Journal of Educational Sciences
Journal homepage: https://jes.ejournal.unri.ac.id/index.php/JES

P-ISSN 2581-1657
E-ISSN 2581-2203

Development Of A Flipped Classroom Learning System Based On Guided Inquiry On Electrolyte And Non-Electrolyte Solution Materials

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ARTICLE INFO

Article history:

Received: 19 July 2022
Revised: 25 Sept 2022
Accepted: 30 Sept 2022
Published online: 24 Oct 2022

Keywords:

Flipped Classroom
Guided Inquiry
Moodle
Electrolyte and Non-Electrolyte Solutions

A B S T R A C T

The era of education influenced by the industrial revolution 4.0 is called Education 4.0. Education 4.0 is an education that is characterized by the use of digital technology in the learning Therefore, research is needed that aims to develop a guided inquiry-based flipped classroom learning system using Moodle on electrolyte and non-electrolyte solutions, as well as to determine the level of validity and practicality of the products developed. This type of research is Educational Design Research (EDR) using the Plomp model. The subjects of this study were 3 chemistry lecturers at FMIPA UNP, 3 chemistry teachers, and 15 students in class XI IPA SMAN 8 Padang. This research was conducted to test the validity using the Aiken's V formula and the practicality test using the percentage formula. Five validators carried out the validity test and one-to-one evaluation by three students. The results of processing the validity test data are 0.88, indicating the valid category. For the data processing results, the practicality test for students is 88%, and the practicality test for teachers is 94% which shows the very practical category.

1. Introduction

Facing the challenges in the Revolutionary Era 4.0, education is also required to change, including education at the primary and secondary levels. The era of education influenced by the industrial revolution 4.0 is called Education 4.0. Education 4.0 is an education that is characterized by the use of digital technology in the learning process, known as a cyber system that can make the learning process run continuously without space and time limits. Changes in the education system will undoubtedly significantly impact the role of teachers as educators (Mursid & Yulia, 2019). Teachers need learning strategies to facilitate students' development and can use online learning media to deliver learning and give

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Doi: https://doi.org/10.31258/jes.6.4.p.538-549

students assignments (Anggraeni, 2018). Then, teachers can also take advantage of the sophistication of digital technology by conducting online learning, known as blended learning.

Blended learning is a combination of face-to-face and online learning (Chaeruman, 2013). Blended learning is a learning process that combines technology-based learning with traditional learning (Maulida, 2020). One way of implementing blended learning is by using the flipped classroom model. Learning with the flipped classroom learning system is carried out in two phases, namely the phase outside the class (asynchronous) and the phase in the classroom (synchronous) (Aumi & Mawardi, 2021). In the flipped classroom, in the learning process, students study subject matter at home before class starts, and teaching and learning activities in class are in the form of doing assignments and discussing material or problems that students have not understood (Yulietri & Mulyoto, 2015). It can be seen that flipped classroom learning can implement a learner-centered learning process by the demands of the 2013 Curriculum.

The 2013 curriculum is developed to improve and balance soft and hard skills, which are attitudes, skills, and knowledge (Pahrudin, 2019). The learning demands of the 2013 curriculum are learner-centered learning with a scientific approach. Scientific process learning requires students to think systematically and critically to solve problems whose solutions are not easy to see (Barringer et al., 2010). The 2013 curriculum demands and trains students to think critically, creatively, collaborate, and communicate in the learning process (Fani & Mawardi, 2022). One of the learning models in the 2013 curriculum is the guided inquiry learning model (Waer & Mawardi, 2021).

Guided inquiry is an active learning model where students can build their own understanding by connecting it with prior knowledge (Hanson, 2005). Guided inquiry can also increase student activity, motivation, and learning outcomes (Asra et al., 2016). The stages in the guided inquiry learning model are orientation, exploration and concept formation, application, and closing (Hanson, 2005). The application of guided inquiry can improve the quality of students' conceptual understanding and instill character in students (Jannah, 2012). The guided inquiry method can increase student learning activities and attention (Handhika, 2010).

