Development of Guided Inductive Inquiry Learning Support Materials Prototype on Energy for Junior High School Level to Improve Students’ Conceptual Understanding: Validity and Practicality Study

M A Mahdiannur
Department of Natural Science, Universitas Negeri Surabaya, Indonesia.

e-mail: muhamadmahdiannur@unesa.ac.id

Abstract. This research purposed to describe the quality of learning support material prototype in energy topics for Junior High School. The quality-focused on this research were (1) validity and (2) practicality aspects. Guided inductive inquiry (GII) is a learning model to facilitate students to have a comprehensive understanding of concepts, develop complex thinking skills, and help internalize the concept of evidence and substantive concepts within students that they can use to solve problems, develop competencies, and improve learning outcomes. This research used Mafumiko’s Model to develop a prototype of learning support materials based on design research. This study conducted at SMPN 1 Tanah Grogot, Paser Regency, East Kalimantan, and involved 3 (three) subject matter experts (SMEs) and 2 (two) observers during the classroom tryout. The SMEs examined the GII learning support materials valid and their appraisal reliable. The implementation of GII learning support materials during learning processes in the very good category and students’ activities reflected the level of active participation. Based on these results, the quality of the prototype of GII learning support materials on energy topics for Junior High School level met the validity and practicality criteria and also improved the students’ conceptual understanding.

1. Introduction
Science education emphasizes that students carry out activities according to the scientific method to improve their thinking skills and to apply it in solving problems. Thinking has a wide variety of which divided into scientific thinking (critical and creative), high order thinking, and logical thinking, although various types of thinking sometimes overlap among indicators. Thinking is a combination of knowledge, skills, and attitudes, and the thinking process generates a critical attitude [1,2]. The importance of the combination of three domains as a basis for being able to think also encourages the government to revise the curriculum according to the Indonesian National Qualifications Framework (INQF) to face the challenges of the 21st century characterized by the collaboration, disruption era, and internet of things. 2013 Curriculum characterizes by the three domains, namely attitudes (spiritual and social), knowledge, and skills.

Research in science education focuses on enhancing the 21st-century science curriculum itself through small-group learning [3–5]. Based on this definition, science education research focusing on the applicable curriculum. 2013 Curriculum itself is in line with the principles of science education globally, namely learning science as it was discovered and developed by scientists by emphasizing the incorporation of thinking skills, science process skills, and manipulative skills [1,6,7]. Imitation of the
behavior of scientists in conducting scientific investigations must be carried out by students so that students become competent in using inquiry skills that are accompanied by the ability to think scientifically. Adaptation of the behavior patterns of scientists can help shape scientific literacy that is useful for solving problems according to the scientific method. The formation of scientific behavioral habits in inquiry processes must begin at an early age to strengthen the ability to think scientifically [8,9]. The habit of scientific behavior is important because the concept itself formed through interaction in formal school settings [10]. The scientific behavior has implications for the importance of the science learning process in junior high schools because inquiry processes are the science itself [11,12].

Science has been introduced in Indonesia since early childhood education to the high school level. Early childhood and elementary school students have studied science content in thematic learning and integrated science. Science as a subject began to be applied at the junior high school level and then developed into subjects of physics, biology, and chemistry through a specialization system at the senior high school level. The awareness toward science education in Indonesia is fundamental, but the level of ability, conceptual understanding, and scientific literacy of Indonesian students is still low in every international assessment. Based on observations, it seems that science learning focused on traditional ways, which tend to be learning-memorizing and minimal scientific investigation activities. Traditional (conventional) learning is not always bad, but learning with inquiry processes is more successful in improving student understanding [13]. The natural science subject teachers are also less able to manage exciting and challenging science learning in identifying and exploring students’ prior knowledge [11]. The inquiry process generally divided into two, namely inductive inquiry and deductive inquiry [1]. Inductive inquiry with a guided level [1], is very suitable for science learning for junior high school students [14]. On the other hand, the inductive approach to science learning based-on inquiry is very suitable because it starts from proving specific things and then moves towards general things, namely by matching the results of experimental activities with substantive concepts. The combination of laboratory activities with substantive concepts will improve students’ conceptual understanding [15,16].

