assessing the effectiveness and practicality of the trial out result instructional tool. Results of limited trial out of instructional tools are presented in Table 2.

Table 2 shows that the instructional tool has valid, effective, and practical criteria so that it can be implemented more widely namely disseminate phase.

3.3. Developmental Product of Instructional Tool Based on Investigation

The disseminate test phase has been conducted with giving teachers response questionnaires to 15 chemistry teachers of SHS. The results of the disseminate test phase are obtained that SHS chemistry instructional tool based on investigations namely ILP, IMB, and test and non-test instruments which are practical, effective, and teachers 'responds with positively and practice category. Data of disseminate results are presented in Table 3.

Based on the perception of teacher in the disseminate phase can be stated that the instructional tool is classified as good or in another word the teachers responded positively to the instructional tool products of this development results.

Table 2. Results of the limited trial out of instructional tool

Observation Object and Appraisal based on the learning tools and test and non-test instruments	Realization/Use, Acquisition Scores and achievement	Category
Realization of ILP	Done entirely	Good and practical
The use of IMB	Used well	Good and practical
The use of ISW	Used well	Good and practical

Observation Object and Appraisal based on the learning tools and test and non-test instruments	**Realization/Use, Acquisition Scores and achievement**	**Category**
Concept mastery	▪ 68.97% of high category. ▪ 96.55% students is complete with average value of 86.72	Effective and high category
Learning management	The average observation is 3.93 (for 5 components and maximum score 4.00)	Very high and effective
Critical Thinking Skills	93.10%	Medium and effective
Student responses	82.76%	Positive responses and effective to study chemistry
Teacher responses	100%	Attracted, motivated, and effective for teaching chemistry
Metacognition	83.25%	Begin to develop

Table 3. Result of disseminate test for instructional tools

Tools	**Categories of conducting**	**Categories of perception**
Investigation Lesson Plan	Can be conducted	Positive and Practice
Investigation Model Book	Can be used	Positive and Practice
Investigation topic instrument	Can be conducted	Positive and Practice
Test Instrument for Concept Mastery of Buffer Solution	Can be used	Positive and practice
Investigation Student Worksheet (ISW) Instrument	Can be used	Positive and practice
MAI instrument	Can be used	Positive and practice
Aspects in Critical Thinking Skill Instrument	Can be used	Positive and practice

Furthermore, the perception of senior high school chemistry teacher on the instructional tools namely ILP, IMB, ISW, Topics of investigation, test and non-test instrument classified interesting and newness category is high.

The all of instructional tools called is practice because it can be used with easy by chemistry teachers for applied and to guided students, and it can involve all students actively in learning process. The instructional tools called is effective because it can increasing critical thinking skill,

metacognition, mastery of concepts of students and called is positive because the instructional tools can be received well by the teachers to implementation in the senior high school.

The all of instructional tool called is interesting because the chemistry teachers feel content with presence the discovery learning tools based investigation and very interest to implementation in the class and also the instructional tools is new for chemistry teachers.

Based on data from the validation of expert, limited trial out test, and disseminate results of instructional tools can be stated that the senior high school chemistry instructional tools based on investigation have valid, effective, practical criteria, and well appreciated by chemistry teachers, so that the instructional tools can be to implementation in the broader level and it compare with others instructional tools.

4. Conclusion

The development phases of chemistry instructional tools refers to the 4-D patterns by Thiagarajan includes define, design, develop, and disseminate of instructional tools. From the results of this process have been obtained (1) instructional tools in the form of ILP, ISW, IMB, and test and non-test instruments are valid, effective, and practical category, (2) the use of instructional tools based on investigation on the level of was able to develop the critical thinking skills of students and improve the level of mastery of concepts in chemistry subjects (buffer solution concept), and (3) based on the appreciation or the perception/responds of senior high school chemistry teachers can be stated that the instructional tools classified as good or in another word the teachers responded positively to the instructional tool products of this development results.

These instructional tool products still need to implementation in SHS and its comparing with the others model/instructional tool via experiment research widely to obtain information that more and more powerful that will be obtained more perfect instructional tools than instructional tools exist today.

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