JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

IMPLEMENTATION OF INNOVATIVE CHEMISTRY LEARNING MATERIAL WITH GUIDED TASKS TO IMPROVE STUDENTS' COMPETENCE

Manihar Situmorang,
Marudut Sinaga,
Jamalum Purba,
Sapnita Idamarna Daulay,
Murniaty Simorangkir,
Marham Sitorus,
Ajat Sudrajat

Abstract. *This research aimed to provide an innovative chemistry learning material with guided tasks to improve students' competence in Chemistry. It involved 180 students enrolled in the Analytical Chemistry course at State University of Medan in academic year of 2016/2017. The samples were purposively selected and divided into two groups. The research consisted of several steps including enrichment, innovation and standardization of learning material, followed by implementation of the developed learning material in class. A set of good quality learning material equipped with the guided task for Gravimetry topic has been provided. It contained relevant contextual examples, laboratory works, students' activities, multimedia, and hyperlink to trustworthy websites. Implementation of innovative learning material has been conducted by using a set of developed learning material in the experimental class while the existing textbook was used in the control class. The research findings highlighted several points: (1) well-implemented innovative learning material was effective to improve the students' competence; (2) learning outcome in experimental class was found higher than that in control class; (3) the guided task in the learning package facilitated the students to learn the selected chemistry topic independently which in turn shifted student learning style from lecturer-oriented to student-oriented; (4) the guided task not only made the students be familiar with searching for scientific documents to complete the given tasks but also improved the students' ability to write and organize their assignments; (5) students' academic attitudes, observed during the learning activities, were categorized as very good.*
Keyword: *innovative learning material, guided tasks, independent learning, students' competence.*

Manihar Situmorang, Marudut Sinaga, Jamalum Purba, Sapnita Idamarna Daulay, Murniaty Simorangkir, Marham Sitorus, Ajat Sudrajat
State University of Medan, Indonesia

Introduction

Implementation of National Qualifications Framework (in Indonesian *Kerangka Kualifikasi Nasional Indonesia*, KKNI) as the basis of competence standard has been shifting the teaching and learning paradigm to adopt competence-based curriculum at Universitas Negeri Medan. The current curriculum needs to apply various learning strategies to provide the students with appropriate knowledge of the subject they learn. Thus, it is compulsory to integrate relevant task to encourage the students to learn and to develop their competence and skills necessary to succeed in their study. The students are required to possess adequate knowledge, skills and good character to adjust themselves to the relevant sector for life. The availability of good quality learning resources is needed to help the students meet the required competence in the learning target. The strategies to improve chemistry teaching and learning process have been carried out, including the variation in learning methods and models (Chamizo, 2013; Jahangiri & Hajian, 2013; Mari & Gumel, 2015), the use of laboratory experiment and virtual laboratory (Arabacioglu & Unver, 2016; Tatli & Ayas, 2013), and the implementation of technology and multimedia (Chroustova, Bilek, & Šorgo, 2017; Khairnar, 2015). Teaching innovation has been proven to be effective to improve learning activities to facilitate the development of students' cognitive skills, and to provide enjoyable learning environment (Fiksl, Flogie, & Aberšek, 2017; Hadjilouca, Constantinou, & Papadouris, 2011; Liu, Hodgson, & Lord, 2010). It can be performed through teaching and learning method, strategy and models, modification of laboratory experiment, integration of learning media and multimedia, and the development of learning material (Maaß & Artigue, 2013; Noor & Ilias, 2013; Slabin, 2013). Teaching innovation with an adaptation of information technology in teaching and learning has become a trend nowadays (Varghese, Faith, & Jacob, 2012). Learning innovation by using technology, such as web-based approach and Massive Open Online Courses (MOOCs), can enhance and facilitate student learning process from traditional classroom to student-centred learning (Dagienė & Gudonienė,

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

2015; Leito, Helm, & Jalukse, 2015). The use of interactive learning by the aid of multimedia has also been introduced (Betten, Roelofsen, & Broerse, 2013; Osman & Vebrianto, 2013; Rusek, Starkova, Chytry, & Bilek, 2017). An innovative learning material is considered as an effort to improve the quality of learning activities (Lee, Lin, & Kang, 2016).

Chemistry is a very challenging subject for undergraduate students as it plays a role on the specific competence in science. Chemistry, as the basic science, is an essential part of the chemistry curriculum from the basic to the advanced level and consists of topics from principles of the methods to problem solving (Broekaert, 2015). The development of innovative chemistry learning material is very important as it could motivate the students to meet the desired knowledge and skills (Trifilova, Bessant, & Alexander, 2016). Similarly, innovation to provide standard learning material has also been made to improve students' competence (Hosler & Boomer, 2011). Good quality learning material helps the students to understand the chemistry concept, while the illustration in the book makes those concepts be easy to remember and ease the students to understand the relationship between the theory and the contexts. A standard learning material can be designed as a learning media to facilitate the learners with complete information from the right sources and can be accessed anytime and be able to facilitate the learner to learn independently (Simatupang & Situmorang, 2013). It has been demonstrated that innovation in the teaching and learning materials is effective to improve students' achievement (Situmorang & Situmorang, 2014). A complete and systematic set of chemistry learning materials can be provided in the format of books, modules and e-book to facilitate the students to learn chemistry based on their need. Chemistry learning material in an electronic format which provides flexibility of uses, both in the class and outside the class (Sinaga, Limbong, & Situmorang, 2016).

Analytical chemistry course is an essential part of the chemistry curriculum from the basic to the advanced level for undergraduate students. The course is purposively made compulsory for science students to achieve high metrological quality and to solve information-related (analytical) problems in order to ensure consistency between required and delivered analytical information (Valcárcel, 2016). It is the basic science for chemical analysis for the determination of the compounds in a high diversity of materials both qualitatively and quantitatively (Broekaert, 2015). Therefore, the topics of analytical chemistry have to be clearly explained in the principles of the methods to problem solving data acquisition, data treatment, measurement values conversion and calibration techniques. Analytical chemistry textbook for university students consisted of the chapters on Gravimetry (Christian, Dasgupta, & Schug, 2013; Harris, 2015; Skoog, West, Holler, & Crouch, 2013). Gravimetry analysis is one of the analytical methods that has been widely implemented in determining the target analyses in real samples (Jacob, Dervilly-Pinel, Biancotto, & Le Bizec, 2014). This gravimetry topic is assigned to be very important in chemistry curriculum for bachelor's degree as it covers the knowledge and skills in chemistry (Zhang & Zhang, 2014). Gravimetry topic, which is ranging from the preparation of the sample, selection of precipitation reagents, formation of precipitate, separation technique and digestion, purification, drying and ignition, to calculation, was very important to be developed for undergraduate chemistry students (Christian, et al., 2013; Harris, 2015; Skoog, et al., 2013). Those techniques are compulsory for chemistry students to develop their skills on the classic method in the analytical determination. The strategy, therefore, has to be made to boost students' interest in learning the Gravimetry topic.

