The development of guided inquiry based student worksheet of chemical equilibrium towards student activities

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Abstract. This study aims to produce a worksheet of chemical equilibrium which based on guided inquiry to determine the validity, practicality and effectiveness the student worksheet on student learning activities. Learning activities are assessed in the form of listening activities, visual activities, mental activities, oral activities, writing activities and motor activities. This research method was a research development using the Plomp model. The research subjects were students majoring in chemistry in 2019. The research instruments used were validation sheets, practicality sheets and observation sheets of learning activities. This research found that the students’ worksheets have a very high level of validity (k=0,91) and very high level of practicality by students (k=0,87) and high by the lecturer (k=0,79). The results showed that in general, the average student learning activity was 81,18% which was included in the very high category. It shows that the students’ worksheets which have been produced can be used as one of the teaching materials in the learning process on chemical equilibrium material.

1. Introduction
Chemistry is defined as the science of the composition, structure, properties, and reactions of compounds, especially atoms and molecular systems, material changes and the energy that accompanies these changes [1]. Chemistry is a product (chemical knowledge in the form of facts, theories, principles, laws) scientific findings and processes (scientific work). There are some concepts in chemistry that are abstract, these abstract concepts make it difficult for students to understand the material. Chemical equilibrium is an important material that is difficult to study because it relates to chemical reactions, where chemical equilibrium answers the question of how far a chemical reaction can go. Chemical equilibrium is one of the compulsory material that students learn in basic chemistry courses. After doing the interview with 3 chemistry lecturers and students majoring in chemistry of Universitas Negeri Padang, The result is the equilibrium material was considered one of the difficult material by students. To provide interesting learning for students, lecturers must have a strategy and completeness of good teaching materials one of which is student worksheet.

Student Worksheets are activity sheets that can be used to activate students during learning. Student Worksheet is a sheet containing the tasks that must be done by students both in the form of questions and active activities during learning. Student use of worksheets can improve and increase the creativity and activeness of students so as to assist students in the process of concept independently. Student
worksheets arranged using a learning model can make students more active because in learning students are guided in finding concepts according to the syntax of the model used in the worksheet.

One of the learning models that can activate student activities is guided inquiry. Guided inquiry is an effective learning model used in learning [2]. This learning model requires the active participation of students in scientific inquiry [3]. The main advantage of guided inquiry is that it can help students improve their ability to solve questions [4]. Guided inquiry is one type of inquiry that focuses on planning and guidance that begin from teacher to improve students' skill for life [5]. The advantages of student worksheets that are arranged using a guided inquiry model are to provide a model (submiscropcopis representation) to assist students in answering key questions [6].

The lecturer has a very important position to make learning successful, because the main function of the lecturer is to design, manage and evaluate learning [7]. Student activities in learning activities are important. Learning activities also really need to be developed in the learning process because learning activities will be more meaningful. The existence of student activities in learning activities has a great impact on learning. Maximum learning activities will show that learning takes place properly and optimally, so that learning is of higher quality. Student activities in learning can provide maximum results if students are actively involved in learning. Paul B. Diedrich made a list of 177 types of student activities [8] which divided into eight groups, namely as follows: Visual activities, oral activities, listening activities, writing activities, drawing activities, motor activities, mental activities and emotional activities (emotional activities)

One of the efforts in increasing student activities in learning is to design teaching materials in the form of student guided inquiry based student worksheet [9] in chemical equilibrium material. This student worksheet that will be developed uses a guided inquiry model and is equipped with multiple representations consisting of three levels. This study aims to produce a guided inquiry based student worksheet of chemical equilibrium and to know the validity, practicality and effectiveness.

2. Methodology

2.1. Research Subject
The subjects in this research were chemistry lecturers as validators of student worksheets and as practical subjects and 45 students of Universitas Negeri Padang majoring in chemistry in 2019.

2.2. Research Design
The type of research conducted is Research and Development (R & D). The research method used in this study is Plomp model. Based on the Plomp development cycle, the Plomp model is divided into three phases, the first stage is preliminary research, the second stage is prototyping phase or development the student worksheet, and the third stage is assessment phase [10]. The research method are shown in Table 1.

| No | Stage                | Activities                                      |
|----|----------------------|-------------------------------------------------|
| 1  | Preliminary research | needs analysis, curriculum analysis, student analysis, concept analysis |
| 2  | Prototyping phase    | making prototypes 1 to 4 and the practicality   |
| 3  | Assessment phase     | field test and effectiveness                    |

2.3. Data Collection
Data analysis techniques for validity and practicality based on a questionnaire from lecturers and students using the kappa kohen (k) formula [12]:
\[ k = \frac{P_o - P_e}{1 - P_e} \]  

Information:
- \( k \) = kappa moment value
- \( P_o \) = realized proportion
- \( P_e \) = proportion not realized

Kappa moments (k) range from 0 to 1, with interpretations presented in Table 2.

