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Developing the Laboratory Inquiry Activity Based Lecturing Guidebook for the Basic Analytical Chemistry Material

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Abstract: ***This study aims to generate a guidebook of basic analytical chemistry lecture using laboratory inquiry-based activity that can increase the Multiple Intelligence of chemistry teacher candidates. Multiple Intelligence which should be developedrelating to the lecture of basic analytical chemistry laboratory improve logical mathematical intelligence, and interpersonal, intrapersonal intelligences. This study uses the design of the 4D model development (define, design, develop, and disseminate), of Thiagarajan et al, (1974). The basic analytical chemistry lecturingguidebook usinglaboratory inquiry-based activity developed was validated by two lecturers and three students, with the validator average 3.43-3.73 result with valid criteria. After obtaining a validated model, it then wasused by 12 students of the 6th semester, with the result that there was little revision on the work instructions, while the contents are understandable enough. Therefore, it is considered as appropriate.***

Keywords: laboratory inquiry-based activity, guidebook, Multiple Intelligence, basic analytical chemistry, chemistry teacher candidates.

1. Introduction

Laboratory activities is one of the approaches in learning chemistry that can improve thinking skills, develop metacognition, work in team and improve communication (Cacciatore, 2009). According Rustaman (2007), during the learning process of science, it should be done through the exploration phase of its experience, searching for journals supporting and developing, designing work step, and being continued with the observation of primary data involving basic capabilities activity inquiry lab, up to finding conclusions into knowledge new. Laboratory activities will achieve its objectives if it is implemented systematically through the stages of inquiry.

Activities of inquiry are started with the search for information from various sources. In this step, the intelligence is associated with the effort to be able to design experiments properly, including developing intrapersonal intelligence/Multiple Intelligence.According to Wardani (2013) phases of inquiry on laboratory experiments greatly develop students' inter-intrapersonal intelligence (Multiple Intelligence). In addition, Lazear (2004), Cacciatore &sevian (2009) also stated that the stage of experiments with inquiry in the laboratory can develop complex thinking, and interpersonal intelligence (Multiple Intelligence).

According to NCR (2005), experiment using experiment guidebook has the tendency of being verificative, therefore it is no longer effective for scientific learning. This opinion is supported with the result of the field study conducted during the odd semester in 2012-2013 for basic analytical chemistry experiment which shows the result of concept understanding of students at 80%; as their scores were under 50 (100 points), while 20% students got scores range between 50-79. Wardani (2013) stated the lack of the students' ability in explaining what it does and the symptoms observed is due to the laboratory activity which carried out today is still verificative. Problems related toward the conditions of less useful chemistry lab including analytical chemistry was also expressed by GianpieraAdami (2006); Amarasiriwardena (2007); Kipnis&Hofstein, (2007).

Based on the description above, it is deemed necessary for the development of basic analytical chemistry lecture guidebooks inquiry-based laboratory activities which can develop Multiple Intelligence of chemistry teacher candidate. The formulated research problem is how the validity and appropriateness of the laboratory inquiry activity based lecturing guidebook which can develop the Multiple Intelligence of chemistry teacher candidate.

2. Method

The stages in this study follow the model of Borg and Gall (1983), which has been simplified; define, design, develop, and disseminate. The stages of *define* and*design*of the lecturing guidebook were validated by the experts. In order to see the appropriateness of the guidebook, the researchers conducted a limited testing.This research was conducted in Chemistry Education Study Program by considering the third semester students of chemistry education which join courses practicum of basic analytical chemistry. The test was limited to 12 semester four students.

3. Result and Discussion

This research yields aguidebook of basic analytical chemistry lectureusing laboratory inquiry-based activity. As for sections in the guidebook are problem identification, hypothesis formulation, laboratory equipment and apparatus usage, the guidance of doing experiment, data presentation, discussion, and drawing the conclusion. The book consists of 38 pages which display qualitative and quantitative analysis of chemistry material. It is composed of seven chapters starting from exercise in identifying cations and anions up to the explanation about gravimetri.