To carry out online learning, we need to use a system to support the online learning process called LMS (Learning Management System) (Rizkivany & Mawardi, 2021). The LMS used for online learning is Moodle. Moodle allows students to enter a digital “classroom” to access learning materials. Some features that can help during the learning process, such as quizzes, collaboration, assignments, communication, and uploading various forms of the material provided, are called main features (Surjono, 2010). The use of this moodle supports efforts to meet the achievement of guided inquiry learning (Ninda & Mawardi, 2022). To see the application of a learning system, this learning is applied to the electrolyte and non-electrolyte solution material studied in class X SMA/MA (Gaja & Mawardi, 2021).

Electrolyte and non-electrolyte solutions are chemistry learning materials in class X semester two that students consider difficult. Materials from the electrolyte and non-electrolyte solutions have factual, conceptual, and procedural dimensions. The material has three aspects that must be studied: macroscopic, submicroscopic, and symbolic. The characteristics of this material are conceptual, so students must understand the basic concepts of the material (Arianti & Zainul, 2020).

Based on the theory and problems described, the researchers conducted research entitled "Development of a Flipped Classroom Learning System Based on Guided Inquiry Using Moodle on Electrolyte and Non-Electrolyte Solution Materials."

2. Methodology

The type of research conducted is Educational Design Research (EDR) using the Plomp development model developed by Tjeerd Plomp. The plomp development model consists of 3 stages, namely (1) the Preliminary Research Phase, (2) the Development or Prototyping Phase, and (3) the Test and Assessment Phase (Plomp & Nieveen, 2007). In the preliminary research stage, needs and context analysis, literature study, and conceptual framework development were carried out. In the prototyping phase, a formative evaluation consists of self-evaluation, one-to-one evaluation, expert review, and small group. The assessment phase is the final stage of research.

The research subjects in this study were 3 chemistry lecturers at FMIPA UNP, 3 chemistry teachers, and 15 students of class XI IPA at SMAN 8 Padang. This study's data collection instruments were validation and practical instruments. The validation instrument was a validation questionnaire given to 3 chemistry lecturers and 2 chemistry teachers. The assessments in the validation questionnaire are the components of the feasibility of content, presentation, language, and graphics. The practical instrument used is a response questionnaire given to students and teachers. Student response questionnaires were obtained from a small group evaluation conducted on 12 students of SMAN 8 Padang. The level of practicality can be assessed from aspect the of ease of use, time efficiency, and benefits.

The validity analysis technique uses Aiken's V scale, where the Aiken's V formula is as follows.

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

$$s = r - I_o$$

Information:

s = The score determined by the validator minus the lowest score in the category used

r = Validator choice category score

Io = Lowest score in the scoring category

n = Number of validators

c = The number of categories selected by the validator

The validity of the guided inquiry-based flipped classroom learning system with five validators will be seen after being converted to the categories listed in table 1 below (Aiken, 1985).

Table 1. Validity level conversion

Interval	Validity
V < 0,8	Invalid
V ≥ 0,8	Valid

The practicality analysis technique uses the following modified formula from Purwanto (2010).

$$NP = \frac{R}{SM}\ x\ 100$$

Information :
NP = percent value sought or expected
R = raw score obtained by students
SM = the ideal maximum score of the test in question
100 = fixed number

The level of practicality of the guided inquiry-based flipped classroom learning system will be seen after being converted to categories such as table 2 below (Yunus & Sardiwan, 2018).

Table 2. Practicality level conversion

Value	Practicality
86% - 100%	Very practical
76% - 85%	Quite practical
60% - 75%	Practical
55% - 59%	Less practical
≤ 54%	Not practical

3. Results and Discussion

The research was conducted using the plomp development model. The plomp development model consists of 3 stages, namely (1) the preliminary research phase, (2) the development or prototyping phase, and (3) the assessment phase (Plomp & Nieveen, 2007). The first stage, namely the preliminary research stage, carried out needs and context analysis, literature studies, and conceptual framework development. The needs analysis stage was conducted by interviewing chemistry teachers in several schools, namely SMAN 7 Padang, SMAN 8 Padang, and SMAN 10 Padang. Based on the results of the interviews, it was concluded that teachers have difficulty in implementing the learning process using digital technology, especially teachers who have not been able to implement a student-centered learning process to the demands of the industrial revolution 4.0 era as well as the needs of the 2013 curriculum which requires student-centered learning. So it takes learner-centered education so that can improve critical thinking skills.

