Implementation of Innovative Learning Material With Project to Improve Students Performance in The Teaching of Complexometry Titration

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Abstract. The implementation of innovative learning material with project-based in the teaching of Analytical Chemistry is very relevant for discussion because the knowledge in the field of analysis becomes a skill that must be possessed by students after completing their studies. The aim of the research is to implement an innovative learning material with project to improve students' performance in the teaching of Complexometry titration topic. The research steps are consisted of providing sets of standard learning materials containing mini projects and learning media on Complexometry titration topic, and implementation of innovative learning material in the class. Research results showed that sets of learning packages containing of mini projects for Complexometry titration topic have been developed suited to the KKNI curriculum. The facility available in a learning package adequate to guide the student to learn chemistry independently and students centre learning style was achieved. Project examples and the videos provided in the learning package are found effective to guide the students to construct their own projects. The developed learning package motivated the students to learn chemistry topic and guide the students for independent learners. The developed learning material with project has been proved to be able to improve students' performance in Analytical chemistry, where students knowledge and skills are developed**..**

Keywords: Innovative learning, Project based learning, students' competence, Analytical Chemistry.

1 Introduction

An afford to chose the right teaching and learning strategy in the teaching of chemistry topic is crusial to discuss as it is known that the knowledge and skills are involved for chemist [1]. The teaching and learning paradigm need to ajust to support the enactment of competence curriculum suited to Indonesian National Qualifications Framework (*Kerangka Kualifikasi Nasional Indonesia*, KKNI) [2]. The policy has been stated in Universitas Negeri Medan to equalize, juxtapose and integrate the world of work with university curriculum, including an Analytical chemistry. Therefore, innovation in the teaching and learning have to be made for all subjects in the implementation of a competence-based curriculum suited to KKNI. Various strategies have been carried out to improve student learning outcomes, including the use of

MSCEIS 2019, October 12, Bandung, Indonesia

DOI 10.4108/eai.12-10-2019.2296541

teaching-learning methods and strategies [3-5], the application of innovations in learning, and the use of learning resources [6-8]. Innovation in teaching and learning is designed to attract students' interest to learn optimally, it is a strategy to empower optimally the available learning resources in achieving the targeted competencies [9].

The application of innovative learning is very appropriate for science learning, including for teaching chemistry. Learning innovation can be done by following the latest advance technologies that are relevant to the needs of students, and in accordance with the development of students [10]. Various learning innovations have successfully been carried out in chemistry teaching, and they are proven to be very effective in improving student learning outcomes [11-13]. One of the very important subject for chemistry students is Analytical chemistry [14,15]. The subject is needed to develop students knowledge and skills on qualitative and quantitative determination [16]. The skills in the field of analysis become one of the competencies that must be possessed by students after completing the study [17]. The students are expected to have adequate knowledge and skills to use chemistry tools and to set laboratory experiments to determine the target compound precisely. Thus, the teaching of Analytical chemistry must be carried out optimally in order to achieve the competence in the field of chemical analysis. One of the strategy that can be done to improve student performance in the analytical field is to apply project-based learning [18-20].

Project-based learning is a very challenging method for science students because it can bring the students closer to the real world, namely the application of theory to practice in the field of chemical analysis [21,22]. It has successfully been used in science teaching including teaching of chemistry. Various skills can be built through project-based learning, including the problem solving, inquiry and discovery [23-25]. This learning model can also build students' thinking skills, the ability to synthesize, to analyze and to conclude experiment results [26]. Thus this learning model is very appropriate to be applied to the teaching of Analytical chemistry. The purpose of this study is to implement an innovative learning material with project to improve students' performance in the teaching of Complexometry titration topic. It is hoped that there will be an independent learning process through innovative learning so that the teaching and learning activities will focus on students, which in turn can improve students' competence on chemistry.