The development of an innovative learning material with guided tasks is a strategy to provide good quality learning resources to be used in teaching and learning activities to improve students' performance as desired in the competence-based curriculum. A standard learning material with guided task is expected to improve students' activities in learning chemistry. Universitas Negeri Medan (UNIMED) has set the guided task in the KKNI curriculum which consists of six tasks, including routine task (RT), critical book report (CBR), critical journal/research report (CJR), idea engineering (IE), mini research (MR), and small project (PR) in relevance to the topic being taught (UNIMED, 2016). The research was conducted with two fold aim: (1) to provide an innovative chemistry learning material with guided tasks in the teaching of Gravimetric analysis topic, and (2) to investigate the effectiveness of the developed standard learning package to improve students' competence through their achievements and academic attitudes.

Methodology of Research

General Background

The study was carried out in the Department of Chemistry, Faculty of Mathematic and Natural Science (FMIPA) Universitas Negeri Medan. The research steps covered the development of innovative learning material for the Gravimetric topic, standardization of the learning package, and implementation of the developed learning material to improve students' competence.

Population and Sample

The research involved 180 second-year students enrolled in Analytical Chemistry course. The samples were purposively selected from the Department of Chemistry and divided into two groups, named as experimental class and control class. The sample in each group was made homogenous by rejecting outlier samples based on student ability to solve chemistry problem in the pre-test. Samples were all treated equally, yet only 30 students per class were included in the data analysis.

Research Procedures

The research followed the procedures as explained in previous work (Situmorang, Sinaga, Sitorus, & Sudrajat, 2017). It consisted of the development of innovative and interactive learning material with guided tasks for analytical chemistry topic, preparation of tasks instruction, evaluation and standardization of learning package, implementation of developed learning material, and evaluation test. The strategy to measure students' competence and academic attitudes was also prepared. The procedure is illustrated in figure 1.

Figure 1. The overview of research procedures on the development and implementation of innovative learning material with guided task on the teaching of chemistry.

Preparation of Innovative Learning Material for Gravimetry

Innovative learning material for Gravimetry topic has been prepared by selecting the relevant sub topic, followed by writing a draft of chemistry material and enriching the topic with relevant local contents as the contextual examples to meet required students' competence based on the KKNI curriculum on Chemistry. Integration of relevant laboratory experiment, preparation of innovative learning media, and selection of hyperlinks to trusted websites related to Gravimetry topics were done based on the procedures explained in the previous study (Situmorang, Purba, & Sihombing, 2016). Sets of guided tasks with the instruction were then included in the learning material in line with the regulation provided by the university (UNIMED, 2016). The feasibility of the innovated learning pack-

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

age was then judged both by chemistry lecturers (n=8) who have the experience in teaching analytical chemistry and by senior students (n=64) who studied Gravimetry topic in the previous year. The performance of the learning package was assessed in accordance with the standard given by Indonesian National Education Standards Board (*Badan Standar Nasional Pendidikan,* BSNP). Preparation and standardization of questionnaire were carried out by following the procedures explained previously (Situmorang & Sitorus, 2012). The questions raised in the questionnaire were provided based on the parameters for a learning material given by the BSNP. Assessment components consisted of questions to reveal the contents, extension, depth, design, and language with four options from strong to weak opinions. The questions were provided in multiple choice options with a very strong opinion of very good (score 4) down to a very weak opinion of very poor/bad (score 1). Chemistry learning material was then provided in printed and electronic format that was ready to be used as a learning media in the teaching of Gravimetry topic.

Guided Task Instructions and the Marking System for Gravimetry Topic

The guided task instructions for Gravimetry topic has been designed following the guidelines given for KKNI curriculum (Lecture material given by Professor Syawal Gultom, Rector UNIMED, 2016). There were six compulsory tasks relevant with sub topic of Gravimetry to be included in the class. The instruction for the tasks has been modified to optimize the students' potential for learning. Learning activities with guided tasks were designed to equip the students with necessary skills and to transform the learning process from the conventional lecture-centred to student-centred learning. Specific tasks, learning activities, and report format were provided in the learning material based on the guideline given by the university (UNIMED, 2016).

The six compulsory tasks assigned for the students were elaborated as follows. First, the learning package included the problem examples and drills for routine task suited to Gravimetry sub topic. Within the routine task, the students were asked to solve problems and submit the answer in the following week. Second, critical book report was prepared by giving copies of book chapters on Gravimetry topic from chosen Analytical Chemistry textbooks. The students were asked to analyse the contents of book chapters and submit the report following the format provided in the handout. Third, critical journal/research report was designed to analyse one out of five selected articles on Gravimetry topic. The students were asked to elaborate their opinion on the content of the article based on the instruction and submit their report via email. Fourth, idea engineering was designed to motivate the students to articulate their raw idea related to the subject matter they learn on Gravimetry topic. With the idea engineering task, the students were given a freedom to express their raw idea on the application of Gravimetry topic, and the report was submitted a month after Gravimetry time table. Fifth, the mini research task was carried out to do an experiment in the laboratory. The students were provided with a package of simple experiment on Gravimetry topic and were free to do the experiment. The marking system was based on how closed the value obtained is to the target value given by the laboratory instructor. Sets of mini research and the procedures on Gravimetry topic were given in the handbook, and the students were asked to choose one experiment from available topics and do the experiment in the laboratory, followed by a personal report. Sixth, the last task was designed as a project-based learning (PBL) on specific Gravimetry topic. The students were given the web link on PBL and the list of chemistry topics related to Gravimetry to be chosen for PBL. The schedule to submit every task and the marking system for submitted assignments are given in the lecture note. The student work was marked individually both from their assignments submission and the average grades of all tasks. All instructions for guided tasks have been integrated into developed chemistry learning material. Separated instructions were also available for students who were not using the developed chemistry learning material. The marking system for the guided task was provided for individual reports portfolio from submitted tasks based on the instruction given in KKNI curriculum (UNIMED, 2016). The marking scale for students' tasks is between 0 – 100.

Teaching and Learning Activities

The procedures in the teaching and learning activities consisted of doing a short training for lecturers, giving instruction for learning activities in the class, and conducting evaluation and marking system. A training was given to the lecturers to explain their involvement in the study, to give general procedures to use the learning package, and to choose the right method to deliver the chemistry subject in the class. Lecturers were assigned to select samples for experimental and control class, to distribute learning packages, to give instruction for guided tasks, to collect reports, and to motivate students to use the developed chemistry materials. The evaluations (pre-test and post-test) were carried out on allocated time at the end of the program. Students' achievement was measured from these evaluation tests. The marks for submitted assignments were collected from their performance to complete their tasks. Students' academic attitudes were also recorded.

