

The assessment of predict-observe-explain (POE)-based chemistry high school teacher's supporting book for reaction rate, acid base solution, and colloidal system

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Abstract. This research aimed to identify the quality of the developed teacher's supporting book which is the POE demonstration for reaction rate, acid base solution, and colloidal system based on the assessment from experts. The assessing experts consisted of a content expert, a learning expert, and a media expert. The content expert assessed the book based on the feasibility of the content component. The learning expert assessed the book based on the feasibility of the presentation component. The media expert assessed the book based on the feasibility of the readability (language and image) and the graphic components. Based on the results of the expert's assessments, it can be seen that the quality of the book in terms of the material or content components was categorised as 'very good', the presentation component was categorised 'very good', the readability component (language and image) was categorised as 'good', and the graphic component was categorised as 'good'. Overall, the quality of the developed books was categorised as 'very good', so that it is feasible to be teacher's supporting book in demonstrating chemistry materials for reaction rate, acid base solution, and colloidal system based on POE strategy.

Keywords: *chemistry demonstration, POE, teacher's supporting book*

1. Introduction

Chemistry is a science-based on experiments, so that without going through practical activities, a chemical concept will not be fully understood [1]. However, in carrying out practical activities, the constraining problems oftentimes are a limited learning time for too many materials to deliver by a teacher. Besides, the constraining problem in practicum implementation is often due to the lack of tools and chemicals. As a result, teachers often only pursue the completion of the material but lack in practical implementation. In fact, this practicum is very important in learning chemistry. Practical activities have long been used to involve students in concrete experiences with objects and concepts [2], which are in accordance with the characteristics of chemistry which contain many abstract concepts [1], such as the reaction rate material, acid-base solutions, and colloidal system.

In the concept of reaction rate, acid-base solutions, and colloidal systems, the teachers do not only need to explain the theoretical concept but also insert the practicum activities so that students can understand the concept better. Besides, the practicum is beneficial for training the students' skills in the science process [3]. By conducting practicum, the students can practice doing scientific work such as preparing hypotheses, making observations, analyzing data, and communicating what they experience with, so that through practicum activities students can practice to discover chemical concepts from the conducted practicum.



However, practicum activities carried out in general high schools have not fully been able to make students active yet in discovering the chemistry concepts from the conducted practicum. Students have very limited opportunities to make hypotheses and observations, construct the explanation, evaluate the alternative explanations, make a conclusion and communicate the findings with appropriate evidence [4]. Therefore, teachers need to do an innovation through the application of an approach, model, method, strategy, or learning technique that can enable students to find out chemistry concepts, to train students' skills of science process including hypothetical or predicting activities, and to integrate it in learning to save time.

One of these innovations is through the implementation of the Predict-Observe-Explain (POE) learning strategy that was developed by White and Gunstone. POE strategy implementation is done through an experiment or demonstration. Students predict what will happen and give the reasons for such predictions based on what they understand. Then, the students make observations of the experiments or demonstrations are shown. If their predictions are not in accordance with the result of observations, the students give an explanation of the discrepancy [5].

POE strategy can be used to improve students' scientific understanding [6] and assess students' level of understanding [7]. This strategy can be an effective tool in diagnosing the types of students' responses to contradictory observations. It also can be used as a mean for summative assessment [5].

POE strategy is carried out through a demonstration. The demonstration is one of the methods commonly applied by chemistry teachers to teach chemistry in the class [1]. The use of demonstrations in chemistry learning can support students' understanding of concepts because students have the opportunity to observe a chemical phenomenon. Demonstrations can make students actively participate in learning [8]. In addition, demonstrations can also be used to develop students' skills in the scientific process and scientific attitudes [3].

Similar to practical activities, demonstrations can be the means to clarify and concretize abstract material [3], such as chemistry. If planned properly, demonstrations can be an effective tool for enhancing students' understanding of certain chemistry concepts and increase their motivation and interest to learn chemistry [9]. Therefore, it is very appropriate to use the POE strategy as the teacher's alternative variation in chemistry learning at high schools, especially in the concept of reaction rates, acid-base solutions, and colloidal systems.

In its application, to make the learning process of chemistry materials about reaction rates, acid-base solutions, and colloidal systems with the POE strategy works well, clearly, and directed, the teacher, in this case, should have understood about the POE strategy and the steps for its application in the learning process. However, not all teachers have known and understood about POE and its application in the learning process. Therefore, the teacher needs a supporting book about the demonstration on chemical concept of reaction rates, acid-base solutions, and colloidal systems, which serves as a teacher's guide in carrying out chemistry learning of these concepts using the POE strategy.