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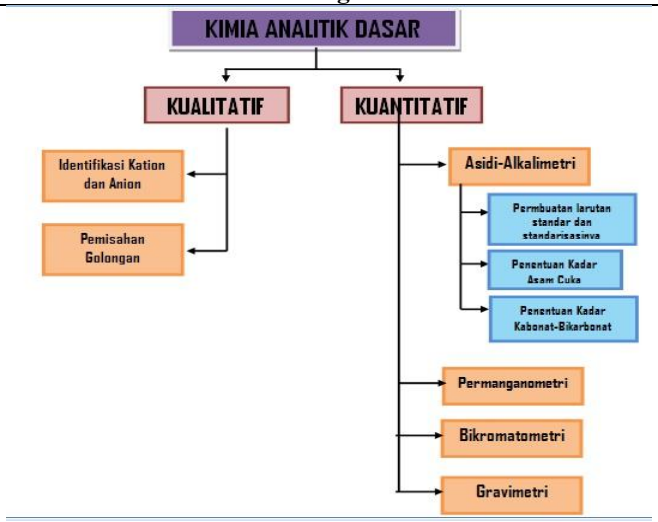
In every activity in the guidebook, students are guided to have the learning model using inquiry-based model. Initially students are guided to read articles that can answer why it is necessary to identify the cations-anions (Chapter I), then students are directed to perform the separation of cations in the class (Chapter II), by making the experimental design itself and keep following the steps of inquiry in the guidebook. There are seven chapters in the guidebook of basic analytical chemistry lecture, representing each activity on a qualitative and quantitative analysis. After reading the direction of questions, students are expected to identify problems and create hypotheses or provisional estimates of the issues mentioned in the "Problems" are provided in the guidebook. Then, students are guided to read the material in the guide books as a source of hypothesis testing that has been compiled. Furthermore, the students are led to prove the truth of the hypothesis by writing explanations and conclusions of these activities in the "Let's Experiment".The design of the guidebook is shown in Table 1.

3.1 The Validation Result of the Lecturing Guidebook

The final design of the guidebook of basic analytical chemistry lectureusing laboratory inquiry-based activity was then discussed with the experts to get some suggestions and corrections. The validators gave assessment and suggestions regarding the lecturing models such as syllabus, lesson plan, pretest-posttest questions, and the guidebook of basic analytical chemistry lectureusing laboratory inquiry-based activity, according to the assessment rubric validated by the experts previously. There are two kinds of assessments, they are first: the assessment according to appropriateness of content, presentation, and language; and second: the assessment of readability by the students. The result of the validation which is shown in Table 2 shows the average result of 3.43-3.73 which belong to the valid criteria with some suggestions and recommendations.

Table 1: The validation result of the guidebook of basic analytical chemistry lectureusing laboratory inquiry-based activity

Section	Design
Conceptual Map	
The Beginning Section of the Chapter or Activity	**Indikator Praktikum Kimia Analitik Dasar** 1 Dapat menjelaskan prinsip-prinsip dasar dalam analisis kualitatif. Identifikasi katioan dan anion dengan benar dan percaya diri dan dapat bekerja mandiri serta bersifat demokratis dan inovatif dalam menganalisis secara kualitatif terhadap yang ada. 2 Dapat menjelaskan prinsip-prinsip dasar dalam analisis kualitatif. Identifikasi katioan kation golongan I dan golongan II dengan benar dan percaya diri dan dapat bekerja mandiri serta bersifat demokratis dan inovatif dalam menganalisis secara kualitatif terhadap yang ada 3 Dapat menjelaskan prinsip-prinsip dasar dalam analisis kualitatif. Identifikasi katioan golongan III dan golongan IV dengan benar dan percaya diri dan dapat bekerja mandiri serta bersifat demokratis dan inovatif dalam menganalisis secara kualitatif terhadap yang ada 4 Dapat menjelaskan prinsip-prinsip identifikasi anion dengan benar dan percaya diri dan dapat bekerja mandiri serta bersifat demokratis dan inovatif dalam menganalisis secara kualitatif terhadap yang ada