In the implementation of teaching and learning activities, all students involved were treated equally without any discrimination, but the data were only taken from homogeneous samples after removing the outlier samples. A preliminary evaluation was performed before the teaching treatment was carried out, followed by the teaching and learning activities to both experimental classes and control class. The developed chemistry learning material with the guided task was used as learning media for experimental class, while existing chemistry textbook was used by the students in control class. During the teaching and learning activities, the students were asked to maximize their potential for self-learning to use the learning resources available in the university. First evaluation test (post-test 1) was carried out after completing all Gravimetry topic, followed by second evaluation test (post-test 2) one month after post-test 1 (Situmorang, Sitorus, Hutabarat, & Situmorang, 2015). The students were asked to submit the tasks at the scheduled due-date, and the penalty was applied for late submission.

Students Achievements and Academic Attitudes Measurement

Students' achievements were measured from student's ability to answer the question items in the objective evaluation test at the end of the teaching session. The evaluation test, consisted of 20 multiple choice tests with five options, was prepared to measure student performance on the pre-test, post-test 1 and post-test 2. The problems provided in the test have covered all Gravimetry topic. The test items varied in the level of difficulty following the procedures explained previously (Situmorang & Sitorus, 2012). The marking system for multiple choice test was counting the right answer, reducing points for the wrong answer, and converting the score to range scale of 0-100. Student's performance was measured by marking portfolio of submitted tasks. The students' competence was measured from the combination of the scores from the evaluation test and the submitted tasks (65:35) (UNIMED, 2016). Students' competence, ideally, has to be counted from their results to complete all subjects on chemistry. However, students' achievements reported in this study were only measured from learning activities on the teaching of Gravimetry topic.

Academic attitudes of every student were also investigated by the chemistry lecturers based on a subjective assessment of their involvement in teaching and learning activities and the judgment of their submitted report of the tasks. There were ten parameters being observed for students' academic attitudes, including: (1) communication ethics, (2) honesty, (3) responsibility, (4) cooperation and collaboration, (5) toughness, (6) caring, (7) discipline, (8), perseverance and persistency, (9) self-sufficiency and independency, and (10) learning initiative (UNIMED, 2016). The marking system has been made for each of them within the score of 1 to 4, with criteria starting from a very strong opinion with positive attitudes of very good (score 4), down to a very weak opinion with negative attitudes of very poor/bad attitudes (score 1). Students' academic attitudes were recorded in the semester academic transcript.

Results of Research

The Development of Innovation of Learning Material

An innovative learning material with guided task has been developed for Gravimetry topic. The total time allocation for learning activities was distributed for class lecture, laboratory works, self-study to complete the tasks, drills activities, and the evaluation test. The distribution of topics and sub-topics of Gravimetry and the type of tasks to be completed are shown in Table 1.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 1. Chemistry topics and sub-topics in Gravimetry and the type of guided task to be included in the learning activities.

No	Chemistry Topic	Name of Sub-Topic in Gravimety	Guided Tasks in Learning Activities
1	Introduction to Precipitation	- Mechanism of Precipitation - Nucleation - Crystal Growth - Aggregate Particle Growth - Crystal Purification (Coprecipitation and Post-Precipitation)	RT and CJR
2	Precipitation Process and Gravimetric Method	Forming the Precipitate (favouring growth over nucleation, coagulating colloid, and minimising impurity) - Separating and Rinsing Precipitate - Drying and Igniting Precipitate - Cooling and Weighing Precipitate - Composition of Product	RT, CBR
3	Precipitating Reagents	- Inorganic Reagents - Organic Reagents	RT, MR
4	Special Technique in Gravimetry	- Homogeneous Precipitation - Direct Volatilization - Indirect Volatilization	RT, IE, PR
5	Application of Gravimetry	- Calculation of Gravimetric Analysis - Determination of Sulphur - Determination of Chloride - Determination of Nickel - Determination of Carbon and Hydrogen	IE, MR, PR

RT = routine task, CBR = critical book report, CJR = critical journal/research report, IE =idea engineering, MR = mini research, and PR = project.

A package of learning material has been developed for Gravimetry topic. Every sub topic has a systematic arrangement consisting of an introduction, main topics with relevant illustration to support chemistry content, problem examples and exercises. The chemistry content has been enriched with contextual examples and the integration of multimedia into learning material. The learning package has been developed as the main learning resource for teaching and learning activities to complete the topics. The learning material has been developed from various learning resources such as textbook, the internet, academic journals, and laboratory manual to suit the need of students in the university. Integration of learning media and multimedia to support chemistry topic, integration of relevant laboratory works, a variation of problem examples and solution and preparation of evaluation test with the key answer were also included in the learning material package. Moreover, hyperlinks to relevant websites for future reading to support given tasks were also provided. Furthermore, the instructions for the tasks were prepared to guide the students to complete their assignments. Chemistry learning package was then made into flipbook to help students using the electronic material. The brief description of innovation that has been integrated into chemistry learning materials is summarized in Table 2.

Table 2. Description of innovation included in the chemistry learning materials for gravimetry topics in analytical chemistry.

No	Chemistry Topics	The descriptions of innovation that was integrated into the chemistry learning materials on Gravimetry topics
1.	Introduction to Precipitation	The development and innovation of learning material for Introduction to Precipitation was carried out by enriching the topic with local contents for the mechanism of precipitation, including the nucleation, crystal growth, aggregate particle growth and crystal purification via precipitation and post precipitation, followed by the integration of a short video on crystal growth. The chemistry material was equipped with virtual learning on crystal purification via precipitation and post precipitation. Learning media and a hyperlink to trusted and relevant websites for future reading on precipitation were also included, as well as the instructions for guided tasks for RT and CJR.
2.	Precipitation Process and Gravimetric Method	Chemistry topic of Precipitation Process and Gravimetric Method was developed to enrich the contents on forming the precipitate through favouring growth over nucleation, coagulating colloid, and, minimising impurity until the composition of compounds in the yield are known. The technique of separating and rinsing precipitate, drying and igniting precipitate, cooling and weighing precipitate was also demonstrated by using video and multimedia. The calculation of the composition of the product and the problem examples were also included. A hyperlink to trusted and relevant websites for future reading has been given. The instructions of guided tasks for RT and CBR were introduced. The developed learning material was equipped with test evaluation.
3.	Precipitating Reagents	The development of chemistry topic on Precipitating Reagents to be used in Gravimetric Method was provided. Contextual learning was applied to introduce inorganic and organic precipitating reagents. Set of mini research has also been provided with the use of precipitating reagents. The material was also equipped with a short video on how the precipitating reagents were selectively precipitate the target compound from mixture solutions. The developed learning material was equipped with hyperlinks to trusted and relevant websites for future reading on the application of Precipitating Reagents. The instruction for guided tasks of RT and MR was given.
4.	Special Technique in Gravimetry	The gravimetric method with the use of the special technique of homogenous precipitation, direct volatilization and indirect volatilization has also been introduced by using contextual examples. The technique was focused to equip the students with skills on the gravimetric techniques in real life. The enriched chemistry topic with local contents has been provided, such as the example of homogenous precipitation, direct volatilization and indirect volatilization, and made as a project. Within the project, the students can determine the target analyses in the samples. The material was equipped with example problem and solution, the evaluation test, and hyperlinks to relevant websites for future reading on solution Gravimetry. The instructions to do RT, IE and PR were formulated for Gravimetry Technique.
5	Application of Gravimetry	The chosen chemistry material related to the Application of Gravimetry has been developed. Among them are the Determination of sulphur, Determination of Chloride, Determination of Nickel, and Determination of Carbon and Hydrogen. The subject was accompanied by the integration of interactive multimedia as an example before the students dealing with the chemical on using Gravimetric determination. The enriched chemistry topic with local contents has been provided such as the example of Gravimetric determination, and the calculation of Gravimetric Analysis via the small project. Within the project, the students can determine the composition percentage of mixture compounds. The use of spread sheet on calculation process was also introduced. The material was equipped with example problem and solution, the evaluation test, and hyperlinks to relevant websites for future reading on solution Gravimetry. The instructions to do MR and PR were formulated.