Supporting books are books that contain material that can enrich elementary, secondary, and tertiary education textbooks. Teachers can use enrichment books in the learning process [10]. The use of this supporting book is very important because it is a complementary or additional material in the textbook. Furthermore, specifically the developed supporting book in this study also serves as teachers' guide in implementing POE learning, students' guide for carrying out chemical demonstrations based on POE steps, as well as the means of evaluating student learning outcomes.

The developed teacher's supporting book has structural components. 1) A general section consisting of preface, table of contents, bibliography; 2) The initial part of the book consisting of an introduction on what POE is, what the benefits of implementing a POE are, book organization, instruction of book, safety rules and guidelines; 3) A section for students consisting of student worksheets containing chemical demonstrations of the concept of reaction rates, acid-base solutions, and colloidal systems; 4) Explanation part for teachers; and 5) Appendices consisting of chemistry laboratory apparatus, Material Safety Data Sheet (MSDS), the example of learning implementation plan, and science process skills rubric.

The compilation of demonstration titles in the book are as follows. 1) Magic Balloon, 2) Weathering Chalk, 3) Lava Lamp, 4) Eggshell Chemical Reaction, 5) Glow sticks, 6) Abracadabra: Missing ...!, 7) Elephant's Toothpaste, 8) What's in a Chicken Heart?, 9) Acid or Base?, 10) Making Acid-Base Indicator Paper, 11) Measuring pH with Universal Indicators, 12) Purple Cabbage Extract as Universal Indicator, 13) Between Solutions, Colloidal System, and Suspension, 14) Tyndall Effect is Colloidal Nature, and 15) Shake ... Shake ... Shake ... Furthermore, in order to obtain a good teacher supporting book, this study was intended to identify the quality of the developed books based on experts' judgment.

2. Research method

This research is a mixed-method research with exploratory mixed-method design and instrument development model. The method is preceded by collecting qualitative data to explore phenomena, then collecting quantitative data to explain the relationships found in qualitative data. The instrument development model was chosen because it was in accordance with the process of developing and implementing quantitative instruments based on qualitative findings.

The research procedures consisted of four stages. They are qualitative, developmental, quantitative, and interpretation [11]. The instrument used in this study consisted of open questionnaire sheets and check-list questionnaire sheets. The open questionnaire sheets are used to obtain input or suggestions, while the check-list questionnaire sheets are used to obtain score data of product quality assessment.

Product quality assessment is based on four assessment components. They are the material or content component, the presentation component, the readability component (language and image), and the graphic component. Each assessment component is elaborated into assessment aspects and assessment indicators, which in total consist of 13 aspects of assessment and 42 indicators of assessment. These aspects and indicators of assessment are adapted from the Book Centre [12] and the Centre for Curriculum & Bookkeeping [13], [14].

The data obtained from this study consisted of qualitative data and quantitative data. Qualitative data were in the form of input data or suggestions. Meanwhile, quantitative data were in the form of data score assessment results of each component of product quality obtained from experts (material experts, learning experts, and media experts) at the stage of product development. Quantitative data were obtained from qualitative data based on assessment using book evaluation sheets that were then converted into quantitative data with a Likert scale into Very Good = 5, Good = 4, Fair = 3, Less = 2, and Very Less = 1.

Qualitative data or product input data were then analyzed qualitatively to determine which input is used and not used as product revision material. The obtained quantitative data or product valuation score data for each assessment component were then calculated on average to determine the categories of each assessment component (table 1) [15]. Next, the data were analyzed descriptively.

Table 1. Product rating category criteria

| Formula | Average score | Category |
|--------------------------------------------------|--------------------|-----------|
| $X > \bar{X}i + 1.8 Sbi$ | $X > 4.2$ | Very good |
| $\bar{X}i + 0.6 Sbi < X \leq \bar{X}i + 1.8 Sbi$ | $3.4 < X \leq 4.2$ | Good |
| $\bar{X}i - 0.6 Sbi < X \leq \bar{X}i + 0.6 Sbi$ | $2.6 < X \leq 3.4$ | Fair |
| $\bar{X}i - 1.8 Sbi < X \leq \bar{X}i - 0.6 Sbi$ | $1.8 < X \leq 2.6$ | Less |
| $X \leq \bar{X}i - 1.8 Sbi$ | $X \leq 1.8$ | Very less |

Explanation:

$\bar{X}i$ (ideal average) = $\frac{1}{2}$ (ideal maximum score + ideal minimum score).