2 Experimental

The research is conducted at Department of Chemistry, Universitas Negeri Medan (State University of Medan), Medan, North Sumatera, Indonesia, at accademic year 2018/2019. The population are including experience chemistry lecturers and undergraduate chemistry students. The sample is purposively selected from bilingual chemistry students that are enrolled on Basic Analytical Chemistry subject. The study is assigned as research and development on project based learning. The procedures are conducted followed the procedures explained previously [23,24,27], they are including: (1) need analysis of requirement for Complexometry titration topic, (2) the development of an innovative learning material with project, and (3) Implementation of the developed learning material in the classto improve students' performance.

Needs analysis was carried out by comparing the chemistry topic with target competency, considering the relevant projects, and providing class activities. The project development stages are including of enriching the chemistry learning materials, integration of sets of relevant and contextual projects into the learning package, validation process to produce a standard chemistry learning material. Validation of the project is carried out by using expert lecturers followed by trial. Implementation of the learning material was conducted to bilingual students, where the students are given the developed learning material and instructional procedures, followed by a given task to design the projects, to conduct project learning and to submit the reports at a given deadline schedule. The research instruments used in this study are including the questionnaire in Likert scale along with observation sheet of process skills. The results data in this study are obtained from direct observation to students activities, marking of submitted reports, and students' performance in Analytical chemistry..

3 Results and Discussion

3.1. Development of Innovative Learning Material

The development of chemistry teaching materials for Complexometry titration topic has been carried out based on the suitability of the competency standard contained in the KKNI Curriculum. The learning activities to achieve these goals is done through project-based learning. The students is expected to be skilled in carrying out analysis, such as conducting titration project for the determination of target analyte in the given sample. One of the topics of Basic Analytical Chemistry is Complexometry Titration **[**28,29**]**. The cemistry material for Complexometry titration has been developed suited to the university competence based curriculum with KKNI approach.

There are seven sub-topics are listed and enriched in the learning material of Complexometry titration topic, which have confirmed adequate to be taught for undergraduate students, they are (1) Introduction to Complexometry titration, (2) Formation of complex compounds and their uses, (3) EDTA and metal ion complexes and conditional formation constants, (4) Complexometry titration using EDTA and determination of equivalent points, (5) Titration techniques using EDTA for quantitative detemination, (6) Protective compound (masking and demasking), and (7) Complexometry titration application [30]. Within the chemistry contents, there are nine sets of projects examples and two sets of learning medias are integrated to the learning package in accordance with the sub-topic of Complexometry titration, and they are believed to be relevant for helping undergraduate students to learn chemistry. The learning facilities such as the drills, evaluation test, and the hyperlinks to relevant and trustworthy website are also provided in the learning set. The chemistry learning package was then prepared in hard copy and softcopy formats. Chemical materials and projects available in teaching materials are complete and can be used by students for independent learning. The hyperlinks to relevant websites are also provided as a reference for increasing the knowledge in the field of Complexometry titration. The descriptions of an innovative learning materials from the development results, the projects and media integrated in the chemistry teaching materials are summarized in Table 1.

Table 1. Description of sub topic, type of innovation and relevant projects and media that are integrated for Complexometry titration topic.

No	Sub-Topic	Description of Innovative Learning Materials with Project and Multimedia	Projects and Media
1	Introduction to Complexometry Titration	Learning material for Complexometry titration, equipped with laboratory experiments, video and multimedia	Teaching media 1
2	Formation of complex compounds and their uses	Laboratory experiments (project) explaining formation of complex compounds with metal and their uses.	Teaching media 2
3	EDTA and Metal Ion Complexes and Conditional Formation Constants	Laboratory experiments (project) for titration by using EDTA and metal ion complexes, conditional formation constants and relevant indicators	Project 1 and 2
4	Complexometry Titration Using EDTA and Determination of Equivalent Points	The project) equipped with video, flash animation showing the color changes for end poit on Complexometry titration using EDTA indicators	Project 3 and 4
5	Titration Techniques Using EDTA for Quantitative Detemination	Preparation steps and procedures to be followed in the preparation of standard solution, standardization procedure to obtain exact concentration of the solution, sample pretreatment for Complexometry titration. The procedures are equipped with video, flash animation showing the step to set a project on preparation of Complexometry titration, including The procedures are including standardized EDTA, direct titration, back titration, exchange titration, inappropriate titration.	Project 5 and 6
6	Protective compound (masking and demasking)	The laboratory experiments and the designed project on Complexometry titration with protective compound (masking and demasking) and their application for sample analysis.	Project 7
7	Complexometry Titration Application	The application of Complexometry titration for the determination of food and industrial samples suitable for projects implemented by students that can be carried out as mini projects	Project 8 and 9