The factor of science knowledge content also has a significant influence in determining science learning itself. One concept that is important in science is energy. The concept of energy itself has long been studied by students and is cross-disciplinary [17]. The concept of energy itself is eclectic, which is divided into four domains and reinforced by various experimental results [18]. Taking into account the complex characteristics of energy material, curriculum objectives, and how science taught to students based on inquiry learning and various inquiry approaches need a learning support material that can mediate the learning process so that students can master scientific thinking skills and improve their conceptual understanding. Learning support material must be structured in such a way that it forms a unified with the interventions that will be designed according to the intended goals. The learning support material on the energy topic must meet the three criteria, namely validity, practicality, and effectiveness [19], to improve students’ conceptual understanding. The three criteria must be fulfilled through an iterative process that involves designing, testing, and evaluation to obtain theory and design relevant to a situation [19]. The fulfillment of each of these criteria is not achieved simultaneously at one time but can be fulfilled gradually and separately [19]. Validity and practicality are two factors that must be fulfilled first because validity is related to fit of the learning devices with state-of-the-art of science itself and curriculum intention, while practicality indicates that learning support materials were successfully implemented by teachers and students in the learning process [19]. Therefore, this study focused on achieving the validity and practicality criteria for the prototype of GII learning support material on energy for Junior High School level to improve students’ conceptual understanding.

2. Method
This research was part of the design-research with micro-phases criteria [19]. The developmental phase applied in this research described as follows:
2.1. Preparation
In this stage, the design specifications for the development of the prototype of learning support materials established based on intended goals.

| No | Developmental Focus     | Design Specification                                      |
|----|-------------------------|-----------------------------------------------------------|
| 1. | Teaching preparation    | ● Learning objectives                                      |
|    |                         | ● Learning times                                           |
|    |                         | ● Experimental material                                   |
|    |                         | ● Barriers and its solution list                          |
| 2. | Subject knowledge       | ● Questions to feed the discussion                         |
|    |                         | ● Important scientific concepts explanation               |
|    |                         | ● Students’ questions during learning example              |
| 3. | Learning model          | ● GII model syntax                                        |
|    |                         | ● Students’ grouping                                      |
|    |                         | ● Scaffolding distribution                               |
| 4. | Assessment and feedback | ● Rubrics                                                  |
|    |                         | ● Assessment instruments                                 |

2.2. The Developmental Phase
This process adopted Mafumiko’s model. The Mafumiko model is a development model that emphasizes the micro phases of each development process that are flexible, and each phase can be presented separately [19]. The process of designing a prototype of learning support materials adjusted to the guidelines and specifications that have been set and revised through a classroom tryout. The process of developing the learning support material prototype emphasized on improving quality. The first stage focused on achieving validity criteria and then tested its practicality in a classroom tryout. Before and after the classroom tryout, the students are given a pretest and posttest to evaluate their gain. To evaluate students’ conceptual understanding, we used normalized change [20], which more sophisticated than Hake’s normalized gain [21].

2.3. Validity Appraisal
The validity of the prototype of learning support materials examined by three SMEs consisting of science education experts, assessment experts, and science content experts. The evaluation of validity uses the screening from the SMEs. The prototype of learning support materials validity calculated using Aiken’s V formula and the average reliability of all expert evaluations ($r_{xx}$), calculated using Ebel formulas [22]. The reliability of the assessment instrument also determined based on trial on small groups of students using the Cronbach Alpha test.

2.4. Practicality Examination
After the SMEs appraisal the validity, the practicality of using learning support material prototype by the teachers and students in the actual classroom settings need to be tested. The testing location determined at SMPN 1 Tanah Grogot, Paser Regency, East Kalimantan Province in the First Semester, Academic Year 2014/2015. The research subjects were 30 students of Class VII A. During the practicality testing process in a classroom, and it involves two observers who snapshot student activities every five minutes. The observers’ reliability is calculated using the Emmer and Millet formulas [23].

3. Result and Discussion
3.1. Result
Based on the screening method, the SMEs appraisal the validity of the learning support material prototype by filling out the validity appraisal form. Based on the results of the appraisal of the SMEs
in general, all components of the learning support material prototype for the Junior High School level on energy material topics have met the criteria of validity. The results of the appraisal of the SMEs also met the reliability criteria. The results of the validity appraisal shown in Table 2, Table 3, and Table 4.