Standardization of Innovative Learning Material

An innovative learning material with a guided task has been standardised based on the opinion of senior lecturers as well as senior students based on the procedures explained previously (Situmorang, et al., 2015). All of the respondents gave a positive response to the developed chemistry learning material (3.88±0.30) of which was assigned as very good (see the results in Table 3). The learning package has met the standard requirements of BSNP parameters regarding the content, extension, depth, design, and language.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 3. Respondents' (chemistry lecturers (L) and senior students (S)) opinion on the developed learning material of Gravimetry.

Components	Brief description of innovative learning material with guided task	Respondents' opinion* (M±SD)		
		L (n=8)	S (n=64)	Average
Content	- Completeness of chemistry contents	3.88±0.35	3.89±0.31	3.88±0.33
	- Accuracy of chemistry content	3.88±0.35	3.94±0.24	3.91±0.30
Extension	- Material is extended by integrating local contents, laboratory experiment, contextual application, learning media and strategy	3.63±0.52	3.89±0.31	3.76±0.41
	- Chemistry material is clearly derived	3.88±0.35	3.92±0.27	3.90±0.31
Depth	- Material is presented in good order: introduction, main concepts, problem example, drills, quiz, and hyperlink to trusted website	3.75±0.46	3.95±0.21	3.85±0.34
	- Concepts can be applied in real life	3.75±0.46	3.94±0.24	3.84±0.35
Design	- Suitability between the design layout with the target material	3.88±0.35	3.92±0.27	3.90±0.31
	- Presentation of illustration, figures, the tables and images	4.00±0.00	3.89±0.31	3.95±0.16
	- Involvement of learners in interactive study	4.00±0.00	3.95±0.21	3.98±0.11
Language	- Language is in accordance with the development of learner	3.88±0.35	3.97±0.17	3.92±0.26
	- Chemistry material is easy to read, language is simple and provides communicative massage	3.88±0.35	3.88±0.33	3.88±0.34
	- Language is straightforward, accurate on chemistry term and symbol	3.75±0.46	3.88±0.33	3.81±0.40
	Average	3.84±0.34	3.92±0.27	3.88±0.30

**Marking criteria: 4 = very good; 3 = good; 2 = poor, and 1 = very poor*

Implementation of Developed Learning Material in Class

The developed learning package has been implemented as a teaching and learning media in the experimental class, while existing textbook was used in the control class. Pre-test was carried out for both classes before teaching and learning activities being started. The students' achievement in the pre-test is presented in Table 4. Students' achievements in experimental class and control class were almost similar. The results revealed that the students did not fully understand the chemistry topic and they were ready to involve in different teaching and learning activities related to Gravimetry topic. Both hard copy and electronic material were distributed to the students in the experimental class. They were also given the instruction to use the innovative learning material based on the given guideline. After completing the learning sessions, the students were given the first evaluation test to measure their achievement on Gravimetry topic as summarized in Table 4.

Table 4. Students' achievements in Chemistry based on the ability to solve chemistry problems on pre-test, post-test 1 and post-test 2 for Gravimetry topic.

Evaluation Test	Students' achievements counted as the average score (M±SD) on Chemistry evaluation test							
	Experimental Class				Control Class			
	A (n=30)	C (n=30)	E (n=30)	Average	B (n=30)	D (n=30)	F (n=30)	Average
Pre-test	22.47±2.01	22.83±2.07	22.83±1.5	**22.71±1.86**	22.57±1.61	22.87±1.66	22.73±1.57	**22.72±1.61**
Post-test 1	83.63±4.51	82.67±4.13	83.37±4.1	**83.22±4.24**	75.60±4.99	77.00±5.86	77.43±4.68	**76.68±5.18**
Post-test 2	86.70±4.27	86.63±3.35	87.90±4.4	**87.08±4.00**	72.53±4.65	74.53±6.13	74.63±5.58	**73.89±5.45**
Learning Effectiveness (%)	104	105	105	**105**	96	97	96	**96**

A = Chemistry Education students in regular A class; B = Chemistry Education students in regular B class; and C = Chemistry Education students in regular C class; D = Chemistry Education students in non-regular class; E = Chemistry students in regular A class; and F = Chemistry students in regular B class

The results showed that students' achievement in experimental class was higher than that in control class. Students' answer sheets along with the sheets containing correct answers for solving problems were distributed to students as a feedback for future study. The announcement of time table for the second formative test was also given to the students to motivate them to review the subject matter. Students' results on post-test 2 are summarized in Table 4. The students' achievement in experimental class was also higher than that in control class. The effectiveness of the innovated learning material with guided tasks to improve students' achievement on chemistry was calculated by comparing their achievement in post-test 2 with post-test 1. In addition, learning effectiveness due to the use of innovative learning material in the experimental class was higher than in control class. Furthermore, the results indicated that students' achievement in chemistry, specifically on Gravimetry topic, improved significantly due to the developed learning package.

Learning Activities with Guided Tasks

The students have involved in the teaching and learning activities by attending the lecture, doing given tasks, and submitting the reports. Various learning activities have been carried out with the aid of guided tasks that have been integrated into the learning package. The observation showed that the students have achieved the knowledge and skills as summarised in Table 5.

Table 5. List of the knowledge and skills achieved by the students from guided tasks on Gravimetric analysis.

