

Development of Electronic Student Worksheets (e-SW) Electrolyte and Nonelectrolyte Solutions based on Project Based Learning (PjBL) on the Learning Outcomes

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Abstract: The purpose of this research is to develop teaching materials in the form of e-SW electrolyte and nonelectrolyte solutions based on PjBL for class X SMA/MA students. The method used is the Plom Model development method with stages the Preliminary Research, Prototyping Phase, and Assessment Phase. The limitation of this research is only small group research. The assessment of this development is valid and practical. The elements that are validated are content, serving, language, and graphical components. The practical element is seen in the questionnaire conducted by 3 students and 2 teachers. The results of this study are teaching materials that meet valid and practical criteria, so they can be used for learning electrolyte and nonelectrolyte solutions for class X SMA/MA students.

Keywords: E-SW; Project based learning; Plom

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Introduction

The process of implementing the current curriculum applies a scientific learning approach or also known as scientific approach. To realize the learning process with a scientific approach, it is necessary to select learning models and choose appropriate teaching materials and the use of learning media is very necessary, this can make it easier for students to achieve the competencies expected in the 2013 curriculum (Wulandari and Novita, 2018).

The 21st century learning process requires a variety of innovative teaching materials in accordance with learning needs so that learning objectives can be achieved. The form of innovation that can be done can be in the form of innovation in electronic teaching materials such as electronic student worksheets (e-SW).

The e-SW teaching material is one that is needed by teachers or students in the online learning process (Suryaningsih & Nurlita, 2021). The advantage of e-SW is that it can facilitate more effective learning. In

addition, e-SW can be an attractive tool when students' interest in learning decreases (Syafitri & Tressyalina, 2020). The characteristics of e-SW have an attractive appearance and use more practical with a variety of multimedia components that will be used to complement and fulfill the achievement of student competencies in the learning process (Sriwahyuni, 2019).

The development of e-SW has been carried out on various innovations in accordance with the needs of teaching materials and learning objectives that are more interesting and practical, including research conducted by Adilla, et al., (2018), namely the development of e-SW-based guided inquiry with Flip PDF Professional and 3D Pageflip based on Problem Based Learning (Hidayah et al., 2020). Educators are required to be able to realize an active and meaningful teaching and learning process through the selection of appropriate and appropriate learning models.

The PjBL model is one of the learning models suggested by the 2013 curriculum because PjBL can make students active, creative, innovative and

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independent so that student learning outcomes can increase (Arizona, et al. 2020). Therefore, PjBL is effective to be considered to be applied to the learning process online during a pandemic or other emergency situation if face-to-face learning cannot be carried out (Fauziah, et al., 2020).

The PjBL learning model can be in the form of projects/products that are carried out by students, both individually and in groups. The stages in PjBL are questions (presentation of problems), planning, scheduling, project monitoring, assessment and evaluation (Harun, 2006; Nelson, 2017; Sani, 2018).

In the application of the PjBL model, students carry out more activities independently or in groups and the teacher acts as a facilitator (Nurfa & Nana, 2020). Apart from that, PjBL can improve critical thinking skills and be able to encourage problem solving experienced by students in real life.

The PjBL learning model emphasizes more on science skills, namely observing, using tools and materials, interpreting, planning projects, applying concepts, asking questions and communicating well (Nurhayati and Harianti, 2019). The process of learning chemistry is inseparable from science skills. Electrolyte and nonelectrolyte solutions expect students to be able to distinguish the electrical conductivity of various solutions through the design and implementation of experiments. The PjBL model can be applied to develop students' creative thinking skills in designing and making a project.

Based on observations at SMAN 5 Padang, SMAN 14 Padang and MAN 2 Pesisir Selatan, information was obtained that the electrolyte and nonelectrolyte solution material showed that there were still students' learning outcomes that had not been completed. The material for class x semester 2 electrolyte and non-electrolyte solutions have many abstract concepts such as the division of a fully ionized, partially, and non-ionized solute. division of the solution based on its electrical conductivity (Hardeli and Citra, 2020; Kamila, et al, 2021). These materials are abstract, so it takes a strong imagination of students to read and analyze the subject matter, so that it makes students difficult to understand it. As a result, students find it difficult to understand the concepts contained in this material (Purwaningtyas, 2012), then some teachers have tried to use the PjBL model but it has not gone well and has not produced a product. Teachers mostly use textbooks and LKPD, but the available LKPD has not guided students to carry out simple project-based learning that produces products.

Based on the description above, it is necessary to innovate teaching materials in the form of project-based e-SW, so the authors are interested in conducting research with the title " Development of Electronic Student Worksheets (e-SW) Electrolyte and Nonelectrolyte Solutions based on Project Based

Learning (PjBL) on the Learning Outcomes of Class X SMA/MA Students".