**Table 2. Lesson plans validity.**

| Lesson Plans | Validity Coefficient | Reliability | Explanation                           |
|--------------|-----------------------|-------------|---------------------------------------|
| I            | 0.97                  | 0.81        | Valid and the examination from the SMEs reliable |
| II           | 0.95                  | 0.95        | Valid and the examination from the SMEs reliable |
| III          | 0.95                  | 0.87        | Valid and the examination from the SMEs reliable |
| Average      | 0.96                  | 0.88        | Valid and the examination from the SMEs reliable |

**Table 3. Student worksheet validity.**

| Student Worksheet | Validity Coefficient | Reliability | Explanation                           |
|-------------------|----------------------|-------------|---------------------------------------|
| I                 | 0.91                 | 0.84        | Valid and the examination from the SMEs reliable |
| II                | 0.95                 | 0.84        | Valid and the examination from the SMEs reliable |
| III               | 0.96                 | 0.81        | Valid and the examination from the SMEs reliable |
| Average           | 0.94                 | 0.83        | Valid and the examination from the SMEs reliable |

**Table 4. Student book and assessment instrument validity.**

| Type             | Validity Coefficient | Reliability | Explanation                           |
|------------------|----------------------|-------------|---------------------------------------|
| Student book     | 0.94                 | 0.85        | Valid and the examination from the SMEs reliable |
| Assessment instrument | 0.96     | 0.85        | Valid and the examination from the SMEs reliable |

Based on the data in Table 2, Table 3, and Table 4, the results of validity for all components of the learning support materials prototype > 0.90 and the reliability of the SMEs’ appraisal > 0.80. These results indicate that the SMEs agree that the learning support material prototype met the validity criteria. Specifically, for assessment instruments, before use, it tested for consistency with a small group of students besides the research subject—the instrument reliability test results using the Cronbach Alpha test. The test results showed that the assessment instrument has good consistency (0.71).

Testing the practicality criteria is based on the implementation of all learning scenarios and the use of all components of the learning support material prototype in a classroom tryout. Also, student learning activities used as parameters in determining the practicality criteria in this study. The learning process in the GII model begins by displaying phenomena packed in multimedia that can arouse curiosity and students’ willingness to ask questions and identify problems. This process is then used by the teacher to conduct more intensive discussions and guide students to carry out inquiry activities in small groups. The experimental process assisted by administering the distribution of scaffolding. The process of carrying out laboratory activities was initially quite difficult for students and teachers to do, but over time could proceed according to the lesson plan. The students then interpret the data and develop and test conclusions through discussion among group members by utilizing student textbooks that developed according to the learning objectives and discussion at the time of presenting the data at the end of the learning process before the ending of the lesson. The implementation of each lesson plan according to observations results by observers is more than 95%. The results of the lesson plan implementation summarized in Table 5.
Table 5. Recapitulation of the lesson plan implementation.

| Lesson Plan       | Percentage of Implementation | Explanation       |
|-------------------|-----------------------------|-------------------|
| Lesson plan I     | 97.22                       | Very Good Criteria|
| Lesson plan II    | 98.15                       | Very Good Criteria|
| Lesson plan III   | 100.00                      | Very Good Criteria|

Student activities generally dominated by inquiry processes. The inquiry activities indicated that students have successfully adapted and are willing to carry out various instructed activities according to the GII model. Various inquiry activities can reduce students’ inappropriate behaviors and begin to express opinions on the material being studied. The students’ activities summarized in Table 6.

Table 6. Recapitulation of the students’ activities.

| Students’ Activities | Percentage of Implementation on Meeting | Explanation       |
|----------------------|-----------------------------------------|-------------------|
|                      | I                     | II         | III |                     |
| Pay attention        | 32.36                  | 31.96      | 32.49 | Very Good Criteria |
| to the teacher’s     |                         |             |     |                     |
| explanation and     | 15.35                  | 15.64      | 15.51 | Very Good Criteria |
| asking               |                         |             |     |                     |
| Inquiry activities   | 36.52                  | 36.05      | 35.45 | Very Good Criteria |
| Communication        | 15.77                  | 16.35      | 16.55 | Very Good Criteria |
| Inappropriate        | 0                      | 0          | 0    | Not Observed        |
| behavior             |                         |             |     |                     |
| Total                | 100                    | 100        | 100  |                     |
| Reliability (observers’ agreement) | 95%       | 98%       | 98%  | Reliable            |

