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 Controlled 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 Controlled or 87.5% > 73.8%. Then the average psychomotor scores of group Experiment was larger than group controlled or 84.64 > 78.42. In addition, the affective scores of group Experiment was larger than group Controlled or 84.64 > 78.42. The hypothesis tested with one way ANOVA at the significant level of α = 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 (Tatlı 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 2\textsuperscript{nd} 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 2\textsuperscript{nd} Public High School were selected to validate the chemistry laboratory workbook. In addition, two sample classes of grade 12\textsuperscript{th} from the high school were selected. The first class of grade 12\textsuperscript{th} of the 1\textsuperscript{st} science class was treated as experimental class (taught with project-based and character chemistry laboratory workbook). The second class of grade 12\textsuperscript{th} of the 2\textsuperscript{nd} science class was treated as controlled group (taught with Conventional chemistry laboratory workbook). Investigation 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.

![Chem lab workbook development stages](image)

\textit{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, presentation feasibility and graphics 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).

<table>
<thead>
<tr>
<th>Feasibility of NESA</th>
<th>Score</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content feasibility;</td>
<td>1</td>
<td>Very poor / very less interesting / very less precise / very unclear.</td>
</tr>
<tr>
<td>Linguistics feasibility;</td>
<td>2</td>
<td>Poor / less attractive / less precise / less clear.</td>
</tr>
<tr>
<td>Presentation feasibility;</td>
<td>3</td>
<td>Good / interesting / right / clear.</td>
</tr>
<tr>
<td>Graphics feasibility</td>
<td>4</td>
<td>Very good / very interesting / very precise / very clear.</td>
</tr>
</tbody>
</table>

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

\[ \bar{X} = \frac{\sum X}{n} \]  \hspace{1cm} (i)

where:
- \( \bar{X} \) = average;
- \( \sum X \) = total scores
- \( n \) = number of validators (Arikunto, 2009)
Table 2
Analysis of the chem lab workbook

<table>
<thead>
<tr>
<th>Average scores</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.26 – 4.00</td>
<td>Very Valid</td>
</tr>
<tr>
<td>2.51 – 3.25</td>
<td>Valid</td>
</tr>
<tr>
<td>1.76 – 2.50</td>
<td>Less valid</td>
</tr>
<tr>
<td>1.00 – 1.75</td>
<td>Not valid</td>
</tr>
</tbody>
</table>

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).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-test</th>
<th>Treatment</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>T₁</td>
<td>X₁</td>
<td>T₂</td>
</tr>
<tr>
<td>Controlled</td>
<td>T₁</td>
<td>X₂</td>
<td>T₂</td>
</tr>
</tbody>
</table>

**Notes:**
- X₁ = Experiment used the innovative chem lab workbook
- X₂ = The conventional chem lab workbook
- T₁ = Pre test; T₂ = Post test

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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 \( \alpha = 0.05 \). If the Chi-squared \( (\chi^2)_{\text{calc}} < (\chi^2)_{\text{table}} \) then the samples were normally distributed. Validity test was carried out using the following formula:

\[
F_{\text{cal}} = \frac{\text{HighVariance}}{\text{LowVariance}}
\]

If \( F_{\text{cal}} < F_{\text{table}} \) then the data were homogenous.

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

\[
\%g = \frac{\text{posttest scores} - \text{pretest scores}}{\text{maximum scores} - \text{pretest scores}} \times 100\%
\]

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

\[
t_{\text{cal.}} = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{s_1^2 + s_2^2}} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}
\]

\( \overline{X}_1 \): student outcomes1
\( \overline{X}_2 \): student outcomes2
\( s \): Standard deviation
\( n \): number of samples

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

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

<table>
<thead>
<tr>
<th>Publisher code</th>
<th>Average feasibility scores of the chem lab workbooks A, B, and C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Content</td>
</tr>
<tr>
<td>A</td>
<td>2.58</td>
</tr>
<tr>
<td>B</td>
<td>2.56</td>
</tr>
<tr>
<td>C</td>
<td>2.58</td>
</tr>
<tr>
<td>Average scores</td>
<td>2.57</td>
</tr>
</tbody>
</table>

Average scores of the NESA indicators = 2.86
Criteria : Valid (no revisions required)

Having analyzed 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**

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

The difference between the average scores of the conventional workbook and the Innovative workbook project based learning and characters integeated 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.
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.

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.
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 shows that students at the experimental group who used Project Based Learning integrated with characters 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 classified into content eligibility are subject delivery and character based. In order to accomplish the new practicum 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 Cambridge curriculum, and is in the very valid category according to NESA.

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**References**


