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Development of chemical element practical workbook based on projects and characters for class xii senior high school

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Abstract:

This investigation based on analysis, design, development, implementation, and evaluation (ADDIE) method intended to develop an innovative chemistry laboratory workbook of Chemistry Element integrated with project-based learning and characters. Two chemistry lecturers and teachers respectively selected to validate three local chemistry laboratory workbook and chemistry laboratory workbook developed. Questionnaires distributed to the lecturer and teacher samples and found that content, language, presentation, and feasibility of graphics scores were 3.31., 3.37., 3.22., 3.15 and 3.15 respectively and the average score was 3.26 which means that the chem. Lab workbook developed is very valid. In addition, student samples consisted of 2 classes of grade XII of science students which classified into experimental group and Controled group. The developed chemistry laboratory workbook and the conventional workbook were tried out to group Experiment and group Controlled respectively. The average scores of student outcomes in group Experiment was higher than group Controled or 87.5%>73.8%. Then the average psychomotor scores of group Experiment was larger than group controled or 84.64>78.42. In addition, the affective scores of group Experiment was larger than group Controled or 82.78>76.38. The hypothesis tested with one way ANOVA at the significant level of $\alpha = 0.05$, and found that $t_{Calc} > t_{Table}$ or $4.536 > 1.697$ It is concluded that the Innovative chemistry laboratory workbook is highly very good.

Keywords: Chemistry laboratory workbook; chemistry element; project-based learning

Introduction

With the rapid development of technological advances in the current era of industrial revolution 4.0 (IR 4.0) have supported teaching and learning education around the world (Ragulina et al. 2018). The IR is defined as the development of knowledge in which the border lines between physical, digital and biological interests are being undetectable (Shahroom & Hussin, 2018). Industry 4.0 introduced in Germany in 2011 which is referred to the potential industrial revolution 4.0 in higher education and the teaching methods (Rojko, 2017).

The 2013 curriculum in its application to learning has been designed through a scientific approach and a contextual method, with the hope that students who are taught can have a balanced competence between attitudes, knowledge and skills much better than before, and the learning outcomes will form innovative, creative, effective and productive characters through strengthening the integrated realm of attitudes, knowledge and skills (Permendikbud, 2013).

Chemistry is a basic natural science center whose existence is between the biological and physical sciences. Chemistry depends on physics in explaining the understanding of the basic of material, and biology relies on chemistry to explain the understanding of the structure of living organisms and the processes that take place in them called life (Cann and Hughes, 2015). Laboratory activities or known as practicum is a means to develop process skills, make knowledge more meaningful for students, learn the facts, symptoms, principles and legal concepts (Situmorang et al. 2013). From a number of obstacles experienced by teachers in schools in learning chemistry, one of them is practicum guides that are not available or inadequate (Tuysuz, 2010). The integration of the 2013 curriculum in high school with the Cambridge curriculum is important to equalize chemistry learning with an international curriculum so that it can compete with overseas education. The IGCSE (International General Certificate of Secondary Education examinations) offers more than 70 subjects to obtain a general certificate of international secondary education exams, and those who pass the US level IGCSE exam can register at various universities abroad according to their fields without taking the college entrance exam in the destination country (Cann and Hughes, 2015). In 2009, the Cambridge syllabus was accredited by a British government body, widely accepted at various Universities and Institutions of Higher Education as entry requirements for Higher Education (Oxford Open Learning, 2019). Current chemistry lab guides still do not provide a picture that supports the development of international standard knowledge. For this reason, it is necessary to develop a characterized high school chemistry lab guide based on the 2013 curriculum adapted to the Cambridge syllabus of Chemistry.

The circulation of practicum guides from various printing practices used by students in schools, still has less impact on project-based learning models and innovative character integrated practices according to the 2013 curriculum. Given the importance of innovative project-based practicum guides and characters, it is necessary to develop innovative chemistry laboratory workbook that meet the standards BSNP (Manalu et al. 2016).

Chemical learning innovation is very important to be done to form innovative, creative, effective, and productive characters through strengthening the integrated realm of attitudes, knowledge and skills, and one of the learning innovations that are successfully used in learning chemistry is learning innovation with laboratory and non-laboratory activities (Situmorang, 2011). This fact is supported by the results of previous research which says that students will find it difficult to construct thoughts related to micro materials such as chemical elements, thermochemistry, acid-base, chemical changes, and so on, if there is a lack of practical activities in laboratories and non-laboratories, and it is recommended that energy educators can apply practicum activities in the learning process because chemistry learning is most effectively done through practicum activities (Tatli and Ayas, 2013).