Sbi (ideal standard deviation) = $\frac{1}{6}$ (ideal maximum score - ideal minimum score).

X = empirical score

3. Results and Discussion

In accordance with the research procedure, the research was carried out in four stages: qualitative, development, quantitative, and interpretation. In the qualitative stage, qualitative data collection was carried out through literature studies and discussions. The study of literature was the study of relevant references sourced from both books and journals. The discussion, in this case, was conducted with the supervisor discussing the reality of chemistry learning, and common practicum in high schools, the rules of the supporting book for teachers, and the structure of the book to be developed. The obtained qualitative data from both the results of the literature study and subsequent discussions were analyzed by qualitative descriptive. From this analysis process, qualitative results can be obtained that are in the form of a book structure description, book assessment indicators, and book development.

After the book structure has been determined, the next step was developing the book, which was compiling the book based on the determined book structure components. Then, the developed product was consulted with the supervisor to get corrections and input. Next, the product was validated to experts (Expert Judgment) that are a material expert, a learning expert, and a media expert. The material expert assessed the feasibility of the product in terms of material components or contents. The learning expert assessed the feasibility of the product in terms of the presentation component. The media expert assessed the feasibility of the product in terms of the readability component (language and images) and the graphic component. The following are the results of product evaluation by experts based on the book assessment component (table 2).

Table 2. Product evaluation results by experts (expert judgement).


| Experts | Component to Assess | Average score | Category |
|-----------------|----------------------------------|---------------|-----------|
| Content Expert | Materials or contents | 4.5 | Excellent |
| Learning Expert | Presentation | 4.8 | Excellent |
| Media Expert | Readability (language and image) | 4.1 | Good |
| | Graphics | 4.0 | Good |
| | Total | 4.4 | Excellent |


Based on the results of the assessment (table 2), it can be seen that the material component or content of the book belongs to the excellent category with a mean score of 4.5 out of maximum, 5. This result in line with the results of the general study of learning media development [16], [17].

The material or content component consists of three aspects of assessment and eight assessment indicators. These aspects of assessment include 1) in accordance with the educational goals, 2) in accordance with the development of science and technology, and 3) in accordance with the reader's reasoning. The assessment indicators include 1) material to develop knowledge, 2) material to develop skills, creativity, and responsibility, 3) material in accordance with the truth of science concepts, 4) material in accordance with current conditions or data, 5) material in accordance with reality (to be factual), 6) material related to critical thinking, 7) material related to creative thinking, and 8) material related to innovative thinking.

As for the three aspects of the assessment, the most prominent aspect is the third aspect which is in accordance with the reader's reasoning with the acquisition of a score of 5 for each indicator. It can be analyzed that the developed material in books is very good for developing students' critical thinking skills, creative thinking, and innovative thinking. The material developed in the book is a chemical demonstration using the Predict-Observe-Explain (POE) strategy. This POE strategy is very good for training students' critical thinking skills. Students are trained to predict or make scientific hypotheses with the support of relevant theories. Students' curiosity is developed to prove the results of their predictions through observation, and students practice to communicate the obtained results after analyzing the results, so this can train students' critical thinking skills. This is also supported by the results of a study stating that learning with POE strategies can train students' critical thinking skills [18], [19], train students to find new knowledge, and improve student learning outcomes [18].

The chemical demonstration that was developed in the book is a chemical demonstration of reaction rate material, acid-base solution, and colloidal system in which most of the tools and materials utilize the currently available tools and materials. For example, the demonstration of the reaction rate concept of the effect of concentration on the reaction rate is the demonstration of the Magic Balloon (figure 1). Tools and materials used include mineral water bottles, rubber balloons, vinegar acid solutions, and baking soda. The tools and materials used are material tools that are easily obtained, so students can get easily and can do it themselves at home. Besides being safe, a demonstration by utilizing the materials that are around can also train students to think creatively and innovatively by utilizing what is around. This is in line with the result of a study that showed a correlation between critical thinking and creative thinking through POE implementation [20].