*List of media and projects that are available in the learning package

3.2. Standardization of Chemistry Learning Package

Sets of chemistry learning materials containing of projects and learning media have been standardized by using expert lecturers. The suggestions and inputs from experts are used to improve the contents of the chemistry materials. The feasibility of the learning materials has also been examined following the eligibility criteria of teaching materials set given by the National Education Standards Agency (BSNP). Evaluation has been performed by using experienced lecturers and senior students who have already studied the topic in the previous year. The assessment results are summarised in Table 2. The results showed that the chemistry learning materials have met the criteria as a standard learning material for Complexometry titration. All respondents gave a very good assessment to chemistry learning material (average 3.67), where the expert lecturers (average 3.70) and senior students (average 3.65) are all assigned to give very good opinions to the developed material.

Table 2. The performances of learning package based on the respondents opinions of Lecturer (L) and chemistry students (S).

No	Feasibility components	Short Description of Innovative Learning Material	Respondents Opinion		
			L (n=3)	S (n=20)	Average
1	Content	- The conformity of project contents with material	4.00	3.95	3.97
		- Accurate in facts, concepts, theories, procedures and in accordance with indicators of learning achievement	4.00	3.55	3.77
		- Project tasks are up to date and follow the SI standards	3.57	3.75	3.71
2	Presentation and Support	- The consistency of serving, logical, demanding and appropriate concepts.	3.00	3.55	3.27
		- The existence of interactive communication and thinking flow centered on learners	4.00	3.65	3.82
		- According to project learning syntax	3.67	3.55	3.61
3	Language	- Consistent with emotional thinking and social development	3.67	3.60	3.63
		- The sentences used are dialogical, interactive and straightforward	3.67	3.55	3.61
		- Understand and conform to the message delivered	4.00	3.65	3.82
4	Design	- The color of writing, symbols, Presentation of illustration, figures, the table and images are shown related	3.33	3.70	3.51
	Total (Average)		3.70	3.65	3.67

It can be stated that the instructional materials have fulfilled the content competitiveness to be used in helping students to study the topic of Complexometry titration [31].

3.3. Implementation of Innovative Learning Material

Innovative project-based learning materials are implemented for the teaching of Analytical chemistry. At the beginning of teaching, students are given a set of standard learning materials contained with sample projects along with the instructions to be followed for implementing the project to commence titration works. Furthermore, a brief teaching is given on how to use the learning materials for independent learning, followed by giving the procedures in implementing the projects related to learned topics. The students are given the freedom to choose three sets of project packages that must be completed, they are assigned to be represented of the sevent sub-topics available in the learning material of Complexometry titration topic. The project implementation assignment instructions consisted of: (1) project planning and project stage design, (2) commencing the projects, data recording, and observations of titration results, and (3) application of Complexometry titration to chosen real samples. When the learning activities are carried out, the lecturers observed the students' learning activities to make sure that laboratory works have been done correctly **[**32**]**. It also used to confirm that the student has mastery titration skills regarding the accuracy of titration results and the ability in processing and organizing data results. Students' attention to work safety in the laboratory has also been noted **[**33**]**. The observations results of students' psychomotor skills are summarised in Table 3.