One of the learning Innovations that can be done in character formation is a project-based learning model (PjBL), which is an innovative learning model that involves project work, where students work independently or in groups to construct their learning which is realized into real products (Fiksl et al. 2017). PjBL based learning developed by two experts, namely The George Lucas Education Foundation and Dopplet (Larmer, 2014), serves as a reference for the PjBL learning syntax recommended by the Ministry of Education and Culture in 2014 (Kemdikbud, 2014) in project based learning which consists of 6 phases: phase 1: start with important questions, phase 2: designing the project, phase 3: making a schedule, phase 4: monitoring students and project progress, phase 5: assessing the results, and. phase 6: evaluation of experience and results.

To improve the quality of international chemistry education and teaching, it is necessary to adjust the chemistry practicum based on the 2013 curriculum syllabus with the Cambridge curriculum syllabus so that High School graduates can compete to enter foreign Universities according to their field of expertise. When compared to the syllabus of the two curricula above, there are some teaching materials which are not discussed in the 2013 curriculum, but are discussed in the Cambridge curriculum. Therefore, in this research, the development of innovative project-based chemistry laboratory workbook and the integrated character of High School class XII practices will be carried out.

Methods

The research was conducted at the 2th Public High School, Medan. The development of chemistry laboratory workbook on Chemistry Element used the ADDIE method (Manalu et al. 2016). Three chemistry laboratory workbook samples selected from three local publishers were A, B and C. These chemistry laboratory workbook were used as standards for developing the innovative chemistry laboratory workbook. Two chemistry lectures from Department of Chemistry, State University of Medan and two chemistry teachers from the 2th Public High School were selected to validate the chemistry laboratory workbook. In addition, two sample classes of grade 12th from the high school were selected. The first class of grade 12th of the 1th science class was treated as experimental class (taught with project-based and character chemistry laboratory workbook). The second class of grade 12th of the 2th science class was treated as controlled group (taught with Conventional chemistry laboratory workbook. Insvestigation was carried out based on the ADDIE method which consisted of syllabus analysis, chem lab workbook analysis, design and development of the guides, implementation, evaluation and data analysis. Investigation and try out was carried out based on the stages listed in the following Fig 1 and Fig 2.