No	Type of Tasks	The knowledge and skills that have been achieved by the students reflected through their submitted guided tasks
1	Routine Task	• Searching and using various learning resources to study Gravimetric analysis • Improving the knowledge and skills in Gravimetric Technique, starting from preparation of the sample, a selection of precipitation reagents, purification and calculation of unknown target in real samples
2	Critical Book Report	• Having the ability to analyse the contents of chemistry topic in various textbooks that are suited to Gravimetric topic and sub topic • Being able to review the textbooks and to explain the strength in the contents of the book to be applied in Gravimetric analysis • Having the ability to choose the right textbook as learning resource based on their need

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

3	Critical Journal/ Research Report	• Having adequate skills to search and to obtain relevant articles on the use of Gravimetry technique in Analytical Chemistry • Being able to read the original article from scientific journals and to share their scientific view based on their reading ability • Having the skill to report main scientific contribution and investigation from the research articles
4	Idea Engineering	• Having the ability to explore the scientific view of raw idea on the Technique and Application of Gravimetry in real life • Being able to express future development and modification in Gravimetry analysis suited to modern analysis • Having the ability to present a sophisticated idea and unexpected scientific view with high dimensional on Gravimetry analysis
5	Mini Research	• Having the knowledge and skills on Gravimetry Technique in the determination of target analyses in an unknown sample • Being able to set Gravimetry method and procedure to determine target analysis from the mixture in the real sample • Having adequate knowledge to collect and to analyse analytical data and to write research report from their investigation
6	Mini Project	• Being able to write laboratory procedures for mini research on Gravimetry analysis for special purposes • Having skills and knowledge to complete a mini project on Gravimetry analysis and being able to handle the analytical product correctly • Having the knowledge to write a standard report from a mini project

The guided tasks, which are integrated into the learning material, have improved students' knowledge and skills in chemistry. The students have submitted their tasks on time and the score of the portfolio has been collected. The average results for both experimental class and control class are summarized in Table 6. It was found that all students were able to complete the tasks on Gravimetry topic. The final score of the given tasks in experimental class (83.43±4.71) was higher than that in control class (74.75±5.31). Integration of guided task in the learning package was very helpful for students to focus their learning on Gravimetry topic. The assignments reports submitted by the students in experimental class were systematically prepared. The availability of the tasks in the developed learning material has driven the students to study independently. The students become familiar in searching and finding the right documents to be used to support the given tasks. Students' ability to write and organize their assignments also improved. The study displayed that the students tended to be self-learners because the facility provided in the innovative learning material is adequate to help them to improve their competence in chemistry.

Table 6. Students' performance based on the score given from submitted tasks portfolio on Gravimetric topic.

Type of guided tasks	Students' performances counted as the average score (M±SD) on guided task portfolio							
	Experimental Class				Control Class			
	A (n=30)	C (n=30)	E (n=30)	Average	B (n=30)	D (n=30)	F (n=30)	Average
RT	82.10±16.37	87.17±9.87	83.50±9.71	**84.26±11.98**	76.63±9.59	81.50±4.71	78.50±9.68	78.88±7.99
CBR	86.63±7.42	83.97±5.44	80.30±6.25	**81.63±6.37**	72.50±11.10	65.30±10.66	71.43±11.18	69.74±10.98
CJR	88.30±8.45	87.33±8.67	82.43±10.57	**86.02±9.23**	75.27±6.27	79.57±2.10	75.00±6.61	76.61±4.99
IE	78.33±7.62	81.03±6.81	77.83±6.04	**79.07±6.82**	70.00±10.07	72.07±14.47	72.43±8.90	71.50±11.14
MR	84.17±8.28	86.47±8.97	81.57±10.99	**84.07±9.42**	76.90±10.29	74.93±10.15	81.57±11.60	77.80±10.68
PR	84.17±7.14	85.00±9.04	85.47±10.63	**84.88±8.94**	74.20±11.08	72.13±10.58	75.57±10.91	73.97±10.86
Average	83.28±5.78	85.16±3.48	81.85±4.85	**83.43±4.71**	74.25±5.13	74.25±5.15	75.57±5.66	74.75±5.31

A = Chemistry Education students in regular A class; B = Chemistry Education students in regular B class; and C = Chemistry Education students in regular C class; D = Chemistry Education students in non-regular class; E = Chemistry students in regular A class; and F = Chemistry students in regular B class
RT = routine task, CBR = critical book report, CJR = critical journal/research report, IE = idea engineering, MR = mini research, and PR = project.

The students were also involved in a progression of learning to complete the task, starting with a simple and easy task to a complex and difficult task based on the order of Gravimetry sub topics. The average score of the submitted routine tasks was summarised in Table 6. The students' performance reflected through the portfolio of the routine task in experimental class (84.26±11.98) was found higher compared to those in control class (78.88±7.99). The students in the experimental class were interested in using the developed learning material in the teaching and learning activities. It was also discovered that the students were able to review the textbooks based on the given guideline. Various opinions have been reported from the textbook. The average score of CBR in experimental class and control class were shown in Table 6, where the students in experimental class (81.63±6.37) scored higher than that in control class (69.74±10.98). The students were also trained to search and read articles on Gravimetry technique in published journals and were then assigned to choose three articles on Gravimetric determination and to elaborate their critique regarding those articles as CJR task. The students were able to analyse the contents of the articles clearly and summarised them on their own as CJR reports. The score from submitted tasks is presented in Table 6. The score of CJR task in experimental class (86.02±9.23) was also higher than that in control class (76.61±4.99). It has been noted from IE report that students suggested a possible modification to be made in Gravimetry analysis to make it suited to modern techniques. Students' score for IE task in experimental class (79.07±6.82) was also higher than that in control class (71.50±11.14). The students' IE reports in relevance with Gravimetry method were mostly realistic to be implemented in real life.

Mini research was conducted as a laboratory work on gravimetric analysis. The research was set to improve students' skills on gravimetry determination. Sets of gravimetry experiments have been offered in the developed learning material that needed to be completed in two-to three-hour laboratory work. The students were using gravimetry technique for determining the target analyses of sulphur, chloride and nickel in a real sample. Students achievement for mini research in experimental class (84.07±9.42) and control class (77.80±10.68) are summarized in Table 6. The ability of students to collect the data and to write standard research reports from their investigation was clearly demonstrated. Marking system for research task was based on the ability to write a report of an experiment and how close their unknown sample recovery was to a given "target" sample. The PBL was also applied for the students' task, where the students were assigned to complete the project on the application of Gravimetry analysis. The description of the project to be done as well as the hyperlink to another project were available in the learning package. The students were free to choose the project and required to submit the report a week after completing the project (Siew, Chin, & Sombuling, 2017). Students' achievements reflected through the submitted project are presented in Table 6, where the students' average score for experimental class (84.88±8.94) was found higher than that obtained in control class (73.97±10.86). It was found that the students were very interested to do the project for it was designed differently from the existing laboratory work. The excitement was displayed when they were successful to determine the target analyses. The PBL was able to equip the student with adequate knowledge of gravimetry technique. The PBL was believed to be able to give deep understanding on Gravimetric analysis.

Students' Competence and Academic Attitudes on Chemistry

Students' competence reflected through the score accumulated from students' achievements and students' attitudes is presented in Table 7. Students' achievements are derived from the combination of students' achievement in post-test 1 and the performance obtained from guided tasks (65:35) (UNIMED, 2016). Students' achievement in experimental class (85.73±3.87) was higher than that in control class (74.87±5.22). The results revealed that the improvement in the students' competence was contributed by the use of innovative learning material as a learning resource in experimental class. Similarly, both systematic presentation of Gravimetric topics in developed learning material and the availability of relevant illustrations integrated into a learning package help the students to learn chemistry effectively. The relevant examples provided at the end of every subject in the learning package make the chemistry topic easy to understand. Learning facilities – such as multimedia, hyperlink, illustrations and images – integrated in the chemistry material were able to motivate the students to maximise their learning potential through the active learning. The strategy provided in the developed learning material improved the students' curiosity to learn chemistry. The developed learning material with guided tasks was also found to be able to shift students' learning style from lecturer-orientated to student-orientated learning. The availability of the tasks in the learning package has eased the learner to

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

search for relevant materials related to the topic they learned. Furthermore, students' ability to write, organize and complete the assignment were also improved.