Table 3. Students performance based on learning activities to carry out the projects on Complexometry titration

No.	Activity assessments	Students achievements*	Concluding Criteria
1.	**Pre-work:** including preparedness in the project work, proposed schedule, and safety equipments)	92.50±2.50	very good
2.	**Implementation of project:** including project completion based on project planning, data collection and data presentation, report results, and experience evaluation	91.40±1.66	very good
3.	**Implementation of experiment:** including achieved skill, systematic work, skills to use analytical tools and materials, working procedures, tidyness and cleanliness, waste management, and note taking	89.10±1.08	Good
4	**Experiment report:** including presentation of results and finding, discussion, applications, conclution, and sugestion and further recomendation	90.70±2.47	very good
	Average value	90.93±1.89	very good

The evaluations of submitted reports have been carried out to see students' ability to do complexometry titration. The evaluation test have been done at the end of the session to find out students' mastery in the concept of Complexometry titration. Students achievements are presented in Table 4. It is known that all students have completed the project package very well in a standard procedures **[**34**]**. They are able to set the relevant projects, conducted the project in a standard procedures, and submitted the final report on time. The students have done the project seriously, and the desired competence has been achieved (Table 4). The students obtained good results (average 87.28±4.10). The results of the learning evaluation showed that the students already have very good learning outcomes (average 90.03±1.44). These results ascertained that the project based learning was able to improve students ability to do Complexometry titration.

Table 4. Students' achievements obtained from the portfolio of submitted reports and evaluation test.

No	Students performance	Students Achievement	Competence summary
1	Students achievement based on portfolio of submitted project reports	87.28±4.10	Competence achieved
2	Students achievement based on evaluation test	90.03±1.44	Competence achieved
Average		83.41±0.99	Competence achieved

An innovative learning materials equipped with project packages can help the students to learn independently. Through project-based learning, the students have been able to construct their own learning so that they are able to organize the projects correctly according to the guideline required in the teaching of Analytical chemistry [35,36]. The students are very enthusiastic in doing independent learning, and eager to do collaboration in a team to complete the given tasks. Students' skills in observing the results of experiments and collecting titration data are formed according to the desired competency target. Students can also apply the knowledge they learned for analysis of target compounds in the real sample. It can be stated that project-based learning is a good strategy in improving student learning activities, fostering critical thinking skills in conducting relevant experiments, and at the same time improving learning outcomes in achieving their competencies [37-39].

4 Conclusion

The development of project-based teaching materials has been successfully developed for the teaching of Analytical chemistry. Sets of standard learning materials for the subject of Complexometry titration has been arranged well in accordance with the national curriculum. The developed material consisted of seven sub-subjects and equipped with relevant project packages and learning medias. Implementation of learning materials in the in the classroom proved to be able to guide the students to study chemistry systematically in achieving competencies in the field of analysis. The students have been able to construct their own projects that are relevant to the subject of complexometry titration. The learning model applied in this study has successfully been used to improve students' thinking skills, to build students' skills in using chemical equipments for analysis, and to improve learning outcomes. The project-based learning model is very appropriate to be used for self learning strategy.

Acknowledgments. The author acknowledged research funding given by The Directorate of Research and Community Service, Directorate General of Research and Development Strengthening, Ministry of Research, Technology and Higher Education Republic of Indonesia, Financial Year 2019, Under Penelitian Tesis Magister, Contract No.045A/UN33.8/LL/2019.

References

[1]. Sinaga, M., Situmorang, M., & Hutabarat, W.: Implementation of Innovative Learning Material to Improve Students Competence on Chemistry. Indian J of Pharmaceutical Education and Research. Vol. 53, No. 1, pp. 28-41 (2019)

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

[3]. Mari, J.S., & Gumel, S.A.: 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. Vol. 5, No. 3, pp. 196-199 (2015)

[4]. Jahangiri, M., & Hajian, R.: Creative Chemistry Teaching, Asian Journal of Chemistry Vol. 25, No. 1, pp. 377-380 (2013)