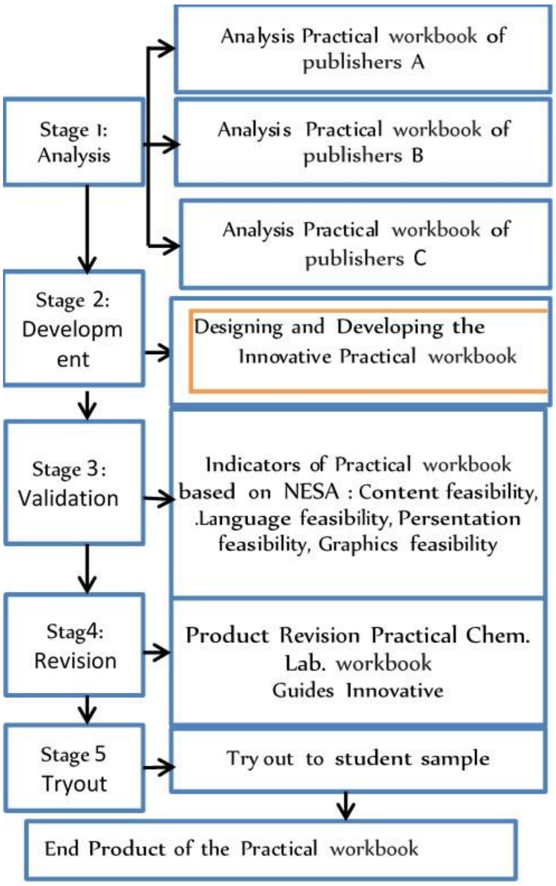

Fig 1. Chem lab workbook development stages

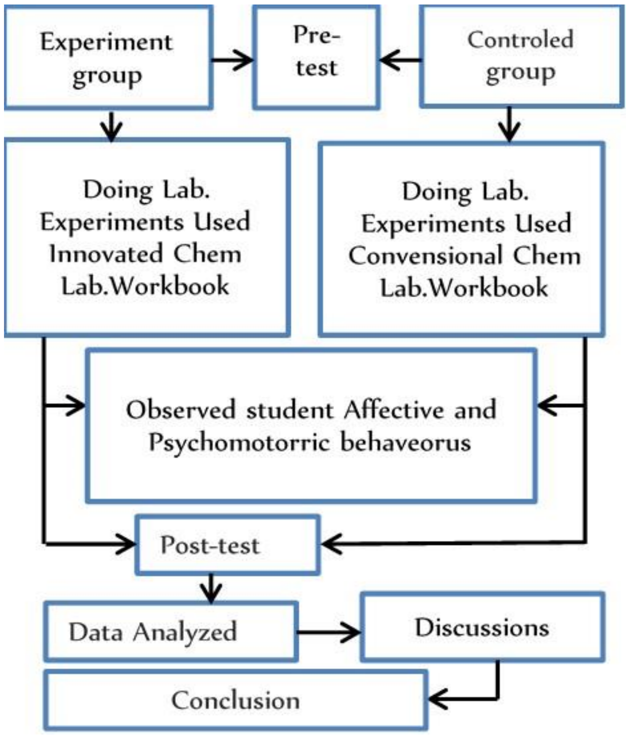

Fig 2. Try out of the chem. lab workbook

Questionnaires were distributed to lecturer and teacher validators to validate the innovated chemistry laboratory workbook based on the National Education Standards Agency (NESA) indicators (Permendikbud, 2013) i.e. content feasibility, language feasibility, presentasion feasibility and grafihcs feasibility.

To obtain the innovated chemistry laboratory workbook analysis data, the validator conducts validation of the chemistry laboratory workbook developed using an assessment questionnaire modified from the National Education Standards Agency (NESA) indicators (Permendikbud, 2013) The expert validator assesses the feasibility of content, the feasibility of language, the feasibility of presentation and the feasibility of graphics, using a Likert scale score of 1 to 4 with the provisions as shown in Table 1. Average scores of the Validated innovated chemistry laboratory workbook were listed in Table 2.

Table 1.
Data collection instrument rubric validation chem lab workbook (BSNP, 2016).

Feasibility of NESA	Score	Indicator
Content feasibility;	1	Very poor / very less interesting / very less precise / very unclear.
Linguistics feasibility;	2	Poor / less attractive / less precise / less clear.
Presentation feasibility;	3	Good / interesting / right / clear.
Graphics feasibility	4	Very good / very interesting / very precise / very clear.

The average scores of the questionnaires were calculated by the following formula:

$$\overline{X} = \frac{\Sigma X}{n} \quad (1)$$

where:

$\overline{X}$ = average;

ΣX = total scores

n = number of validators (Arikunto, 2009)

Table 2
Analysis of the chem lab workbook

Average scores	Cathegory
3.26 – 4.00	Very Valid
2.51 – 3.25	Valid
1.76 – 2.50	Les valid
1.00 – 1.75	Not valid

Analysing chemistry laboratory workbook data were carried out based on knowledge, affective, and skills. Determination of knowledge comprehension was carried out by calculating knowledge gain meanwhile for affective and skills measurement were carried out by using rubrics. Hypothesis testing was carried out by using one way ANOVA, after normality and homogenity tests were carried out.

Chemistry laboratory workbooks analysis

Before investigation carried out, the chemistry syllabus 2013 and syllabus Canbrigde of grade 12 and conventional chem. lab workbooks were analyzed. Having analyzed the conventional chemistry laboratory workbook, continued to design an innovative chem. lab workbook based on ADDIE methods. The innovated workbook was developed based on project-based learning and characters.

Chemistry laboratory workbook development

In developing the innovative chemistry laboratory workbook, three conventional chemistry laboratory workbook published were A, B and C used as reference books in designing, organizing and developing the new innovative chemistry laboratory workbook intended.

Chemistry laboratory workbook validation

The innovative chemistry laboratory workbook was validated based on the NESA indicators (Permendikbud, 2013). Validation was carried out by the two lecturer and teacher validators selected. Validation was intended to find out the weaknesses and strength of the sample workbooks selected. The data used for developing an innovative chem. lab workbook integrated with project-based learning and characters.