In addition to students' competency, the attitudes of the students were also judged subjectively by the assigned lecturers from cumulative activities during their study time. Students' attitudes in the class were observed, whereas some were judged subjectively from their report performance (Alkan, 2013). The academic attitudes were subject to subjective judgment from ten parameters during the learning activities in the class, group discussion, self-study, tasks performance and submitted assignments. The average results for students' academic attitudes are summarized in Table 7. The results showed that students' academic attitudes in the experimental (3.52±0.21) and control classes (3.46±0.19) were all categorized as very good.

Table 7. Students' competence in the Department of Chemistry, FMIPA, State University of Medan at the academic year of 2016/2017.

No	Outcomes	Score of students' competence and academic attitudes (M±SD)							
		Experimental Class				Control Class			
		A (n=30)	C (n=30)	E (n=30)	Average	B (n=30)	D (n=30)	F (n=30)	Average
1	Students Achievement*	85.63±4.21	85.25±3.40	86.31±4.01	**85.73±3.87**	73.59±4.61	75.40±5.89	75.61±5.16	74.87±5.22
2	Academic Attitudes**	3.45±0.22	3.56±0.22	3.54±0.18	**3.52±0.21**	3.41±0.20	3.43±3.53	3.53±0.18	3.46±0.19

A = Chemistry Education students in regular A class; B = Chemistry Education students in regular B class; and C = Chemistry Education students in regular C class; D = Chemistry Education students in non-regular class; E = Chemistry students in regular A class; and F = Chemistry students in regular B class
**Students' achievement derived from the combination of evaluation test score and the average score of guided tasks portfolio (65:35)*
***The academic attitudes are lecturers' subjective judgment from ten parameters within the criteria of: (4) very good, (3) good, (2) satisfaction, and (1) very poor/bad.*

Discussion

The learning material developed in this study has been designed based on KKNI curriculum (UNIMED, 2016). Innovation and guided tasks integrated into the learning material have been arranged systematically suited to the need of university students. The lecturers and senior students agreed to book parameters and gave a positive contribution to the developed chemistry learning material. A package of learning material was categorised as very good and has met the standard requirements given by BSNP.

The development of an innovative learning material with guided tasks has a positive impact on the teaching and learning process, specifically on improving students' achievement (Situmorang, et al., 2015). Learning innovation conducted in this study has enriched the chemistry contents with contextual examples and the task instructions have supported the learning activities in chemistry (Onen & Ulusoy, 2014). Implementation of innovative learning material in the teaching of Gravimetry topic has proven to be able to motivate the learners to maximise their potential for studying chemistry. The results were similar to other innovations, such as modification of laboratory experiment, integration of learning media and multimedia (Noor & Ilias, 2013) and the development of learning method (Yang & Sima, 2013). Innovation was able to make learning activity efficient and effective to achieve professional skills (Maaß & Artigue, 2013; Trifilova, et al., 2016). Students' learning potential has been optimised by the aid of developed learning package (Tomlinson, 2012).

The developed chemistry learning material with guided task has demonstrated to be a good strategy to improve students' achievement on chemistry. The task on critical book report has brought students' comprehension on textbooks analysis. The students were provided with the knowledge of detailed explanations from specific book chapter. Students' critical thinking was improved significantly due to the developed learning material (Bailin, 2002; Hager, Sleet, Logan, & Hooper, 2003; Lee, Green, Johnson, & Nyquist, 2010). It has been evaluated from the submitted tasks which indicated that the students have become familiar with searching and selecting various learning resources to complete their routine tasks. Most of them only relied on the developed learning packages. The availability of problem examples presented in a learning package help the students to complete their routine task. The drills provided at the end of sub-topic were also sufficient for the students to self-master the calculation examples which cover the subject of calculation of the composition of the product by using gravimetric analysis, the determination of sulphur, chloride, nickel, carbon and hydrogen in mixture compounds, in solution stoichiometry.

Critical thinking is needed in the teaching of science and can be made through the assessment of textbook (Zemple´n, 2007). There are four electronic Analytical Chemistry textbooks used for CBR task in this study. The chapter of Gravimetric Analysis has been distributed to students for them to analyse the contents of the Gravimetric topic and to give critical reports on the strength of every book they read. Many students prepared their review in short (3-4 pages) reports, while some of them who had critical skills with evaluative writing made complete and long (6-10 pages) reports. This strategy has familiarized the students to choose the right book to study chemistry. Critical journal/research report was very important on the students' preparation for engaging the primary literature such as current and new articles related to Gravimetry analysis. It has been reported that reading the primary literature enhances student learning in writing, interpreting the figures and data, as well as their critical thinking skills from evaluating the evidence and critiquing the arguments (Kovarik, 2016; Tu¨may, 2016). The given tasks have changed students' approach over the contents of the articles for future application (Murray, 2014). The students were able to share the scientific view and the contribution given by the research report. The investigation presented in the article has been clearly described in the report. However, some students were found having difficulties to express CJR report, and they just rewrote the content from journal abstract and conclusions. The students were able to express their vision of science through the IE report (Haglund & Hultén, 2017). In this study, the students were given a freedom to express their future expectation on the use of Gravimetry in analysis through their idea engineering. The students gave their view on special technique in Gravimetry and the application of Gravimetry in real life. A few number of students presented unexpected scientific view with high dimension on Gravimetry topic. Many students expressed their raw idea in normal format and a few of them gave sophisticated idea which was difficult to be implemented nowadays.

The strategy to introduce a research-oriented subject was successfully conducted by the incorporation of research experience into the curriculum (Thurbide, 2016) for instance, through guided tasks such as mini project and mini research. The task gave practical exposure to work with the analytical instrument on Gravimetry method, including overcoming troubleshooting problem existed in Gravimetry applications. The students were very enthusiastic to do the project in the laboratory, so at the end, it contributed positively to the students' development of knowledge, skills and improvement of learning output (Lakhvich, 2017; Robinson, 2013). The chemistry which has been taught clearly like a language art makes the students be motivated to learn (Laszlo, 2013). The contribution of developed learning material has been helpful to guide the student to learn chemistry systematically. The availability of innovation in the learning package motivated the students to become independent learners. However, it has been admitted that few students faced some difficulties in studying with the new learning approach since they preferred their old learning style which was lecturer-oriented learning. Another problem existed was that some students in a group have submitted works similar from one to another.