Method

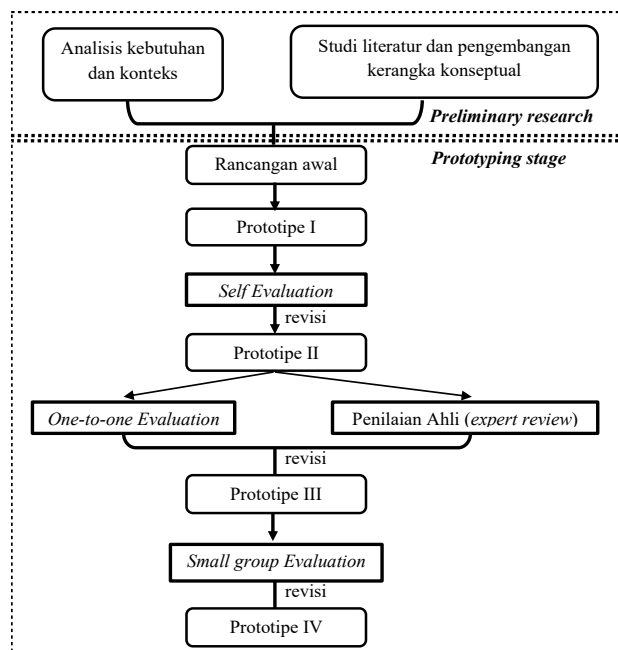


Figure 1. Flowchart of E-SW Development Procedure

The type of research used in this study is EDR (Educational Design Research) which is a systematic study of designing, developing, and evaluating interventions such as programs, strategies, teaching materials, products and learning systems that become problems in the education cycle. (Plomp & Nieveen, 2013).

This research design uses the Plomp model which consists of 3 stages including: preliminary research (Preliminary Research), the prototyping stage (development or prototyping phase), and the assessment stage (assessment phase). The study was limited to the small group assessment stage, which consisted of self-evaluation, expert review, one-on-one evaluation, and small groups.

Preliminary research stages (Preliminary Research) consist of a needs analysis process, context analysis, reviewing various literatures, developing a framework of teaching materials. Analysis of the needs of students conducted interviews and gave questionnaires to students and teachers. Context analysis is done by selecting materials, syllabus, analyzing lesson plans, Expected Learning Outcomes, and sub-materials taught to be developed into a series of appropriate and appropriate learning objectives. Literature study was conducted by analyzing several articles. The articles were analyzed to strengthen the reasons for the research, as well as supporting articles for this research. The end of the preliminary research by making a conceptual

framework that will briefly explain the problems that occur in the world of education today in particular at SMAN 14 Padang and the solutions offered to solve it.

Prototyping stage (development or prototyping phase), is the stage of developing teaching materials through formative evaluation until the refinement process runs according to the objectives. The first stage is the design of learning in the form of PjBL-based e-SW Electrolyte and Nonelectrolyte Solutions to produce prototype I.

The second stage of self-evaluation, namely the stage of researcher assessment related to the product that has been designed. This analysis was carried out based on a valid self-evaluation questionnaire, then revised the product based on the assessment, to produce prototype II.

The third stage is expert review, and one-to-one evaluation. The expert review was carried out by 4 chemistry lecturers and 2 chemistry teachers. Assessment is based on valid content validation and construct validation. Then the product was revised based on suggestions from the validator. Furthermore, the one-to-one evaluation stage was carried out on 3 students of class XI SMAN 14 Padang, with high, medium, and low categories as representatives of the population. Each student will observe and use the product in general, then provide responses and suggestions based on the interview questionnaire that has been provided. The product was revised based on all the suggestions given, until prototype III was obtained.

The fourth and final stage (Prototype IV) of this research is a small group practicality test and teacher practicality. The small group was held for 6 students of class X SMAN 14 Padang as representatives with categories of 2 people each with high, medium, and low ability levels, which were seen based on the midterm exam scores. Meanwhile, the teacher's practicality test was given to 2 chemistry teachers at SMAN 14 Padang.

Data from observations and interviews were processed in the form of conclusions. Then the data obtained from the expert validator is processed using the Aiken's V formula, to see the validity of the resulting product, equation (1) can be used.

V Aiken's Formula 1:

$$V = \frac{\sum s}{n(c-1)} \tag{1}$$

Information:

S : r - I_o

r : the value given by the validator

i_o : lowest validity value

n : number of expert validators

c: highest validity score

While the data obtained through the small group stage in the form of student and teacher responses, to

determine the practicality of the resulting product, use equation 2 (Practical formula):

$$P = \frac{f}{N} \times 100 \tag{2}$$

Information:

P : final value

f : score

N : maximum score

Result and Discussion

The research that has been done has produced several parts based on the implementation of the plomp stage. This teaching material (e-SW) was developed based on the needs and characteristics of the students of SMAN 14 Padang. The goal is to make students understand the material better and be interested in learning when studying electrolyte and nonelectrolyte solutions. Analysis of the needs of students conducted interviews and gave questionnaires to students and teachers.