Chemistry laboratory workbook tried out

The Innovative Chemistry. Laboratory workbook tried out toward the experimental group and the conventional workbooks tried out towards the controlled group which consisted of 30 students respectively. Before trying out, the two class samples were given a pretest and continued to carry out experiments on Chemistry Element using the innovative Chemistry Laboratory Workbook and the conventional workbooks respectively. The Chemistry Laboratory workbook was presented through learning project-based learning and characters. At the end of the class, they were given posttest concerning with the Chemistry Element. During the classroom activities, the teachers observed student affective behaviours and the results could be tabulated in the following Table 3.

Table 3
Research design (Arikunto, 2009).

Groups	Pre-test	Treatment	Post-test
Experimental	T1	X_1	T_2
Controlled	T1	X_2	T_2

Notes:
X_1= Experiment used the innovative chem lab workbook
X_2= The conventional chem lab workbook
T_1= Pre test; T_2= Post test

Chem lab workbook evaluation

At this stage, student outcomes were analyzed. Questionnaires were distributed towards teacher and lecture samples selected. Pretest was carried out before chem. lab experiment carried out and posttest carried out after the experiment. Student activities were observed and noted by four observers during the experiments.

Normality test was measured by Chi-squared test at a significant level of α = 0,05. If the Chi-squared $(\chi^2)_{calc.} < (\chi^2)_{table}$ then the samples were normally distributed. Validity test was carried out using the following formula:

$$F_{cal.} = \frac{HighVariance}{LowVariance} \qquad (2)$$

If $F_{cal.} > F_{table,}$ *then the data were homogenous.*

Student achievement percentage was calculated by using gain score normalized (g) using the following formula:

$$\%g = \frac{posttestscores - pretestscores}{maximun\ scores - pretestscores} \times 100\% \qquad (3)$$

Hypothesis was tested by using one way ANOVA with the following formula:

$$t_{cal.} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \qquad (4)$$

$\bar{X}_1$ = *student outcomes1*
$\bar{X}_2$ = *student outcomes2*
S= Standard deviation
n = numberof samples

Results

Conventional chemistry laboratory workbook analyzed

The three conventional chemistry laboratory workbooks A, B and C were analyzed. The workbooks convered Chemistry Element were analyzed based on the NESA indicators (Permendikbud, 2013) and the results were shown in Table 4.

Table 4
Average feasibility scores of the conventional chemistry laboratory workbook A, B, and C

Publisher code	Average feasibility scores of the chem lab workbooks A, B, and C			
	Content	Language	Presentation	Graphics
A	2.58	3.09	2.88	2.98
B	2.56	3.06	3.04	2.96
C	2.58	2.78	2.86	2.94
Average scores	2.57	2.98	2.92	2.96
Average scores of the NESA indicators = 2.86				
Criteria : Valid (no revisions required)				

Having analized the three conventional workbooks A, B and C, it was found that there books have a number of weaknesses. They were not provided with chemical equipment and application of the Chemistry Element properties in daily life. It was also not provided with laboratorium basic techniques and skills, and not well designed and colored and the workbooks were relatively good. In addition the workbooks were not facilitated with project-based learning and characters integrated. There was not general implementation guides i.e. practicum guidelines, laboratory safety, equipment safety, waste handing, and toxicity indicators (corrosive, oxidator, explosive and flammable substances). There was not Figure of chemical equipment.

Innovative chemistry laboratory workbook validated

Questionnaires were distributed to the teachers and lecturers sample selected in order to validate the Chemistry laboratory workbook based on the Project Based Learning and Characters integrated. The workbook validated contained Chemistry Element and the results were listed in Table 5.

Table 5
Average scores of the validated innovative chemistry laboratory workbook

Feasibility of the NESA indicators	Average Scores of the practical guide A, B, and C	Average scores of the Innovative practical guides
Content	2.57	3.31
Language	2.98	3.37
Presentation	2.92	3.22
Graphics	2.96	3.15
Average	2.86	3.26
The NESA indicators:	Relatively Valid	Highly valid

The difference between the average scores of the conventional workbook and the Innovative workbook project based learning and caracters integread were shown in the following Fig 3.