Conclusions

An innovative, complete and standard chemistry learning material with guided tasks for the Gravimetric topic has been developed to suit the need of undergraduate students. Set of learning package contains adequate chemistry topics accompanied with multimedia and the hyperlinks for self-learning and is prepared as printed and electronic format. Guided tasks instruction provided in the learning material is found to be able to guide the students to complete the assignments given for relevant sub-topics. An innovative learning package has been implemented as learning media to support learning activities to study chemistry. The developed learning package helps the students to learn chemistry systematically and makes the study become more enjoyable, resulting in the improvement of students' competence. Students' skills in collecting data and writing reports are developed by completing the guided tasks. It has been observed that the students tend to work together in discussing the academic ideas and solving problems related to chemistry. The results reveal that both students' competence and academic attitudes in the experimental class are higher than that in the control class. Learning facilities provided in the developed learning package make the students become active learners.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Acknowledgment

This research was supported by Directorate Research and Community Service, Directorate General Research and Development Reinforcement, Ministry of Research, Technology and Higher Education of the Republic of Indonesia, Under Tim Pascasarjana, with contract No.045A/UN33.8/LL/2017. The author would like to express the gratefulness to Nora Susanti, Kawan Sihombing, Anna Juniar, Lecturers in The Department of Chemistry, Faculty of Mathematics and Natural Science (FMIPA), Universitas Negeri Medan who have helped during the teaching activities, and Isli Iriani Pane from the Language Centre of Universitas Negeri Medan who have helped in English editing process.

References

Alkan, F. (2013). The effect of alternative assessment techniques on chemistry competency perceptions and chemistry success of prospective science teachers. *Journal of Baltic Science Education, 12* (6), 774-783.
Arabacioglu, S., & Unver, A.O. (2016). Supporting inquiry-based laboratory practices with mobile learning to enhance students' process skills in science education. *Journal of Baltic Science Education, 15* (2), 216-231.
Bailin, S. (2002). Critical thinking and science education, *Science& Education, 11*, 361–375.
Betten, A. W., Roelofsen, A., & Broerse, J. E. W. (2013). Interactive learning and action: Realizing the promise of synthetic biology for global health. *Systems and Synthetic Biology, 7*, 127–138.
Chamizo, J. A. (2013). A new definition of models and modeling in Chemistry's teaching. *Science & Education, 22*, 1613-1632.
Christian, G. D., Dasgupta, P. S., & Schug, K. (2013). *Analytical Chemistry*. *7th ed*. John Wiley & Sons.
Chroustova, K., Bilek, M., & **Šorgo**, A. (2017). Validation of theoretical constructs toward suitability of educational software for Chemistry education: Differences between users and nonusers, *Journal of Baltic Science Education, 16* (6), 873-897.
Dagienė, V., & Gudonienė, D. (2015). The innovative methods for massive open online course design. *Baltic Journal of Modern Computing, 3* (3), 205-213.
Fiksl, M., Flogie, A., & Aberšek, B. (2017). Innovative teaching/learning methods to improve science, technology and engineering classroom climate and interest. *Journal of Baltic Science Education, 16* (6), 1009-1019.
Hadjilouca, R., Constantinou, C. P., & Papadouris, N. (2011). The rationale for a teaching innovation about the interrelationship between science and technology. *Science & Education, 20*, 981-1005.
Hager, P., Sleet, R., Logan, P., & Hooper, M. (2003). Teaching critical thinking in undergraduate science courses. *Science & Education, 12*, 303–313.
Haglund, J., & Hultén, M. (2017). Tension between visions of science education. The case of energy quality in Swedish Secondary Science curricula. *Science & Education, 26*, 323–344.
Harris, D. C. (2015). *Quantitative chemical analysis*. 9th ed., New York: W.H. Freeman and Company.
Hosler, J., & Boomer, K. B. (2011). Are comic books an effective way to engage nonmajors in learning and appreciating science? *CBE-Life Sciences Education, 10*, 309-317.
Jacob, C.C., Dervilly-Pinel, G., Biancotto, G., & Le Bizec, B. (2014). Evaluation of specific gravity as normalization strategy for cattle urinary metabolome analysis. *Metabolomics, 10*, 627–637.
Jahangiri, M., & Hajian, R. (2013). Creative chemistry teaching. *Asian Journal of Chemistry, 25* (1), 377-380.
Jose, A., & Broekaert, C. (2015). Daniel C. Harris: Quantitative chemical analysis. 9th ed., *Analytical and Bioanalytical Chemistry, 407*, 8943–8944.
Khairnar, C. M. (2015). Advance pedagogy: Innovative methods of teaching and learning. *International Journal of Information and Education Technology, 5* (11), 869–872.
Kovarik, M. L. (2016). Use of primary literature in the undergraduate analytical class. *Analytical and Bioanalytical Chemistry, 408*, 3045–3049.
Lakhvich, T. (2017). Student research: Acquiring knowledge about the nature and process of science. *Journal of Baltic Science Education, 16* (6), 832–835.
Laszlo, P. (2013). Towards teaching chemistry as a language. *Science & Education, 22*, 1669–1706.
Lee, A. D., Green, B. N., Johnson, C. D., & Nyquist, J. (2010). How to write a scholarly book review for publication in a peer-reviewed journal a review of the literature. *The Journal of Chiropractic Education, 24* (1), 57–69.
Lee, P. C., Lin, C. T., & Kang, H. H. (2016). The influence of open innovative teaching approach toward student satisfaction: A case of Si-Men Primary School. *Quality & Quantity*, 50 (2), 1-17.
Leito, I., Helm, I., & Jalukse, L. (2015). Using MOOCs for teaching analytical chemistry: Experience at University of Tartu. *Analytical and Bioanalytical Chemistry, 407*, 1277–1281.
Liu, A., Hodgson, G., & Lord, W. (2010). Innovation in construction education: The role of culture in e-learning. *Architectural Engineering and Design Management, 6*, 91–102.
Maaß, K., & Artigue, M. (2013). Implementation of inquiry-based learning in day-to-day teaching: A synthesis. *ZDM Mathematics Education, 45*, 779–795.

Mari, J. S., & Gumel, S. A. (2015). Effects of jigsaw model of cooperative learning on self-efficacy and achievement in chemistry among concrete and formal reasoners in colleges of education in Nigeria. *International Journal of Information and Education Technology, 5* (3), 196–199.

Murray, T. A. (2014). Teaching students to read the primary literature using POGIL activities. *Biochemistry and Molecular Biology Education, 42*, 165–73.

Noor, M. M, & Ilias, K. (2013). Practice teaching and learning using interactive multimedia innovation for non-optional teachers teaching in music educations. *Academic Research International, 4* (2), 338–346.

Onen, A. S., & Ulusoy, F. M. (2014). Developing the context-based chemistry motivation scale: Validity and reliability analysis. *Journal of Baltic Science Education, 13* (6), 809–820.

Osman, K., & Vebrianto, R. (2013). Fostering science process skills and improving achievement through the use of multiple media. *Journal of Baltic Science Education, 12* (2), 191–204.

Robinson, J.K. (2013). Project-based learning: Improving student engagement and performance in the laboratory. *Analytical and Bioanalytical Chemistry, 405*, 7–13.

Rusek, M., Starkova, D., Chytry, V., & Bilek, M. (2017). Adoption of ICT innovations by secondary school teachers and pre-service teachers within chemistry education. *Journal of Baltic Science Education, 16* (4), 510–523.