[5]. Chamizo, J.A.: A New Definition of Models and Modeling in Chemistry’s Teaching, Sci & Educ, Vol. 22, pp. 1613-1632 (2013)

[6]. Noor, M.M, & Ilias, K.: Practice Teaching and Learning Using Interactive Multimedia Innovation for Non-Optional Teachers Teaching in Music Educations, Academic Research International, Vol. 4, No. 2, pp. 338-346 (2013)

[7]. Maaß, K., & Artigue, M.: Implementation of inquiry-based learning in day-to-day teaching: a synthesis, ZDM Mathematics Education, Vol. 45, pp. 779–795 (2013)

[8]. Slabin, U.: Teaching General Chemistry with Instructor’s Screen Sharing: Students’ opinions about the idea and its implementation, Journal of Baltic Science Education, Vol.12, No. 6, pp. 759-773 (2013)

[9]. Gleadow, R., Macfarlan, B., & Honeydew, M.: Design for learning – a case study of blended learning in a science unit [version 2; referees: 2 approved] F1000Research. 4: 898 (2015)

[10]. Varghese, J., Faith, M., & Jacob, M.: Impact of e-resources on learning in biochemistry: first-year medical students’ perceptions, BMC Medical Education, Vol. 12, pp. 21-29 (2012)

[11]. Siew, N.M,, Amir, N., & Chong, C.L.: The perceptions of pre-service and in-service teachers regarding a project-based STEM approach to teaching science, Springer Plus. Vol. 4, No. 8 (2015)

[12]. Sheng, T., & Hu, Q.: Human Extracellular Superoxide Dismutase Recombination: a Project Based Learning Program in Biochemistry Designed for Nursing Students. Asian J. Nursing Edu. and Research. Vol. 2, No. 3, pp. 135-139 (2012)

[13]. Atasoy, B.M., Sarikaya, O., Kuscu, M.K., Yondem, M., Buyukkara, E., Eken, E.G. & Kahyaoglu, F.: Students Meeting with Caregivers of Cancer Patient: Results of an Experience-Based Learning Project. J Canc Educ. Vol. 27, pp. 656–663 (2012)

[14]. Harris, D. C.: Quantitative Chemical Analysis, 9th ed., W.H. Freeman and Company, New York (2015)

[15]. Christian, G. D., Dasgupta, P. S., & Schug, K.: Analytical Chemistry, 7th ed. John Wiley & Sons (2013)

[16]. Broekaert, J. A. C.: Daniel C. Harris: Quantitative chemical analysis, 9th ed., Anal Bioanal Chem. Vol. 407, pp. 8943–8944 (2015)