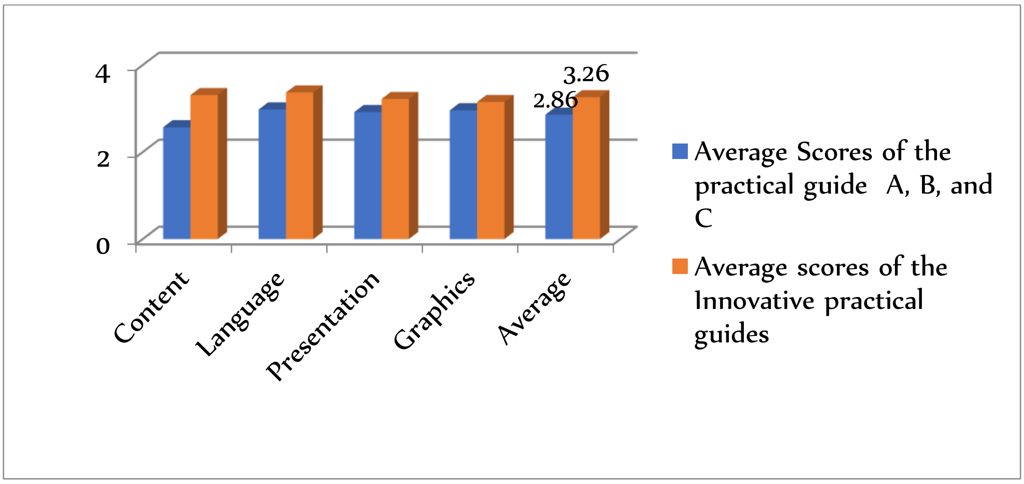

Fig 3. Comparison of the conventional workbook and innovative workbook scores

Percentage of student outcomes and hypothesis testing

Percentage of student learning gain scores was calculated based on the equation 2 above and it was found that the percentage of student learning scores of the experimental group was considerably higher than the controlled group or 87.5% > 73.8%. as shown in Fig 4.

Hypothesis testing was carried out after normality and homogeneity tests. Analysis through One Way ANOVA shown that $t_{cal.} > t_{table}$ or 4,536 > 1,697, it means that hypotetic alternative accepted and the used of innovative chemistry laboratory workbook is better and highly very good than the conventional workbook.

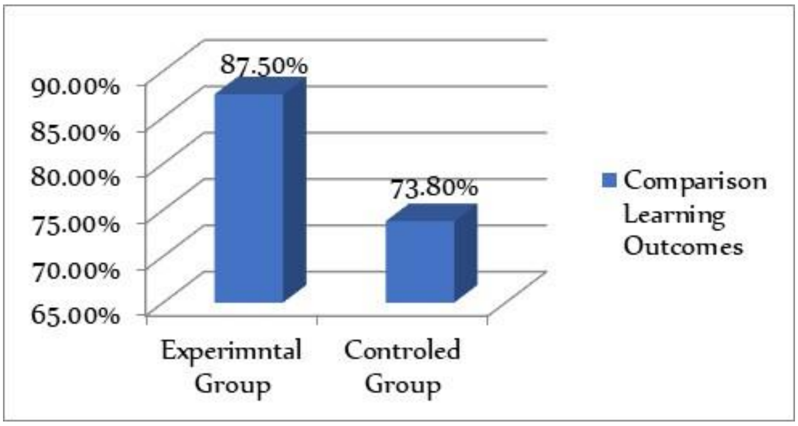

Fig 4. Comparison Student outcomes percentages.

Psychomotoric evaluation

The psychomotoric scores of the experimental group is higher than the controlled group or 86.8 > 78.5. The average scores of the two groups were shown in Fig 5.

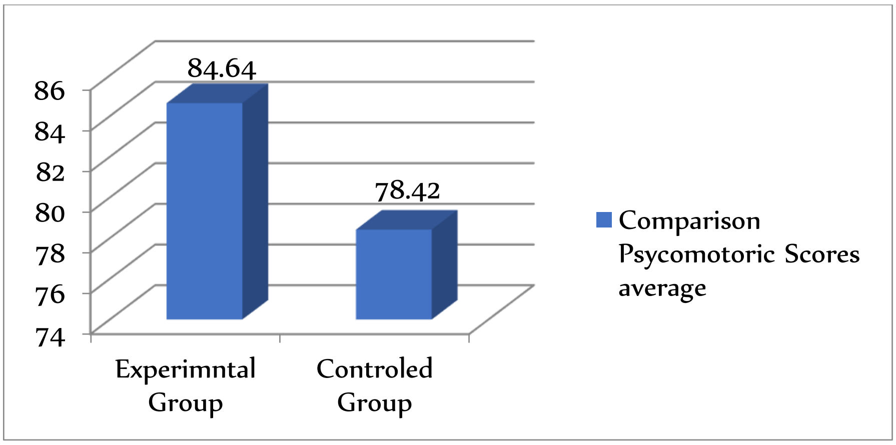

Fig 5. Psychomotoric scores average of the experimental and controlled groups.