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Section	Design
Problem Identification Stage	**BAB IV** **PENENTUAN KADAR CAMPURAN KARBONAT-BIKARBONAT** **I. TUJUAN** Menentukan kadar campuran karbonat-bikarbonat **II.LANDASAN TEORI** Ion karbonat dapat ditentukan dengan cara titrasi dua langkah yaitu dengan menggunakan dua indikator : $CO_3^{2-} + H_3O^+$ $HCO_3^- + H_2O$ (Fenolftalein) $HCO_3^- + H_3O^+$ $H_2CO_3 + H_2O$ (Metil Orange) Fenolftalein bekerja sebagai indikator untuk titrasi tahap pertama dengan perubahan warna dari merah ke tidak bewarna. Metal orange bekerja sebagai indikator tahap kedua dengan perubahan warna dari kuning menjadi jingga . fenolftalein dengan jangkauan pH 8,0 sampai 9,6 merupakan indikator yang cocok untuk titik akhir pertama, karena pH larutan $NaHCO_3$ berjumlah 8,35. metal orange dengan jangkauan pH 3,1 – 4,4 cocok untuk titik akhir kedua. Suatu larutan jenuh CO_2 mempunyai pH kira – kira 3,9 . kedua titik akhir tersebut tidak satu pun membentuk patahan yang sangat tajam. **MENGANALISIS KOMPONEN SODA KUE DI PASARAN**  Gambar 2. Roti dan minuman berkarbonasi di Pasaran Soda kue merupakan bahan pengembang pembuatan roti donat, bolang baling, dan minuman berkarbonasi. Dalam soda kue ($NaHCO_3$) juga terdapat zat Na_2CO_3 dan pengotor. Buktikan dengan percobaan untuk mengetahui senyawa yang terdapat pada sampel yang akan dianalisis!
Guiding Questions	**Pertanyaan** 1. Larutan standar apa yang digunakan untuk menstandarisasi $NaHCO_3$ dan Na_2CO_3? 2. Apa nama larutan standar yang digunakan? 3. Indikator apa yang digunakan untuk menstandarisasi? 4. Bagaimana cara menghitung kadar $NaHCO_3$ dan Na_2CO_3 yang dimungkinkan terdapat dalam soda kue?
Hypothesis Formulation Stage	**Mari berehsperimen** 1. Tentukan rumusan masalah yang berkaitan dengan percobaanmu! a. Zat apakah yang dapat digunakan untuk memisahkan Ag^+ dan Pb^{2+}? b. ..... c. ..... d. dst. 2. Buat hipotesis percobaanmu! .... 3. Alat dan bahan apa saja yang kalian perlukan? ....