PREDICT-OBSERVE-EXPLAIN


PREDICT-OBSERVE-EXPLAIN

LEMBAR KERJA SISWA

Konsep : Pengaruh konsentrasi terhadap laju reaksi


Tujuan : Siswa dapat mempelajari pengaruh konsentrasi terhadap laju reaksi

KEGIATAN 1 : MAGIC BALLOON

Alat dan Bahan yang harus dipersiapkan :

- Gelas Ukur
- Pipet tetes
- 2 buah corong gelas
- Neraca Analitik
- Stopwatch
- Spatula

- 3 buah botol
- 3 buah balon karet
- Larutan asam asetat 0,1 M; 0,2 M; 0,3 M
- Soda Kue (NaHCO_3)



PREDICT

Sebelum memprediksi, terlebih dahulu lakukan langkah-langkah demonstrasi "Magic Balloon" berikut!

- Masukkan sebanyak 25 mL larutan asam asetat 0,1 M ke dalam botol dengan menggunakan corong gelas.
- Isikan 5 gram soda kue ke dalam balon karet dengan menggunakan corong gelas lainnya.
- Pasang balon karet pada mulut botol. Hati-hati jangan sampai soda kue jatuh ke dalam larutan asam asetat. Pastikan balon terikat kuat pada mulut botol.
- Jatuhkan soda kue tersebut ke dalam larutan asam asetat.
- Nyalakan stopwatch tepat pada saat soda kue jatuh ke dalam larutan asam asetat dan hentikan stopwatch tepat pada saat balon bisa berdiri. Catat waktunya pada Tabel 1.

Perhatian : Pada saat balon mulai mengembang, pegang erat balon pada bagian mulut botol agar balon tidak lepas.

6. Ulangi langkah 1-5 untuk larutan asam asetat konsentrasi 0,2 M dan 0,3 M.

Tabel 1. Laju Reaksi Soda Kue pada Larutan Asam Asetat Berbagai Konsentrasi

| Konsentrasi asam asetat (M) | Waktu (s) | Laju Reaksi (s^{-1}) |
|-----------------------------|-----------|---------------------------------|
| 0,1 | | |
| 0,2 | | |
| 0,3 | | |

Dengan melihat data hasil pada Tabel 1. di atas, jawablah pertanyaan berikut.

- Perubahan apa yang dapat kamu amati ketika soda kue dimasukkan ke dalam larutan asam asetat?
 Jawaban : _____

- Apakah ada perbedaan kecepatan mengembangnya balon? Pada larutan asam asetat konsentrasi berapakah balon paling cepat mengembang?
 Jawaban : _____

Laju Reaksi | 19

20 | Laju Reaksi

Figure 1. Print screen student worksheets (magic balloon).

Another benefit is that teachers can save learning time because the demonstration can be used as the student's assignments at home. POE demonstration can also be integrated in the learning process, both at the beginning as an introduction to the material to deliver, in the middle as the core of learning that can be the means of proving concepts and to clarify the material that has been delivered by the teacher, and at the end of the learning, called as feedback, to find out the extent of student understanding of the concepts that have been delivered by the teacher, as well as being a means of evaluation for teachers to improve further learning.

The learning expert assessed the feasibility of the book in terms of the presentation component consisting of six aspects of assessment and eighteen assessment indicators. The six aspects of assessment include 1) using a systematic presentation, 2) ease of understanding, 3) stimulating the development of creativity, 4) growing motivation to know more, 5) developing thinking skills, and 6) developing academic skills.

The assessment indicators include 1) the presentation of the material is carried out logically, 2) the presentation of the material is carried out systematically, 3) the presentation of the material refers to the students' science process skills, 4) the presentation of the material in the book is familiar to the reader, 5) the presentation of the material creates a pleasant atmosphere, 6) the presentation of the material is complemented by pictures and messages, 7) the presentation encourages the reader to do creative work, 8) the presentation of the material leads to psychic activity, (9) the presentation

stimulates the reader to try something positive, 10) the presentation encourages the curiosity of the reader, 11) the presentation encourage interest to gather information, 12) the presentation of material encourage to search for similar textbooks, 13) the presentation can lead readers to think critically, 14) the presentation can lead readers to think creatively, 15) the presentation can lead readers to think innovative, 16) the presentation can guide readers explore information, 17) the presentation can guide skills in solving problems, and 18) the presentation can lead to decision making.