Table 2. Interpretation of Kappa moment values (k)

| K value     | Category     |
|-------------|--------------|
| 0.81–1.00   | Very high    |
| 0.61–0.80   | High         |
| 0.41–0.60   | Medium       |
| 0.21–0.40   | Low          |
| 0.00–0.20   | Very low     |
| < 0.00      | Invalid      |

The effectiveness of student worksheet in this research is seen from the activities of students for analysis using the percentage formula approach [13] with the following equation:

\[ \%A = \frac{\text{score obtained}}{\text{maximum score}} \times 100\% \]  

The criteria for student activeness [14] shown in Table 3.

Table 3. Criteria for Analysis of Student Activity Observation Sheets

| %        | Category      | Criteria after conversion |
|----------|---------------|---------------------------|
| 81-100   | Very high     | Very effective            |
| 61-80    | High          | Effective                 |
| 41-60    | Medium        | Effective enough          |
| 21-40    | Low           | Less effective            |
| 0-20     | Very low      | Ineffective               |

3. Results
3.1. Preliminary Research
After doing the interview with 3 chemistry lecturers and students majoring in chemistry, Universitas Negeri Padang regarding problems in basic chemistry courses, especially in chemical equilibrium material. The result is the teaching materials used in chemistry courses basic, especially chemical equilibrium material is a textbook and there is not yet student worksheet as teaching material. Teaching materials that must be mastered by students based on syllabus and semester learning plans are: 1) Dynamic equilibrium, 2) Equilibrium law, 3) Homogeneous and heterogeneous equilibrium, 4) Dissociation equilibrium, 5) Kc and Kp relationships, and 6) Equilibrium shift.

3.2. Prototyping Phase
After formulating learning objectives based on the Basic Chemistry semester learning plan, development continues with designing student worksheet. The components of student worksheets that are designed are cover, preface, table of contents, list of pictures, characteristics of student worksheets, instructions for using student worksheets, Expected Learning Outcome (ELO) of chemistry education program, expected end learning ability, study material (teaching material), learning objectives, concept maps, activity sheets, worksheets, and references.
After producing prototype 1 in the form of an initial design, the next step is to personally check the worksheets that are designed or called self-evaluation. Self-evaluation is carried out with a check list system of important parts that must be contained in the student worksheet. After the results of the revision prototype 2 was formed. Then the chemistry lecturer is validated the student worksheet. Revision based on the validator's suggestion is to change the cover of student worksheets, add some key questions and eliminate formulas from the information provided and in order to guide students in discover the concepts based on the key questions given. The validation results show that the student worksheets were valid with a very high validity category with k value 0.91. If it has met the requirements in terms of content and construct, then a product can be said to be valid [13]. Validation analysis are shown in Table 4.

| Assessment Aspects | k   | Category     |
|--------------------|-----|--------------|
| Content            | 0.87| Very high    |
| Construction       | 0.94| Very high    |
| Linguistic         | 0.90| Very high    |
| Graphic            | 0.93| Very high    |
| Average            | 0.91| Very high    |

After validity by expert review, then do the one to one evaluation by three students majoring in chemistry. The results of the interview found that in terms of cover design and color selection makes students interested in learning it and the use of the language is easily understood. This revision of student worksheets a prototype 3 is formed. After prototype 3 is formed, next is to do small group evaluation. Small group evaluation was carried out involving 6 students with research instruments in the form of questionnaires. The results show that the student worksheets were practical with a very practical category with k value 0.82. The results of small group evaluations conducted on students with practicality questionnaire instruments whose analysis results are shown in Table 5. After evaluating a small group, a prototype 4 will be formed which will be tested in the field test.

| No | Aspect           | k   | Category     |
|----|-----------------|-----|--------------|
| 1  | Ease of Use     | 0.86| Very practical|
| 2  | Time efficiency | 0.80| Very practical|
| 3  | The benefits    | 0.81| Very practical|
|    | Average         | 0.82| Very practical|

### 3.3 Assessment Phase
This assessment phase aims to see the practicality and effectiveness of student worksheet that are tested on large groups (field test). Practicality data was achieve from student response questionnaire and two chemistry lecturers response questionnaire after learning is complete using student worksheets. The result analysis of students and lecturers response questionnaire are shown in table 6 and table 7.

| No | Aspect           | k   | Category     |
|----|-----------------|-----|--------------|
| 1  | Ease of Use     | 0.87| Very practical|
| 2  | Time efficiency | 0.85| Very practical|
| 3  | The benefits    | 0.86| Very practical|
|    | Average         | 0.82| Very practical|
Table 7. Results of lecturer response questionnaires

| No | Aspect          | k   | Category   |
|----|----------------|-----|------------|
| 1  | Ease of Use    | 0.83| Very practical |
| 2  | Time efficiency| 0.76| Practical   |
| 3  | The benefits   | 0.77| Practical   |
|    | Average        | 0.79| Practical   |

From table 6 it can be seen that the average k value from the questionnaire in the evaluation of large groups is 0.82 with a very practical category, this shows that this student worksheet is very practical to be used by students in learning. In table 7 based on the lecturer response questionnaire obtained an average value of k is 0.79 with a practical category.