Meanwhile, in the context analysis stage, an analysis of the curriculum and syllabus was carried out. Curriculum analysis is carried out to identify and systematically develop learning objectives, materials, and strategies selected as objectives for expanding learning. The study of the syllabus begins with analyzing the competencies that students must have in the form of Basic Competencies. From the basic competencies, it can be reduced to indicators of competency achievement and learning objectives on electrolyte and non-electrolyte solutions.

Several literature reviews found that the combination of the flipped classroom learning method with the guided inquiry learning model used an application in the form of Moodle. A flipped classroom is a computer-based learning media by the development of learning in the industrial revolution 4.0 (Overmyer, 2014). Guided inquiry is a series of activities that allow students to search and investigate systematically, critically, logically, and analytically so that they can confidently present their findings (Sari & Mawardi, 2022). Moodle (Modular Object-Oriented Dynamic Learning Environment) is a software package helpful in creating and conducting internet-based courses/ training/ education (Prakoso, 2005).

At the conceptual framework stage, research is carried out by identifying problems and finding solutions to problems encountered in learning. So from the preliminary research stage, the prototype I was produced in the form of a guided inquiry-based flipped classroom learning system on electrolyte and non-electrolyte solutions that were inserted into the moodle. The following is the flipped classroom learning system design using the stages of guided inquiry.

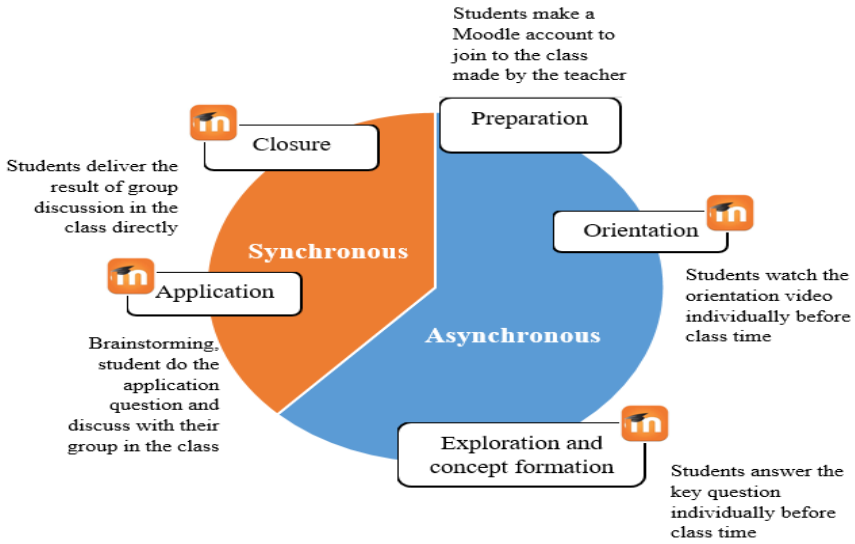


Figure 1. Flipped-guided inquiry learning model cycle
(Ismail & Mawardi, 2021)

At the orientation stage, students are asked independently to watch a video orientation that the teacher has presented in the moodle. At the exploration and concept formation stage, students explore the models given in the form of images, videos, graphics, tables, etc., accompanied by answering critical questions so that students can find the concepts and learning objectives that have been set. At the

application stage, students work on practice questions that are carried out in groups in the comments column of the Quiz Assignment feature, and students are divided into groups with small-group characteristics. The closing stage can be done using the jitsi (virtual synchronous) feature or face-to-face in class (live synchronous).

The results of prototype I that have been developed are then developed (formative evaluation) using self-evaluation in the form of a checklist sheet to produce prototype II. In prototype II, then it was developed and evaluated through expert assessment by three chemistry lecturers at the Faculty of Mathematics and Natural Sciences UNP and two chemistry teachers used a validation questionnare. The valid prototype II was then revised again based on the suggestions and inputs given by the experts before being tested in an individual evaluation (one-to-one evaluation). The validation results will obtain an average validity value of 0.88 with a valid category. The results of the validity analysis are shown in Figure 2.