The implementation of student-centered learning and supported by the prototypes of learning support materials also have a positive impact on improving students’ understanding of energy concepts. The mean of pretest 33.11 with a range of 33.33, while the mean of posttest increased to 84.00 with a range of 40.00 (Table 7). The average value of normalized change ($c$) shows good results, which is 0.78 with a standard deviation of 0.172 and a range of 0.56, and the majority of students are in the intermediate and high $c$ clusters (Figure 1).

Table 7. Result of pretest and posttest before and after the intervention.

| Parameter(s)               | Pretest | Posttest |
|----------------------------|---------|----------|
| Mean                       | 33.11   | 84.00    |
| Median                     | 33.33   | 86.67    |
| Mode                       | 20.00   | 100.00   |
| Maximum                    | 53.33   | 100.00   |
| Minimum                    | 20.00   | 60.00    |
| Standard Deviation         | 11.001  | 13.171   |
| Standard Error             | 2.008   | 2.405    |
Figure 1. The plot of students’ clusters indicates improvement in conceptual understanding.

Based on the data in Table 5, Table 6, Table 7, and Figure 1, all scenarios in each lesson plan can be implemented in a classroom tryout, and student activities are also following the inquiry processes and have an impact on the improvement of students’ conceptual understanding according to the test results, before and after intervention. Based on these data, the learning support material prototype met the criteria of practicality.

3.2. Discussion

The results of the SMEs appraisal showed that all components of the prototype of learning support materials had met the criteria of validity. These results reflected that the development of material under the four principles of the organization of energy materials, all stages of learning could be carried out by teachers and students, and construction is coherent among the curricular components. All components of the prototype of learning support materials developed by combining scientific inquiry and social inquiry to improve students’ thinking skills. The entire component integrated into the syntax of the GII learning model. These results are expected to improve the students’ ability to think and develop a conceptual understanding that emphasizes the process of identifying previous experiences and knowledge of students on things studied like scientists because of the inquiry process is the science itself [11,12].

The learning support materials prototype has met the validity criteria, then proven by the results of the implementation of all the learning scenarios that have been previously designed (see Table 5). These results indicate that the SMEs have been able to appraisal whether the prototype learning support materials can be implemented or not in a classroom tryout setting. Student activities also tend to be dominated by inquiry activities, such as working in teams, conducting scientific inquiry activities, and simple scientific communication. Inductive inquiry processes assisted by scaffolding distribution according to the guided level tend to minimize the appearance of inappropriate behavior, and also improved the students’ conceptual understanding. Inquiry processes attracted students to be active and gain meaningful concepts from the learning process [11,12]. Adaptation of the behavior patterns of scientists is beneficial for developing scientific thinking skills that are supported by the mastery of strong content knowledge [6,7] to solve problems. The active student participation levels also confirm that guided inductive inquiry-based learning is better than traditional learning [13,14]. It also shows that students do not need too long to be able to participate in inductive inquiry-based learning because it is following the development process of children who are always curious about new things [8,9]. Also, cooperation in teams during the experimental activities provides opportunities for students to interact with each other because concepts formed through interaction [16]. Data from the research showed how important the planning process and stages in the development of learning support materials. The SMEs have an important role in examining whether a prototype learning support material is by scientific developments and can implement in the learning process in a
classroom. The validity and practicality criteria an inseparable unity. Fulfilments of these criteria (validity and practicality) gradually, shows that the Mafumiko’s model is design research or design experiment design that is suitable for researchers who cannot conduct large-scale fieldwork [19]. Validity and practicality have an essential role in improving the learning process quality and learning achievement.

4. Conclusion
Based on the results of the appraisal of SMEs and the results of the classroom tryout indicated that the GII Learning Support Materials Prototype on Energy for Junior High School Level met the validity and practicality criteria and also improved the students’ conceptual understanding. However, to evaluate the effectiveness of learning support materials prototypes requiring more classroom tryout processes to obtain the same trend of results continuously.

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