[17]. Zhang, S., & Zhang, X.: Teaching analytical chemistry in China: past, present, and future perspectives, Anal Bioanal Chem. Vol. 406, pp. 4005–4008 (2014)
[18]. Petersen J. C, Judge L, & Pierce D. A.: Conducting a Community-based Experiential-Learning Project to Address Youth Fitness. Journal of Physical Education, Recreation & Dance. Vol. 83, No. 6, pp. 30-36 (2012)
[19]. Rhodes, C., & Garrick, J.: Project-based learning and the limits of corporate knowledge. Journal of Management Education. Vol. 27, No. 4, pp. 447-471 (2003)
[]. Robinson, J. K.: Project-based learning: improving student engagement and performance in the laboratory. Analytical and bioanalytical chemistry, Vol. 405 No. 1, pp. 7-13 (2013)
[20]. Kayal, N., & Singh, N.: Selective masking and demasking for the stepwise complexometric determination of aluminium, lead and zinc from the same solution. Chemistry Central journal. Vol. 2, No. 4 (2008)
[21]. Tobiszewski, M., Marć, M., Gałuszka, A., & Namieśnik, J.: Green Chemistry Metrics with Special Reference to Green Analytical Chemistry. Molecules (Basel, Switzerland). Vol. 20, No. 6, pp. 10928–10946 (2015)
[22]. Martalina, D. S., Situmorang, M, & Sudrajat, A.: The Development of Innovative Learning Material with Integration of Project and Multimedia for the Teaching of Gravimetry, Advances in Social Science. Education and Humanities Research. Vol. 200, pp. 735-740 (2018)
[23]. Simaremare, S., Situmorang, M., & Tarigan, S.: Innovative Learning Material with Project to Improve Students Achievement on the Teaching of Acid-Base Equilibrium, Advances in Social Science. Education and Humanities Research. Vol. 200, pp 431- 436 (2018)
[24]. Uskokovíc, V.: Major Challenges for the Modern Chemistry in Particular and Science in General. Found Sci. Vol. 15, No. 1, pp. 303–344 (2010)
[25]. Karimi R.: Interface between problem-based learning and a learner-centered paradigm. Advances in Medical Education and Practice. Vol. 2, pp. 117-125 (2011)
[26]. Azer, S. A., Hasanato, R., Al-Nassar, S., & Somily, A., AlSaad M. M.: Introducing integrated laboratory classes in a PBL curriculum: impact on student's learning and satisfaction. BMC Medical Education. Vol. 13, pp. 71-83 (2013)
[27]. Skoog, D. A., West, D. M., Holler, F. J. & Crouch, S. R.: Fundamentals Of Analytical Chemistry, 9th ed., international ed. Brooks/Cole, Cengage Learning (2013)
[28]. Kayal, N., & Singh, N.: Stepwise complexometric determination of aluminium, titanium and iron concentrations in silica sand and allied materials. Chemistry Central Journal. Vol. 1, No. 24 (2007)
[29]. Situmorang, M.: Kimia Analitik I (Dasar Kimia Analitik), FMIPA Unimed Press, Medan, Indonesia (2013)
[30]. Situmorang, M., Sitorus, M., Hutabarat, W., & Situmorang, Z.: The Development of Innovative Chemistry Learning Material For Bilingual Senior High School Students in Indonesia, International Educational Studies. Vol. 8, No. 10, pp. 72-85 (2015)
[31]. Haglund, J., and Hultén, M.: Tension Between Visions of Science Education. The Case of Energy Quality in Swedish Secondary Science Curricula, Sci & Educ. Vol. 26, pp. 323–344 (2017)
[32]. Scida, K., Stege, P. W., Haby, G., Messina, G. A., & García, C. D.: Recent applications of carbon-based nanomaterials in analytical chemistry: critical review. Analytica Chimica Acta. Vol. 691, No. 1-2, pp. 6–17 (2011)
[33]. Valcárcel, M.: Quo vadis, analytical chemistry? Anal Bioanal Chem. Vol. 408, pp. 13–21 (2016)
[34]. Wenzel T. J.: General chemistry: expanding the learning outcomes and promoting interdisciplinary connections through the use of a semester-long project. CBE life sciences education. Vol. 5, No. 1, pp. 76–84 (2006)
[35]. Jensen, M., Mattheis, A., & Johnson, B.: Using student learning and development outcomes to evaluate a first-year undergraduate group video project. CBE life sciences education. Vol. 11, No. 1, pp. 68–80 (2012)
[36]. Lee, A. D., Green, B. N., Johnson, C. D., & Nyquist, J.: How to Write a Scholarly Book Review for Publication in a Peer-Reviewed Journal a Review of the Literature, The Journal of Chiropractic Education. Vol. 24, No. 1, pp. 57-69 (2010)
[37]. Bailin, S.: Critical Thinking and Science Education. Sci & Educ. Vol. 11, pp. 361–375 (2002)

[38]. Hager, P., Sleet, R., Logan, P., & Hooper, M.: Teaching Critical Thinking in Undergraduate Science Courses, Sci & Educ. Vol. 12, pp. 303–313 (2003)
[39]. Tomlinson, B.: Materials development for language learning and teaching, Lang. Teach. Vol. 45 No. 2, pp. 143–179 (2012)