Affective measurements

Affective scores of the experimental group was larger than the controlled group 82,78 > 76,38. The average affective scores were plotted in Fig 6.

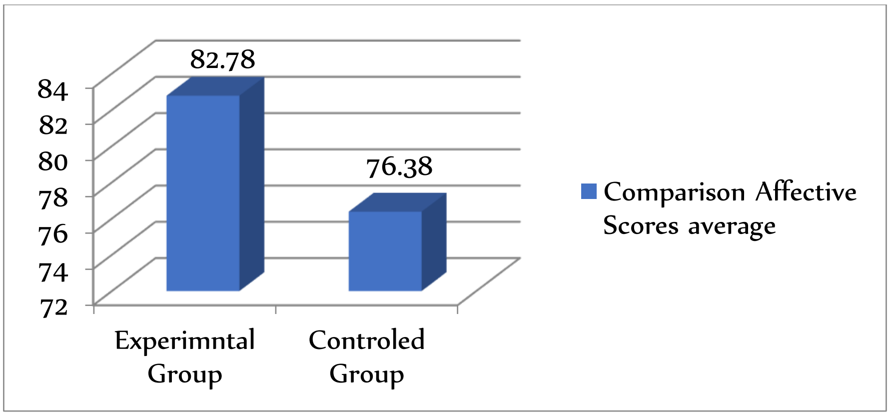

Fig 6. Affective scores average of the experimental and controlled groups.

Discussion

Practicum activities are a means to develop process skills, making knowledge more meaningful for students (Situmorang, 2015). Through practical activities students will learn the facts, symptoms, principles and legal concepts. Based on the workbooks feasibility study, it was found that A, B, and C Books were not met the NESA indicators as shown in table 4 above and the results can be simplified in the following: They were not provided with chemical equipment and application of the Chemistry Element properties in daily life. It was also not provided with laboratorium basic techniques and skills, and not well designed and colored and the workbook were relatively good. In addition the workbooks were not facilitated with project-based learning and characters integrated. There was not general implementation guides i.e. practicum guidelines, laboratory safety, equipment safety, waste handing, and toxicity indicators (corrosive, oxidator, explosive and flammable substances). There was not Figure of chemical equipment. It was also integrated into technological computers based on the NESA indicators to meet the 2013 National Curriculum of Indonesia as shown in Table 4.

It was found that student outcomes in the experimental group was higher than the controlled group (79,5%>68%). The results shown that students at the experimental group who used Porject Based Learning integrated with caracters have higher outcomes compared to the controlled group. As a result, it enhanced student ability to construct things from what they learned from technological skills and experiences based on their previous knowledge and it increases student achievements The results also in line with Gorlatova et al. (2014) who found that Project-based learning improved student ability to work within multidisciplinary teams. It was also found that the affective and psychomotoric scores of the experimental groups respectively were higher than the controlled group.

In general, the quality of the project-based chemistry practicum guides and the results of the character development are classifid into content eligibility are subject delivery and character based. In oder to accomplish the new practcum guides the subjects were integrated with the 2013 curriculum and the Cambridge curriculum. The scope of the material reflects the description of substance in CC and BC, indicators and objectives. The depth of material has been expanded according to the content. Chemical applications in life, basic laboratory techniques and skills have been included, as well as pictures of chemical tools. Language worthiness is determined according to EYD i.e. concisenes, clarity and simplicity of the sentences. In other words. Using sentences according to EYD. The next step is to determine the Presentation eligibility shown at the front and back covers synchronously presented i.e. A-4 paper size and attractive colored backgrounds. Completeness of presentation includes: Table of contents; Laboratory work safety; Laboratory safety symbol; SPU; Name and picture of experiment equipment; Materials needed in the experiment; Each trial title contains indicators and objectives; References; Illustration, glossary, index list, and question. Completeness of presentation includes: table of contents; laboratory work safety; laboratory safety symbol; SPU; name and picture of experiment equipment; Materials needed in the experiment; Each trial title contains indicators and objectives; References; Illustration, glossary, index list, and questions. The feasibility of graphics related to writing letters in alphabetically consistent. Layout of images and writing are in accordance with the proportions of the object. Contain images of chemists in their fields, illustrations, examples in everyday life. Position of MSDS materials and laboratory work safety listed in front. A collection of multiple choice questions, essay loaded before the glossary. Glossary, index list, and SPU loaded on the last page.