Siew, N. M., Chin, M. K., & Sombuling, A. (2017). The effects of problem-based learning with cooperative learning on pre-schoolers' scientific creativity. *Journal of Baltic Science Education, 16* (1), 100–112.

Simatupang, N. I., & Situmorang, M. (2013). Innovation of senior high school chemistry textbook to improve students' achievement in chemistry. *Proceeding of the 2nd International Conference of the Indonesian Chemical Society 2013 October, 22-23th 2013*, pp. 44–52, Universitas Islam Indonesia, Yogjakarta, Indonesia.

Sinaga, M., Limbong, F.M., & Situmorang, M., (2016), Inovasi bahan ajar berbasis kontekstual dalam bentuk elektronik (*e-book*) untuk pengajaran sistem kesetimbangan. [Innovation of learning material with contextual based in electronic book (e-book) on the teaching of equilibrium]. *Prosiding SEMIRATA Bidang MIPA 2016; BKS-PTN Barat, Palembang 22-24 Mei 2016,* pp. 1684-1690, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Sriwijaya, Palembang, Indonesia.

Situmorang, M., & Sitorus, C.J. (2012). The innovation of demonstration method to increase student's achievement in the teaching of solubility product. *Jurnal Penelitian Bidang Pendidikan, 18* (1), 1–7.

Situmorang, M., & Situmorang, A.A. (2014). Efektivitas modul pembelajaran inovatif untuk meningkatkan hasil belajar pada pengajaran laju reaksi [The effectivity of innovative learning module to improve students' performance on the teaching of reaction rate]. *Jurnal Penelitian Bidang Pendidikan, 20* (2), 139–147.

Situmorang, M., Purba, J., & Sihombing, R.H. (2016). Pengembangan bahan ajar kimia inovatif dan interaktif berbasis multimedia untuk pengajaran senyawa aromatis [The development of innovative and interactive chemistry learning material with multimedia on the teaching of aromatic compound]. *Prosiding SEMIRATA Bidang MIPA 2016; BKS-PTN Barat, Palembang 22-24 Mei 2016,* pp. 1667–1673, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Sriwijaya, Palembang, Indonesia.

Situmorang, M., Sinaga, M., Sitorus, M., & Sudrajat, A., (2017), Inovasi bahan ajar interaktif berbasis multimedia untuk meningkatkan kompetensi mahasiswa pada pengajaran kimia analitik dasar [Innovation of interactive learning material with multimedia to improve students' competence on the teaching of Analytical chemistry]. *Prosiding Seminar Nasional dan Rapat Tahunan BKS PTN-B Bidang MIPA* di Ratu Convention Center (RCC) Kota Jambi, Jambi, Tgl 12 - 14 Mei 2017, pp. 1796-1806. http://semirata2017.mipa.unja.ac.id/wp-content/uploads/2017/11/Prosiding-Kimia_Updated.pdf.

Situmorang, M., Sitorus, M., Hutabarat, W., & Situmorang, Z. (2015). The development of innovative chemistry learning material for bilingual Senior High School students in Indonesia. *International Educational Studies, 8* (10), 72–85.

Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2013). *Fundamentals of Analytical Chemistry*. 9th ed., international ed. Brooks/Cole, Cengage Learning.

Slabin, U. (2013). Teaching general chemistry with instructor's screen sharing: Students' opinions about the idea and its implementation. *Journal of Baltic Science Education, 12* (6), 759–773.

Tatli, Z., & Ayas, A. (2013). Effect of a virtual chemistry laboratory on students' achievement. *Educational Technology & Society, 16* (1), 159–170.

Thurbide, K. B. (2016). Incorporating analytical research experience into the undergraduate curriculum. *Analytical and Bioanalytical Chemistry, 408*, 5397–5401.

Tomlinson, B. (2012). Materials development for language learning and teaching. *Language Teaching, 45* (2), 143–179.

Trifilova, A., Bessant, J., & Alexander, A. (2016). Innovating innovation management teaching. Proceeding of The XXVII ISPIM Innovation Conference, Porto, Portugal on 19-22 June 2016.

Tu¨may, H. (2016). Emergence, learning difficulties, and misconceptions in chemistry undergraduate students' conceptualizations of acid strength. *Science & Education, 25*, 21–46.

UNIMED, (2016). *Kurikulum Berorientasi Kerangka Kualifikasi Nasional Indonesia* (KKNI) [Indonesian National Qualifications Framework Curriculum]. Universitas Negeri Medan, Medan, Indonesia.

Valcárcel, M. (2016). Quo vadis, analytical chemistry? *Analytical and Bioanalytical Chemistry, 408*, 13–21.

Varghese, J., Faith, M., & Jacob, M. (2012). Impact of e-resources on learning in biochemistry: First-year medical students' perceptions. *BMC Medical Education, 12*, 21–29.

Yang, Q., & Sima, Y. (2013). Innovation on teaching methods of foundation engineering course. *Applied Mechanics and Materials, 438-438*, 2006-2008.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Zemple´n, G.A. (2007). Conflicting agendas: critical thinking versus science education in the international baccalaureate theory of knowledge course. *Science & Education, 16*, 167–196.

Zhang, S., & Zhang, X. (2014). Teaching analytical chemistry in China: Past, present, and future perspectives. *Analytical and Bioanalytical Chemistry, 406*, 4005–4008.

Received: *March 20, 2018* Accepted: *June 06, 2018*

Manihar Situmorang	Dr. Professor. Department of Chemistry, Faculty of Mathematics and Natural Sciences (FMIPA), State University of Medan, Medan, North Sumatera, Indonesia, 20221. Phone: (062)-61-6613365, Faximile: (062)-61-6613319, E-mail: msitumorang@unimed.ac.id
Marudut Sinaga	Ph.D Student, Department of Chemistry Education, Graduate Study Program (Program Pascasarjana), State University of Medan, Medan, North Sumatera, 20221 Indonesia.
Jamalum Purba	Ph.D Student, Department of Chemistry Education, Graduate Study Program (Program Pascasarjana), State University of Medan, Medan, North Sumatera, 20221 Indonesia.
Sapnita Idamarna Daulay	M.Sc Student, Department of Chemistry Education, Graduate Study Program (Program Pascasarjana), State University of Medan, Medan, North Sumatera, 20221 Indonesia.
Murniaty Simorangkir	Dr. Senior Lecturer, Department of Chemistry Education, Graduate Study Program (Program Pascasarjana), State University of Medan, Medan, North Sumatera, 20221 Indonesia.
Marham Sitorus	Dr. Senior Lecturer, Department of Chemistry, Faculty of Mathematics and Natural Sciences (FMIPA), State University of Medan, Medan, North Sumatera, 20221 Indonesia.
Ajat Sudrajat	Dr. Senior Lecturer, Department of Chemistry, Faculty of Mathematics and Natural Sciences (FMIPA State University of Medan, Medan, North Sumatera, 20221 Indonesia.