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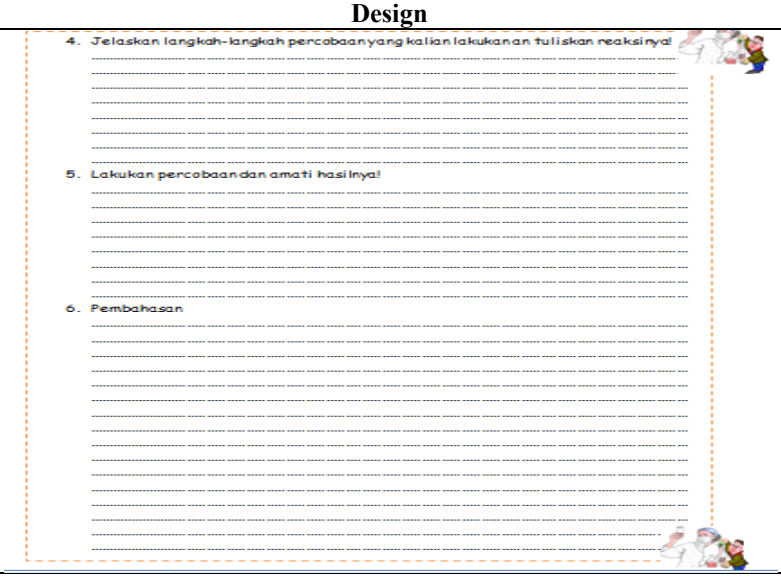
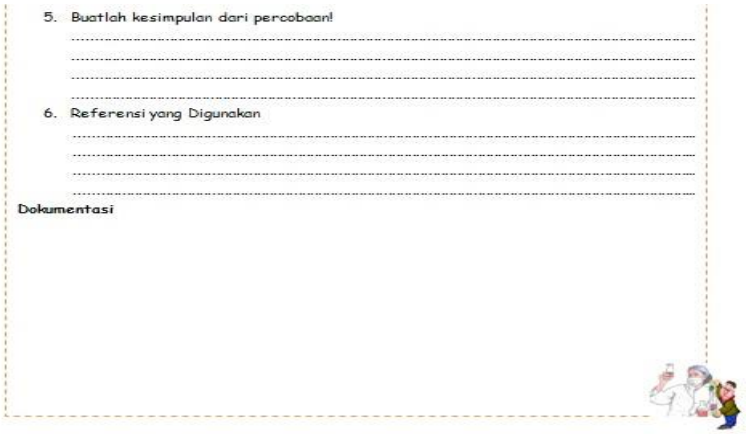
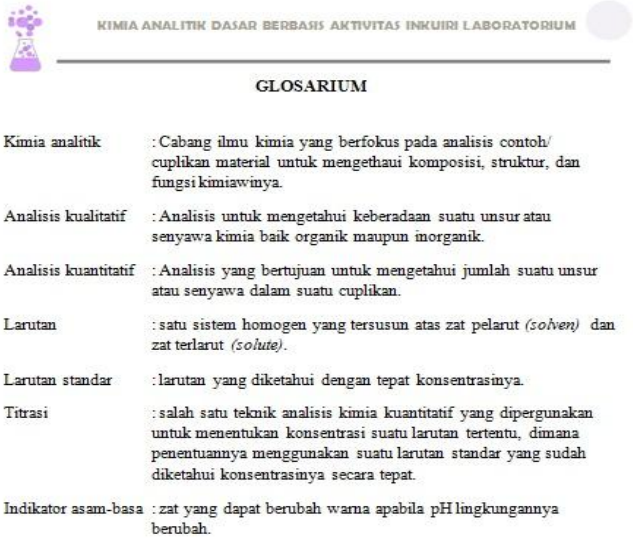
Section	Design
Data Collection Stage	
Conclusion Stage	
Glosarium	

3.2 The Validation Result of the Lecturing Guidebook

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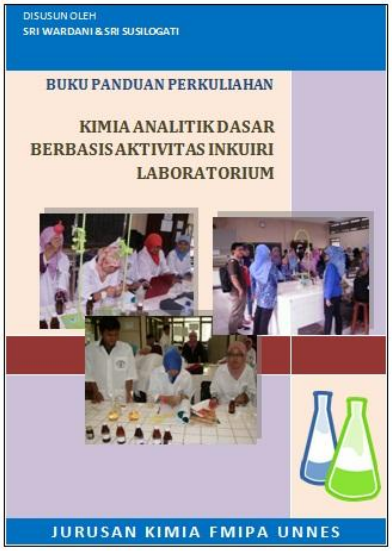
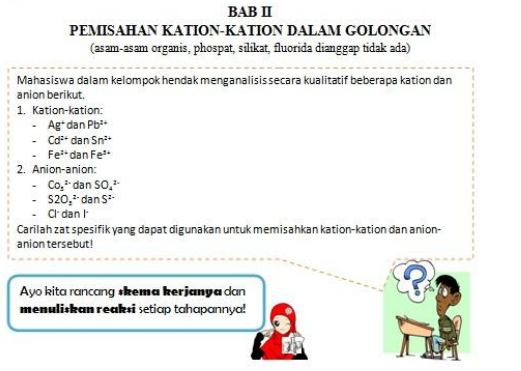
which belong to the valid criteria with some suggestions and recommendations.

Table 2: The validation result of the guidebook of basic analytical chemistry lectureusing laboratory inquiry-based activity

Validator	Total			Average		
	Appropriateness of Content	Presentation	Language	Appropriateness of Content	Presentation	Language
Student A	11,40	14,43	17,83	3,80	3,61	3,57
Student B	10,80	13,98	16,00	3,60	3,49	3,20
Student C	10,90	14,81	16,50	3,63	3,70	3,30
Lecturer A	10,80	14,83	17,83	3,60	3,71	3,57
Lecturer B	12,00	13,64	17,50	4,00	3,41	3,50
Average	**11,18**	**14,34**	**17,13**	**3,73**	**3,58**	**3,43**

In the validation stage, there are some suggestions and recommendations from the validators. Those suggestions and recommendations are then used bby the researchers to improve the guidebook in order to achieve the perfection of the guidebook of basic analytical chemistry lecture*(Kimia AnalitikDasar (KAD))*using laboratory inquiry-based activity. The corrections are shown in Table 3.