Based on the assessment of the learning expert, the book presentation component gets an average score of 4.8 so that it belongs to the excellent category. Of the six aspects of the assessment, all aspects obtained a score of 5 for all indicators except the second aspect, namely the aspect of ease of understanding which obtained a score of 4 for all indicators. It can be analyzed that the presentation of book material is very good in terms of systematic presentation, development of creativity, motivation to find out more, development of thinking skills, and developing academic skills. However, it is included in both categories in terms of the ease of understanding.

The aspect of ease of understanding consists of three assessment indicators, namely the presentation of material in a book familiar with the reader, the presentation of material creates a pleasant atmosphere, and the presentation of material is complemented by pictures and messages. Based on this assessment it can be analyzed that the presentation of material in the book is not yet too familiar to the reader. This is because the developed chemical demonstration material is a demonstration based on the POE strategy using tools and materials that are around, but it is not yet too common to be implemented by teachers in schools.

Meanwhile, the presentation of book material has not fully created in a pleasant atmosphere because in the development of this initial product there is still a lack of presentation of images that support the presentation of material, so that the input obtained from the learning expert is used as an improvement material so that the presentation of book material is more interesting and pleasing to the reader. However, apart from the presentation of the picture, when viewed from the presentation of POE demonstration material it should be a fun learning variation for students. This is supported by a research result which states that students give positive responses and feel happy to have participated in POE learning [21]. Besides that, learning becomes more interesting [22].

The media expert assessed the feasibility of books from the readability component (language and images) and the graphic component. The readability component consists of four aspects of assessment and ten assessment indicators. Aspects of assessment include 1) the suitability of images with language, 2) understanding of language or images, 3) accuracy in using language, and 4) accuracy in using images or photos.

The assessment indicators include 1) using language and images proportionally, 2) using language or images that are in accordance with the development of cognition, 3) using clear image media, 4) using complete picture captions, 5) using correct spelling, 6) using words or terms appropriately, 7) using sentences properly and correctly, 8) using the size of the image that is suitable and attractive, 9) using the color of the image that is suitable and attractive, and 10) using the shape of the picture that is suitable and attractive.

Based on the assessment of the media expert, the readability component (language and picture) obtained an average score of 4.1 so that it was included in good categories. As for the four aspects of the assessment above, the most prominent is the second aspect, namely the understanding of language or images. It can be analyzed that the use of language or images used in the preparation of books is in accordance with the development of cognition, the use of clear image media, and the use of complete picture captions.

In terms of the graphic component, the book is in the good category because it gets a mean score of 4.0. This result is different from the results of the study in general [16], [17] that show a very good category on the graphic component. This is because of some revisions especially on the appearance and color of images. This is why the result of readability component also gets a good category because of some revisions on the appearance of images and the writing.

The graphic component consists of six assessment indicators, namely 1) book cover: illustrations represent content, typeface has high readability, attractive, balanced and harmonious composition between the front cover and back cover, 2) students worksheets cover: illustrations represent content, typeface has high legibility, interesting, balanced composition, 3) cover explanation for the teacher: illustrations represent content, typeface has high legibility, interesting, balanced composition, 4) layout of book content is done consistently and in accordance with the cover of the book, 5) type, font size, and numbering throughout the contents of the book is consistent, and 6) illustrations are appropriate for the target reader and clarify the material.

Of the six indicators of assessment the most prominent or very good is the first indicator that is the cover of the book: the illustration represents the content, the type of letter has a high readability, attractive, balanced and harmonious composition between the front cover and back cover. Meanwhile, the other indicators are categorized as good except the third indicator which is the explanation cover for the teacher: the illustrations represent the contents, the type of letter has high legibility, is interesting, the composition is balanced including enough categories. This is because based on input from the media expert there needs to be a color improvement on the text "explanation for the teacher" (on the cover explanation for the teacher) so that the writing stands out. The following is the "explanation for teacher" cover before and after the improvement is made (figure 2).



Figure 2. Print screen cover teacher's explanation before (left) dan after (right) revision

Overall, based on the results of the assessment of the four components namely material or content, presentation, legibility (language and images), and graphics, the average score of 4.4 is obtained. Thus, it can be stated that the quality of the teacher enrichment books developed is in the excellent category.

4. Conclusion

Based on the analysis of the results and the discussion previously, it can be concluded that overall the chemistry teacher enrichment book for Prediction-Observe-Explain (POE) based demonstration for reaction rate material, acid-base solution, and colloidal system is very good. Thus, this book is appropriate for the teacher to use as a guide in carrying out chemical demonstrations of reaction rate materials, acid-base solutions, and colloidal systems based on POE strategy.

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