The first stage of preliminary research begins with a needs analysis describing that the implementation of the 2013 curriculum currently applies a scientific learning approach (scientific approach). In addition, it also expects students to be skilled in utilizing technology in learning (Kemendikbud, 2014). The use of technology in education includes innovation in teaching materials. The form of innovation that can be done can be in the form of innovation in electronic teaching materials such as electronic student worksheets. E-SW is able to facilitate more effective learning. In addition, e-SW can be an attractive tool when students' interest in learning decreases (Syafitri & Tressyalina, 2020).

The development of e-SW has been carried out by Adilla, et al., (2018), namely the development of e-SW-based guided inquiry with Flip PDF Professional and 3D Pageflip based on Problem Based Learning (Hidayah et al., 2020). The developed E-SW is able to make students more interesting to learn and able to improve science process skills and students' critical thinking skills (Wazni & Fatmawati, 2022; Rizki, et al., 2021). In addition to innovative teaching materials, educators are required to be able to realize an active and meaningful teaching and learning process through the selection of appropriate and appropriate learning models.

The PjBL model is one of the learning models suggested by the 2013 curriculum because PjBL can make students active, creative, innovative and independent so that student learning outcomes can increase (Arizona, et al. 2020). Therefore, PjBL is effective to be considered to be applied to the learning process online during the corona virus pandemic this

and other emergency situations if face-to-face learning cannot be carried out (Fauziah, et al., 2020).

Based on observations at SMAN 5 Padang, SMAN 14 Padang and MAN 2 Pesisir Selatan, information was obtained that the electrolyte and nonelectrolyte solution material showed that there were still students' learning outcomes that had not been completed. Then some teachers have tried to use the PjBL model but it has not gone well and has not produced a product. Teachers mostly use textbooks and LKPD, but the available LKPD has not guided students to carry out simple project-based learning that produces products.

Based on this analysis, teaching materials in the form of e-SW based on Project Based Learning (PjBL) were developed which can be an alternative to meet current needs, one of which is electrolyte and nonelectrolyte solution materials, especially at SMAN 14 Padang.

Context analysis is carried out by analyzing basic competencies based on the 2013 revised 2018 curriculum syllabus. Based on the 2018 revised 2013 curriculum chemistry subject syllabus, there are 2 Basic Competencies that must be mastered by students, namely BC 3.8. Analyzing the properties of the solution based on its electrical conductivity and BC 4.8. Distinguishing the electrical conductivity of various solutions through the design and implementation of experiments (Permendikbud, 2014). then it is translated into several indicators of competency achievement (GPA) and from the GPA the learning objectives are obtained.

The second stage is making prototypes (stages of developing teaching materials). This development stage is obtained from the design and realization of the preliminary research. The development of these teaching materials is in accordance with the results of filling out the questionnaire of SMAN 14 Padang students, in which students want a teaching chart (e-SW) that is easy to understand, attractive and illustrated. Development of teaching materials produced in the form of e-SW electrolyte and nonelectrolyte solutions based on Project Based Learning (PjBL) which contains the following e-SW components: cover, preface, table of contents, module usage instructions, core competencies, basic competence, indicators of competency achievement, learning objectives, concept map, activity sheet, worksheets and evaluation sheet, besides that it is also equipped with material presentation based on PjBL syntax. After product development, this stage produces prototype I. Cover and activity sheets can be seen in Figures 2 and 3.

The cover section of the e-SW contains the identity of the e-SW which includes the name of the e-SW, the title of the material, the target user, the name of the author and the name of the supervisor. The name of the e-SW and the title of the material are published to

provide information about the learning model used in the e-SW, namely Project Based Learning (PjBL) and the title of the material in the e-SW, namely electrolyte and nonelectrolyte solutions. The cover is designed with attractive colors to be able to arouse the interest of students to read and study it. The e-SW cover is also equipped with images related to electrolyte and nonelectrolyte solution materials.