In learning, the use of Chemistry Laboratory Workbook for the results of development has shown project-based learning models and characters, which can foster students' innovative, creative, affective, productive, collaborative, responsible, hard work, and critical thinking and disciplined characters. This can be seen from the acquisition of an average percent increase in learning outcomes of the experimental class that is higher than the control class Likewise the psychomotor and affective scores of the experimental group students are higher than the control class. In project-based learning, students learn primarily by building knowledge and meaning through active learning processes, sharing, and reflection.

In project-based learning, students learn primarily by building knowledge and meaning through active learning processes, sharing, and reflection. In learning, the use of practicum guides for the results of development has shown project-based learning models and characters, which can foster student character innovative, creative, effective, productive, collaborative, responsible, hard work, and critical thinking and discipline (Nainggolan et al. 2018).

This can be seen from the acquisition of an average percent increase in learning outcomes of the experimental class that is higher than the control class likewise (Silaban, 2017) the psychomotor and affective scores of the experimental group students are higher than the control class. In project-based learning, students learn primarily by building knowledge and meaning through active learning processes, sharing, and reflection. Learning services emphasize education that is interdisciplinary, student-centered, collaborative, integrated with real-world practice issues (Chiang and Lee, 2016; Lukman et al. 2019). Project-based learning is a good discussion opportunity for students, working on direct discoveries of real-world problems, giving pleasure in learning and being an effective teaching strategy. Project-based learning focuses on the activities of students conducting exploration, assessment, interpretation, synthesis and information to produce various forms of learning outcomes. Project-based learning is a learning method that uses problems as a first step in gathering and integrating new knowledge based on experience in real activities (Scott and Pentecost, 2013; Harahap et al. 2018; Nasution et al. 2018).

Conclusion

Chemistry Laboratory Workbook experiment integrated with project-based learning and characters increased student achievements which was shown by the student achievement of the experimental group was higher than the controlled group. It was due to the fact that the innovative Chemistry Laboratory Workbook integrated with based on the NESA indictors met the IR 4.0. Chemistry Laboratory Workbook for Innovative Chemistry Practicum Project-Based and Character Class XII High School Development results are good, it is appropriate to use High School students because there is already a chemistry suitability between the 2013 curriculum with the Cambrigde curriculum, and is in the very valid category according to NESA.

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References

Arikunto, S. (2009). *Prosedur Penelitian: Suatu Pendekatan Praktik* (*Research Procedure: An Approach to Practice) (revised edition VI)*. Jakarta: Rineka Cipta.

BSNP. (2016). *Peraturan BSNP tentang Prosedur Operasi Standar Penyelenggaraan Penilaian Buku Paket Pelajaran dan Buku Panduan Guru Pola "Inisiatif Masyarakat (BSNP Regulations regarding Standard Operating Procedures for Organizing Appraisals of Learning Package Books and Teacher's Guidance Patterns "Community Initiatives"),* Badan Standar Nasional Pendidikan. Jakarta.

Cann, P., & Hughes, P. (2015). *Cambridge International AS and A Level Chemistry*. London, UK: Hodder Education.

Chiang, C. L., & Lee, H. (2016). The effect of project-based learning on learning motivation and problem-solving ability of vocational high school students. *International Journal of Information and Education Technology*, 6(9), 709-712, doi: 10.7763/ijiet.2016.v6.779

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.