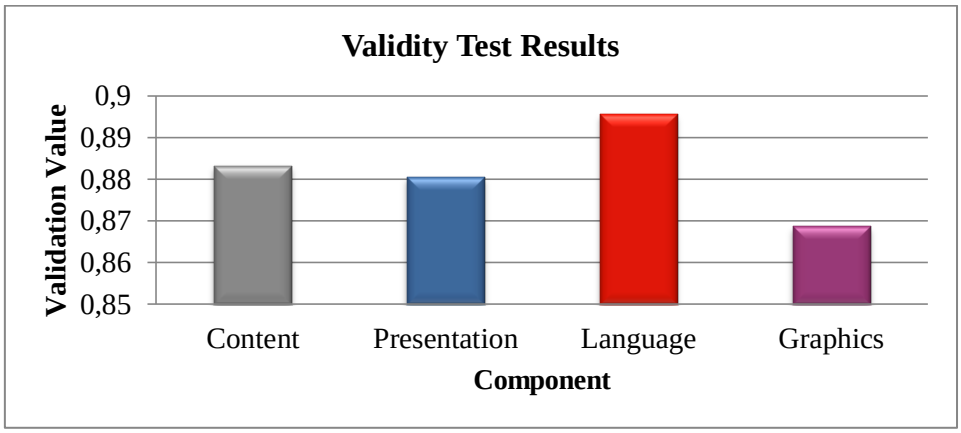
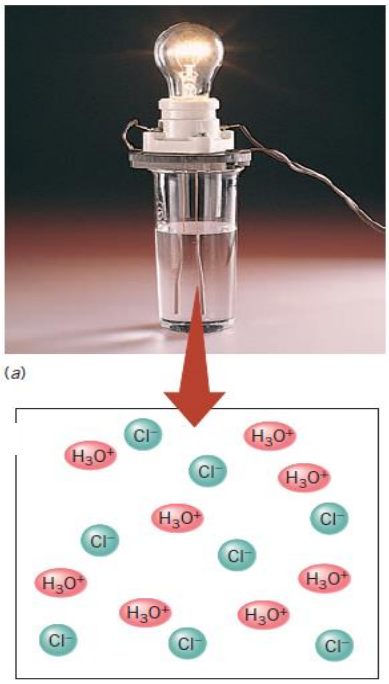


Figure 2. Validation Results

The valid prototype II was then revised again based on the suggestions and inputs given by the experts before being tested in an individual evaluation (one-to-one evaluation). In the particular evaluation test (one-to-one evaluation), interviews were conducted with three students with different abilities, namely high abilities, moderate abilities, and low abilities. The instrument used is an interview sheet. The results of the individual evaluation test (one-to-one evaluation) can be concluded that the quality of the sound and display on the video is clear, the language used is easy to understand, the instructions given are easy to understand, and the model provided is transparent and can help answer key questions. After revision of the expert review (expert review) and individual evaluation test (one-to-one evaluation), prototype III was produced.

The last stage of the development and manufacture of prototypes is the evaluation of a small group (small group) that will produce prototype IV, which aims to determine the level of practicality of prototype III (the product being developed). Small groups were conducted for three chemistry teachers and twelve students in class XI SMA/MA with different levels of ability, namely high, medium, and low. The results of the practicality of students can be concluded that the model

provided is easy to understand and can help students answer key questions so that they can understand and find their own concepts of electrolyte and non-electrolyte solutions. In the exploration and concept formation stages, models and key questions can be given, as shown in Figure 3.



(Source: Brady, 2012)

Figure 3. Example of The Model Used in The Exploration and Concept Formation Stage Model 1

An overview of students' understanding of the concept of strong electrolyte solutions and weak electrolytes can be seen in table 3.