To see the effectiveness of student worksheets, an analysis of student activities in learning was conducted. This observation was carried out on 5 February 2020 for the first meeting, and the second meeting on 6 February 2020 and 12 February 2020 for the last meeting. Student learning activities obtained from observers observations. The observer consists of two people who observe the learning process when using guided inquiry based student worksheet of chemical equilibrium. This observation was conducted to determine the level of student activity in learning using this student worksheet. For the percentage of student learning activities in each activity are shown in Table 8.

Table 8. Results of Analysis of Student Learning Activities by Observer

| Observed Activities   | Percentage (%) of Activities per Meeting | Average |
|-----------------------|------------------------------------------|---------|
|                       | I            | II          | III         |        |
| Listening Activities  | 78.89%       | 84.44%      | 82.00%      | 81.78% |
| Visual Activities     | 81.11%       | 82.00%      | 83.33%      | 82.15% |
| Mental Activities     | 81.67%       | 80.00%      | 83.33%      | 81.67% |
| Oral Activities       | 80.56%       | 81.67%      | 82.22%      | 81.48% |
| Writing Activities    | 78.33%       | 81.67%      | 82.22%      | 80.74% |
| Motor Activities      | 78.90%       | 78.90%      | 80%         | 79.27% |
|                       | Average      | 81.18%      |             |         |

4. Discussion
4.1. Validity

Validation of student worksheets by chemistry lecturers by filling out a questionnaire that has been arranged according to the grid. Results of the content validity analysis obtained the level of validity is very high category with a k value of 0.87. The model used on student worksheets is scientifically correct and in accordance with the material taught and can be explored to answer key questions. This is approval with the purpose of the model that is used so that students or students find a certain pattern that refers to the understanding of concepts [14]

Based on the results of the analysis of construct validity (presentation) the validity level of student worksheets is in the very high category with k value of 0.94. The high value of k indicates the components in the worksheet are related to each other and are well connected [15]

The linguistic component assessment of student worksheets has a very high validity category with a kappa moment value of 0.90. This means that the language used is communicative and the sentences used are easy to understand.

Graphic component assessment of student worksheets has a very high validity category with a k value of 0.93. This shows that the model presented, the type of font used, layout and colour selection
are appropriate and can attract the attention of students. The results of the student work sheet validation are shown in Figure 1.

![Validation Result](image)

**Figure 1.** Average validation results of student worksheets.

4.2. **Practicality**

Practicality data was collected using the questionnaire practicality of student responses and practicality questionnaire responses of lecturers. The ease of use of student worksheets shows a very practical with the acquisition of kappa moments of 0.83 from the lecturer practicality questionnaire and 0.87 from the student practicality questionnaire. This shows that the student worksheets have instructions for use that are easy to understand, the steps of the activities undertaken are clear and neatly arranged so that it can be understood by the teacher and students.

The time efficiency component of student worksheets shows practical with the acquisition of a kappa of 0.76 moment from the lecturer practicality and a very practical with the acquisition of a 0.85 from the student practicality. This shows that student worksheets are practical in terms of learning time.

The aspect of the benefits of student worksheets shows a very practical with the acquisition of of kappa moments of 0.77 from the lecturer practicality and a very practical with the acquisition of a 0.85 from the student practicality. This shows that student worksheets can motivate students to find concepts with guidance through key questions. The results of practicality can be seen in Figure 2.

![Practicality of lecturers and students](image)

**Figure 2.** Average practicality results.
4.3. Effectiveness
The effectiveness of student worksheets is seen from the learning activities of students observed by the observer while learning takes place. Based on observations by observers the percentage of students doing listening activities is 81.78% with a very high category, it can be concluded that students are already very good at conducting listening activities from lecturers or peers. The percentage of students doing visual activities is 82.15% with a very high category, it can be concluded that students are already very good in carrying out activities related to vision in learning such as reading and paying attention to the lecturer explaining. The percentage of students doing mental activities is 81.67% with a very high category, it was concluded that the students were very good at responding, remembering and solving problems in the learning process.

The percentage of students doing oral activities is 81.48% with a very high category, it was concluded that the students were very good at asking questions, giving opinions, and discussing in the learning process. The percentage of students doing writing activities is 80.74% with a high category, it is concluded that students are already good at carrying out activities of noting important things in learning. The percentage of students doing motor activities is 79.27% with a high category, it is concluded that students are already good at doing work activities in learning. Overall the average student learning activity is 81.18% which is included in the very high category. This results analysis proves that student worksheets that are designed very effectively are used in chemical equilibrium learning.

![Percentage of Student Learning Activities](image)

Figure 3. Percentage of Student Learning Activities.

5. Conclusion
Based on the results of the development of guided inquiry-based student worksheet of chemical equilibrium towards student activities. This research found that the students’ worksheets have a very high level of validity (k=0.91) and very high level of practicality by students (k=0.87) and high by the lecturer (k=0.79). The results showed that in general, the average student learning activity was 81.18% which was included in the very high category. It shows that the students’ worksheets which have been produced can be used as one of the teaching materials in the learning process on chemical equilibrium material.

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