Table 3: Suggestions and Corrections

Before	After
The cover of the guidebook should use light colors and the arrangement of the book title should be corrected. 	The background color of the book cover is changed and the book title is re-arranged. 
The problems which are going to be investigated should be more detailed. 	The addition of cations and anions to be investigated. 

The result after corrections from the validators is then tested for its readability to the sixth semester students who have accomplished the practicum of basic analytical chemistry (KAD) course. There are 12 students joining the readability test. The result of the readability test is mostly the correction of the problem statements which are less understood by the students. The corrections are done to the question number one and three since there were 6 of 12 students who did not answer the questions. Therefore, the researchers think that there should be the correction to the problem statement. The readabilitiy of the guidebook belongs to good, in which all of the semester sixth students are able to understand the content and the stages of laboratory inquiry activity model.

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The guidebook of basic analytical chemistry lectureusing laboratory inquiry-based activity which has been validated and assessed in terms of its readability, as well as corrected according to the suggestions from the experts, is then tested to see its appropriates and implementation. The test was initiated with a pretest of qualitative-quantitative material to the third semester students who join the basic analytical chemistry course. After the pretest, the students were given the guidebook of basic analytical chemistry lectureusing laboratory inquiry-based activity, so that they can learn what experiments should be designed and what literature to be searched. In the next meeting, the students in each group hd been ready with their designs to be discussed before doing the experiment. After the experiment, the students wrote the result report and discussed it classically.

The guidebook of basic analytical chemistry lectureusing laboratory inquiry-based activity has been developed and used in every learning activity during the lecture. Percentage results obtained from this activity are that almost all the students can follow the instructions of the guide properly; therefore all groups can design experiments of the source journal that they are looking for.

The percentage of the application of the guidebook of experiment using laboratory inquiry-based activity shows that every section in the book both in the section of qualitative and quantitative analyses can be followed by students properly with the range of result as 84%-96%. The lowest rate of chapter application is shown in the alkalimetry section as the students did a mistake for misapply the sample of baking soda; it did not apply quite well therefore it is needed some instruction in choosing sample. The highest rate of percentage is achieved on acidimetry and permanganometry as there are quite sample options. It causes these two sections received better and optimum results in the experiment design.

The implementation of intrapersonal intelligence assessment has been done well since there has been the assessment rubric available. The assessment result of experimental report with five intrapersonal indicators showed the highest result on the metacognition indicator.Observation on the development of interpersonal intelligence was done by assessing the percentage of draft and experimental result report, that is the percentage to get the experimental design and reporting in accordance with the practicum guideline of laboratory inquiry-based activity.The presentation made to practice expressing opinions, respond to the opinion of friends, work in group, this activity is expected to explore and develop the interpersonal intelligence(Wardani,2013).

This result is consistent with the opinion of Kipnis (2007), Cacciatore (2009), and Wardani(2016), which states that the inquiry-based lab learning can improve student's metacognition. Similar results also stated that the problem-based learning can improve students' metacognition (Haryani, 2011). Similarly, the findings of Wardani (2014) that in solving complex problems required multiple intelligences including the use of metacognition.In addition, Wardani(2014), Zhang, (2002); Adami, (2006); AviHofstein, (2007)stated that study in a group can develop the skills of cooperation, skills of expressing opinion and communication skills in scientific argumentation. Neither the opinion of NRC, (2005); Aerospace, (2008); Cacciatore, (2009) that the laboratory inquiry-based learning can improve the ability to work together, the ability to communicate, skillful in asking questions and expressing their opinions (interpersonal intelligence).

4. Conclusion

The guidebook gets the validation result of 3.43- 3.73 with valid category, and the implementation percentage reaches 84%-96%with appropriate category.

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