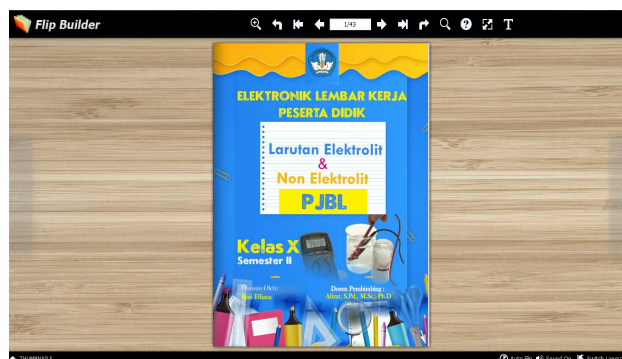


Figure 2. Cover

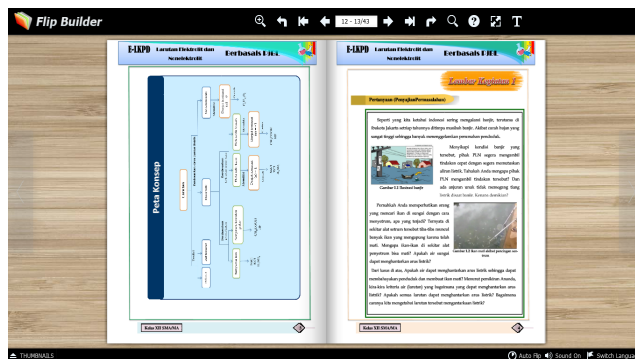


Figure 3. Activity Sheet

The student activity sheet contains the subject matter of electrolyte and nonelectrolyte solutions which are arranged based on a project-based learning model consisting of 6 stages: questions (presenting problems), planning, scheduling, project monitoring, assessment and evaluation (Sani, 2018).

The results of prototype I were self-evaluated. At this stage, a personal assessment was obtained that prototype I needed to be revised. The revision made was in the form of adding an e-SW component, namely adding an evaluation question component. So that this stage produces prototype II.

Prototype III carried out an expert review. Expert reviews are carried out by content experts and construct experts, by assessing and reviewing products carried out either with or without the presence of the researcher (Tessmer, 1993). Validation was carried out by 6 experts including 4 UNP chemistry lecturers and 2 chemistry teachers at SMAN 14 Padang. Validation is carried out based on the guidelines of a valid validation sheet. Validation was carried out on several components including content, presentation, linguistic and graphic

components. Aspects of validator validity measured using aiken's V formula, with a valid category of 0.78 for 6 validators (Aiken, 1985).

Table 1. Obtaining E-SW validity test scores

Rated aspect	formula Aiken's V	Category Validity
Content Component	0.84	Valid
Components of Serving	0.85	Valid
Component language	0.91	Valid
Graphical Component	0.85	Valid
Rata-Rata Formula		
Aiken's V	0.86	Valid

In Table 1 above, the level of validity is 0.86. The validity of the e-SW is included in the valid category, so that the e-SW can be submitted to the teacher for practicality testing.

The next stage is a one-to-one evaluation, to see student responses to the developed e-SW. Three students as respondents observed, and worked on several activities on the e-SW that had been developed. Then an interview was conducted on the e-SW to find out the student's response.

Based on the results of the interviews, it can be concluded that, the cover display is quite attractive, the display of images and videos has made students learn the contents. Then revisions were made based on suggestions from expert reviews, and suggestions from respondents at the one-to-one evaluation stage, until prototype III was produced.

The last stage is to produce prototype IV which is generated from the results of small group evaluations. At this stage, a small-scale trial was conducted, on 6 students of class XI IPA SMAN 14 Padang who represented the population. The selected students consisted of 3 students with high, medium, and low abilities.

At the small group stage, practicality questionnaires were distributed to students to see student responses to the teaching materials developed.

Table 2. Obtaining E-SW Practicality test scores

Evaluator	Persentase	Practicality Category
Students (Small group)	82%	Very Practical
Teacher	88%	Very Practical

In table 2 above, it can be seen that the percentage of students (small group) is 82% and the percentage of teachers is 88%. Student and teacher responses stated the results that each component of the assessment was stated to be practical. Assessment and suggestions for improvement obtained at this stage, it becomes a guideline for further product revisions which then produces prototype IV.

This shows that the developed e-SW can help the independence of students in finding the concept of learning material. The PjBL model is designed to increase student activity, be more process-oriented and seek their own information in achieving learning goals, and educators only act as facilitators in learning activities (Randy, 2019; Sari, et al., 2020). E-SW is easy to use, practical and has various features where teachers can load material, learning videos, links and various types of questions such as multiple-choice questions, short entry, drop & down, and others (Latifah, et al., 2021). Therefore, PjBL-based e-SW electrolyte and nonelectrolyte solutions are useful in studying electrolyte and nonelectrolyte solutions.

Conclusion

Based on the results of research and study of PjBL-based electrolyte and nonelectrolyte e-SW products, it can be concluded that: PjBL-based E-SW electrolyte and nonelectrolyte solutions produced based on expert assessments obtained valid criteria and are suitable for use for learning. PjBL-based E-SW electrolyte and nonelectrolyte solutions that are produced based on the responses of students and teachers to the e-SW developed in small-scale trials are obtained practically for use in learning.

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