Gorlatova, M., Sarik, J., Kinget, P., Kymissis, I., & Zussman, G. (2013). Project-based learning within a large-scale interdisciplinary research effort. Proceedings of the 18th ACM Conference on Innovation and Technology in Computer Science Education - ITiCSE '13, doi: 10.1145/2462476.2465588

Harahap, N.M., Hutabarat, W., & Silaban, S. (2018). The effect of model problem based learning (pbl) assistance of prezi media on student learning outcomes in colloid materials. *Advances in Social Science, Education and Humanities Research*, 200,456-458, doi: 10.2991/aisteel-18.2018.98

Kemdikbud. (2014). *Materi pelatihan guru implementasi kurikulum 2013 tahun ajaran 2014/2015: Mata pelajaran IPA SMP/MTs (Teacher training materials for the implementation of the 2013 curriculum in the 2014/2015 school year: Natural Sciences subject for SMP/MTs),* Jakarta: Kementerian Pendidikan dan Kebudayaan.

Larmer, J. (2014). Project-based learning vs. problem-based learning vs. X-BL. Edutopia, George Lucas Educational Foundation.

Lukman, I., Damanik, M., Silaban, S., & Kembaren, A. (2019). Development of problem based learning innovative student worksheets in learning the concept of chemistry for senior high school students. *Journal of Transformative Education and Educational Leadership*, 1(1), 23-28.

Manalu, E., Silaban, S., Silaban, R., & Hutabarat, W. (2016). The development of chemical practice guidebook colloid system-based integrated contextual character values. *Jurnal Pendidikan Kimia*, 8(2), 87-89.

Nainggolan, B., Pinem, I. S. A., & Hutabarat, W. (2018). Development of chemical practice guides class xi project based to improve student's chemical learning outcomes on acid base materials. *Jurnal Pendidikan Kimia*, 10(2), 393-396. doi: 10.24114/jpkim.v10i2.11018

Nasution, R., Silaban, S., & Sudrajat, A. (2018). The influence of problem based learning, guided inquiry learning models assited by lectora inspire, and scientific attitudes to student's cognitive values. *Advances in Social Science, Education and Humanities Research*, 200, 265-269, doi: 10.2991/aisteel-18.2018.58

Oxford Open Learning, 2019, *https://www.ool.co.uk/examinations/igcse-and-gcse-whats-the-difference/. Download on 4/17/2019. At 4.55 am.*

Permendikbud. (2013), *Standar Kompetensi Lulusan Pendidikan Dasar dan Menegah*. (*Competency Standard for Primary and Secondary Education Graduates*), p. 59.1-15.

Rojko, A. (2017). Industry 4.0 concept: background and overview. *International Journal of Interactive Mobile Technologies (iJIM)*, 11(5), 77-90, doi: 10.3991/ijim.v11i5.7072

Ragulina, Y. V., Semenova, E. I., Zueva, I. A., Kletskova, E. V., & Belkina, E. N. (2018). Perspectives of Solving the Problems of Regional Development with the Help of New Internet Technologies. *Entrepreneurship and Sustainability Issues*, 5(4), 890-898, doi: 10.9770/jesi.2018.5.4(13)

Scott, P., & Pentecost, T. C. (2013). From Verification to Guided Inquiry: What Happens When a Chemistry Laboratory Curriculum Changes?. *Journal of College Science Teaching*, 42(3), 82-88.

Shahroom, A., & Hussin, N. (2018). Industrial revolution 4.0 and education. *International Journal of Academic Research in Business and Social Sciences*, 8(9), 314-319, doi: 10.6007/IJARBSS/v8-i9/4593

Silaban, S. (2017). *Dasar-dasar pendidikan matematika dan ilmu pengetahuan alam*. Medan: Harapan Cerdas Publisher.

Situmorang, M., Sinaga, M., Tarigan, D. A., Sitorus, C. J., & Tobing, A. M. L. (2011). The effectivity of innovated chemistry learning methods to increase student's achievement in teaching of solubility and solubility product. *Jurnal Penelitian Bidang Pendidikan*, 17(1), 29-37.
Situmorang, M. (2014). Pengembangan buku ajar kimia Sma melalui inovasi pembelajaran dan integrasi pendidikan karakter untuk meningkatkan hasil belajar siswa. *Prosiding SEMIRATA 2013*, p: 237 – 247.
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 Education Studies*, 8(10), 72-85, doi: 10.5539/ies.v8n10p72
Tatli, Z., & Ayas, A. (2013). Effect of a virtual chemistry laboratory on students' achievement. *Educational technology & society*, 16(1), 159-170.
Tüysüz, C. (2010). The effect of the virtual laboratory on students' achievement and attitude in chemistry. *International Online Journal of Educational Sciences*, 2(1), 37-53.