Table 3. Description of Students' Answers at The Stages of Exploration and Concept Formation

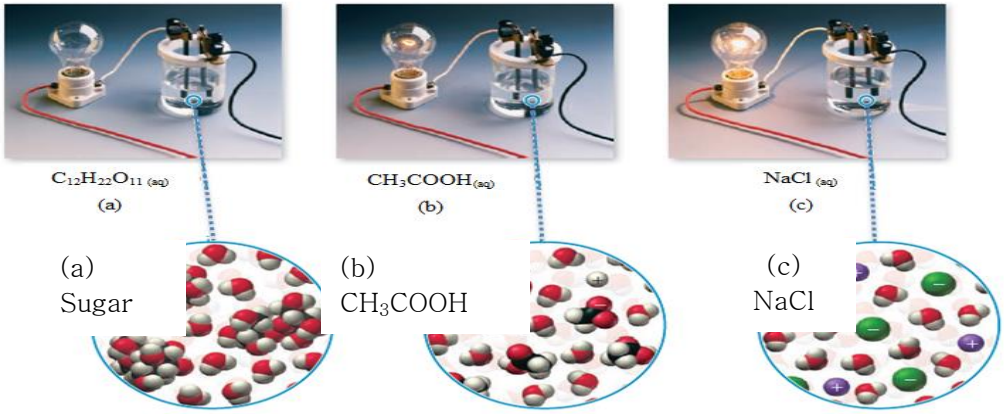
Student 1	HCl solutions include polar covalent compounds, and HCl solutions can be completely ionized in water to conduct electric currents.
Student 2	HCl solution is an ionic compound and can be ionized in water.
Student 3	HCl solution is a polar covalent compound and can be ionized in water.

To see students' explanations, it can be adjusted to the principles or theories contained in the literature (general textbooks).

Table 4. Description of Textbook Answers at The Stages of Exploration and Concept Formation

Text Book	HCl is a covalent compound and has no ions. HCl will have ions when dissolved in the air. HCl is 100% ionized in water and is a strong conductor (Brady, 2012; Tro, 2018).

Based on Figure 3, a model that describes the multi-presentation of chemistry related to the concept of a robust electrolyte solution is given. Student 1 has high analytical skills, so understanding the material is not much different from the explanation in the textbook. Student 2 also has good analytical skills, so the understanding of the material is almost close to the description in the textbook. Then students 1 and 2 can analyze the model and think critically in answering key questions to guide students in finding concepts related to solid electrolyte solutions. Then, student 3 found misconceptions when determining the HCl solution, including ionic or polar covalent compounds, where student 3 answered that the HCl solution included ionic compounds. According to Nivaldo J. Tro (2018), HCl is a covalent compound with no ions. HCl will have ions when dissolved in the air. It can be concluded that the HCl solution is a polar covalent compound, has no ions, and can be perfectly ionized in water to conduct electricity (a strong conductor).



(Source: Tro, 2019)

Figure 4. Example of The Model Used in The Exploration and Concept Formation Stage Model 2

An overview of students' understanding of the concept of strong electrolyte solutions, weak electrolytes, and non electrolyte solutions can be seen in table 5.

Table 5. Description of Students' Answers at The Stages of Exploration and Concept Formation

Student 1	Picture (a) the lamp does not light up because the sugar solution does not decompose in water. Figure (b) the light is dim because the CH_3COOH solution can partially decompose in water. Picture (c) the light is bright because the NaCl solution can decompose entirely in water.
Student 2	Picture (a) the lamp is not lit and includes a non-electrolyte solution, picture (b) the lamp is dim and includes a weak electrolyte solution, while picture (c) is a bright lamp and includes a strong electrolyte solution.
Student 3	Figure (a) Completely ionized, the solute will be completely decomposed. Figure (b) Partially ionized only partially dissolved solute. Figure (c) Not ionized, so the solute will not deteriorate in water

To see students' explanations, it can be adjusted to the principles or theories contained in the literature (general textbooks).

Table 6. Description of Textbook Answers at The Stages of Exploration and Concept Formation

Text Book	Figure (a) is classified as a non-electrolyte solution because the sugar solution does not contain ions, does not decompose in water, and the light bulb does not light up. Figure (b) is classified as a weak electrolyte solution because the CH_3COOH solution contains a small number of ions, partially decomposes in water, and the light bulb glows dimly. Figure (c) is classified as a strong electrolyte solution because the NaCl solution contains many ions, can decompose entirely in water, and the light bulb glows brightly (Chang, 2011).

Based on Figure 4, a model describes the multipresentation of chemistry related to the concept of strong electrolyte solutions, weak electrolytes, and non-electrolytes. Student 1 has high analytical skills, so understanding the material is not much different from the explanation in the textbook. Student 2 has good analytical skills so that the understanding of the material is almost close to the description in the textbook. Then student 1and 2 can analyze the model and think critically in answering key questions to guide students in finding concepts related to strong electrolyte solutions, weak electrolytes, and non-electrolytes. Then student 3 found misconceptions when grouping some of these solutions, where student 3 did not group strong electrolyte solutions, weak electrolytes, and non-electrolytes. According to Chang (2011), NaCl solution is a powerful electrolyte solution because the NaCl solution contains many ions, can decompose entirely in water, and the light bulb glows brightly. The CH_3COOH solution includes a weak electrolyte solution because the CH_3COOH solution has a small number of ions, and can partially decompose in water, so the light bulb glows dimly. The sugar solution is a non-electrolyte solution because the sugar solution is not ionized in water, and the light bulb doesn't light up.

Based on the analysis of answers from 3 students as samples in the small group test, they can understand the concept of electrolyte and non-electrolyte solutions through the models and key questions provided. The key questions gave start from simple queries to complex questions. Key questions are beneficial for students in answering questions so that they can conclude the given model.

The aspects assessed in practicality are ease of use, time efficiency, and benefits. Based on the results of processing practicality test data for students, an average value of 88% is categorized as very practical and for teachers, an average value of 94% is obtained with a very practical category. Thus, the learning system developed is declared practical. The results of the practicality analysis are shown in Figure 5.

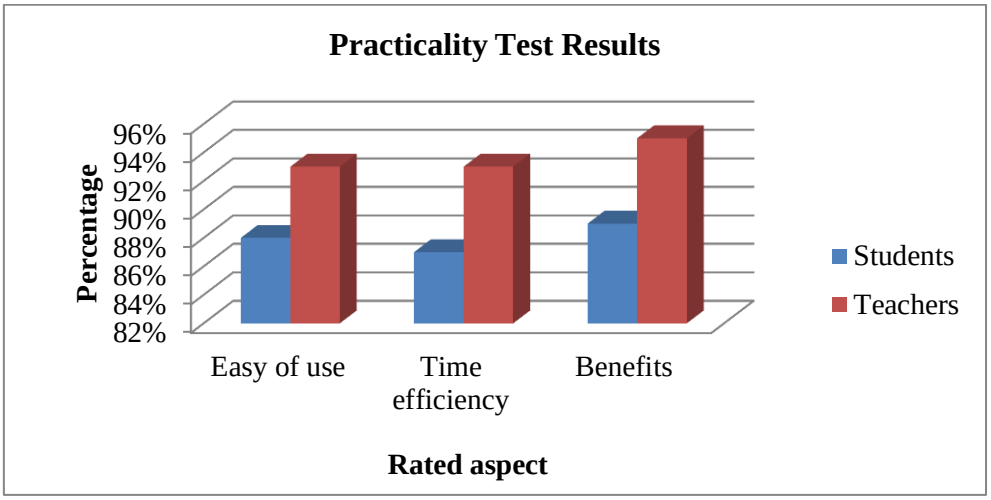


Figure 5. Practicality Test Results

4. Conclusion

Based on the results of the study, it can be concluded that the guided inquiry-based flipped classroom learning system using Moodle on electrolyte and non-electrolyte solution material for class X SMA / MA can be developed using the plomp model which has a valid category and is very practical to use by teachers and students.

Acknowledgement

Thanks to the Head Department Of Chemistry; Mrs. Guspatni, S.Pd, M.A, Mr. Effendi, S.Pd., M.Si, and Mrs. Dr. Desi Kurniawati, M.Si, as a validator who has provided suggestions and input to researchers; Mrs. Dra. Asra, M.Pd, Ms. Elvi Yanti, S.Pd, and Ms. Fitriani, S.Pd as chemistry teachers and validators; Mr. Zahroni, M.Pd as the Principal of SMA Negeri 8, has given research permission to researchers; Class XI SMA Negeri 8 students have helped researchers carry out research.

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How to cite this article:

Alfidyah, M., & Mawardi. (2022). Development Of A Flipped Classroom Learning System Based On Guided Inquiry On Electrolyte And Non-Electrolyte Solution Materials. *Journal of Educational Sciences*, *6(4)*, 538-549.