Measuring level of inquiry (LoI) in senior high school Surakarta city

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Abstract. This study aims to measure the level of inquiry (LoI) of students in high school Surakarta, so that teachers can choose an alternative model inquiry suitable for use in accordance with the ability of students. Level of inquiry (LoI) is divided into 6 namely: discovery learning, interactive demonstration, inquiry lesson, inquiry laboratory, real-world application, and hypothetical inquiry. This research is qualitative using checklist modification from Wenning. The level of inquiry (LoI) criteria scale is based on: LoI > 70% have a high category, 30% LoI 70% have a medium category and LoI <30% have a low category. The results showed that high school students in Surakarta city have high criteria on; discovery learning (79.11%), criteria medium on; interactive demonstration (65.18%); inquiry lesson (39.11%); inquiry laboratory (30%) and low criterion on; real-world application (28.04%); Hypothetical inquiry (25.18%). Teachers can use the inquiry model on high and medium criteria that match with student's ability.

1. Introduction
The inquiry is generally interpreted as a process of obtaining information to know a phenomenon that occurs through scientific investigation [1,2]. Inquiry learning model can build students to solve problems and draw conclusions according to the purpose of investigation in learning through observation and or experiment [3]. Students are said to have learned if they are able to solve the problem. Delivery of problems early in the course of learning or encouraging students to formulate their own problems will allow students to transfer their knowledge into the search for a solution through a series of processes to produce the chosen solution. As a teacher, it is important to prioritize students to become active problem solvers [4]. Learning with the inquiry model is one example of meaningful learning. First, students are involved in the assimilation process when incorporating existing experience and knowledge with new information being learned. Second, the students modify the existing concept to overcome the existing problems so as to generate new ideas. Both processes require students to have the experience to dig up information, collect data, analyze and organize knowledge of a phenomenon in a cognitive structure [5].

According to [6] the inquiry learning model is divided into 6 levels, namely discovery learning, interactive demonstration, inquiry lessons, inquiry laboratory, real-world application, and hypothetical inquiry, level of inquiry model adjusted to a cognitive level of students and teacher activity in learning process [6-7]. Wenning formulated the level of inquiry model level based on John [8] which stated that experience and investigation aimed at improving the ability of learners in finding what they want in learning in school, because according to him science learning is not supposed learners accept and
use existing law, but they can discover and prove it through their own experiences, and therefore their level is tailored to their experience in learning [6]. Experience-based learning model itself has been developed for a long time, until finally Wenning find the phase that according to him most suitable applied in this modern era for science learning, in phase there are five steps the same for each model of learning at the level of inquiry, the difference is the cognitive level and learners' experiences in learning [9], therefore it is necessary to measure the level of inquiry to the students before applying the inquiry learning model to fit their experience and cognitive level. Inquiry model is recommended for use in learning because it can improve the ability of high-order thinking which is an attribute to achieve success in the 21st century [10,11,12].

Table 1. Level of inquiry, student skills, and syntax.

| Model of Inquiry | Discovery Learning | Interactive Demonstration | Inquiry Lesson | Inquiry Laboratory | Real-Word Application | Hypothetical Inquiry |
|------------------|--------------------|---------------------------|----------------|--------------------|----------------------|---------------------|
| Level Of Student Skills | Rudimentary Skills | Basic Skills | Intermediate Skills | Integrated Skills | Culminating Skills | Advanced Skills |
| S                | Observation        |                           |                |                    |                      |                     |
| Y                | Manipulation       |                           |                |                    |                      |                     |
| N                | Generalization     |                           |                |                    |                      |                     |
| T                | Verification       |                           |                |                    |                      |                     |
| A                | Application        |                           |                |                    |                      |                     |
| X                |                    |                           |                |                    |                      |                     |

Based on Table 1. It can be seen that the inquiry model is divided into 6 based on the student skills, the 6 levels have the same syntax in the learning, which distinguishes the activities performed in each syntax is students who are at the cognitive level of rudimentary skills will get guides from different teachers with those at the advanced level as well as other levels.

Table 2. Hierarchy of inquiry-oriented science teaching (Source: Adapted from Wenning (2005)).

| Discovery Learning | Interactive Demonstration | Inquiry Lesson | Inquiry Laboratory | Real-world Applications | Hypothetical Inquiry |
|--------------------|---------------------------|----------------|--------------------|------------------------|---------------------|
| Low                | Intellectual Sophistication |.High            |Locus of Control    |Student                 |

Hierarchy of Inquiry-oriented science teaching on Table 1. It is an additional feature such as from a simple to complex, from conceptual to analytical, from concrete to abstract, from general to specific, from inductive to deductive, from broad to narrow, and from principle the general principle to the special [13]. Based on that, the treatment of each level of inquiry will be different depending on the condition of the student's ability and the needs of the teacher.

2. Research Method

The purpose of this study was to measure the level of inquiry (LoI) of students in the city of Surakarta, in the measurement using a questionnaire modified from Wenning to get inquiry level in students in Indonesia, then in describing the results of the questionnaire used in this study using the criteria of [14]. This study is a qualitative research. The sample in this research 560 students class X IPA MA Surakarta City, Indonesia.
3. Scale of criteria rubric level of inquiry information: Level of Inquiry (LoI).

| Scale Value                  | Category |
|------------------------------|----------|
| LoI > 70%                    | High     |
| 30% ≤ LoI ≤ 70%              | Medium   |
| LoI < 30%                    | Low      |

The criteria in the table above explain at which level students in Surakarta city are learning using inquiry models.

3. Result and Discussion

This research was conducted based on an interview with 7 Chemistry Teachers about the learning process commonly used, the teacher mentioned that have applied the inquiry learning model. Therefore, the measurement level of inquiry to 560 students and the measurement results showed that high school students in Surakarta city, Indonesia have criteria that are shown in Figure 2.

Based on the data in Figure 1, it can be seen that the level of student inquiry in Surakarta city, Indonesia is at a high level in Discovery learning (79.11%), is in medium Level at Interactive Demonstration (65.18%), Inquiry Lesson (39.11%) and Inquiry Laboratory (30%) while students are at a low level for Real-World Application (28.04%) and Hypothetical Inquiry (25.18%). This criterion is based on statistical calculations referring to [14].

3.1. Discovery Learning

Discovery Learning is the most fundamental question-oriented learning, in the model Discovery learning teachers largely control the learning process by providing questions that lead students to find concepts [7,15]. At the discovery learning level students will find the concept and relate it to the facts that exist in science, then the indirectly cognitive ability will also increase [16-18].

Level of inquiry students on discovery learning can be known by providing questions about learning ever done so far:

Table 4. Checklist level of inquiry discovery learning.

| Syntax          | Activity                               | Yes (✓) | No (✗) |
|-----------------|----------------------------------------|---------|--------|
| Observation     | Make a direct observation and describe it |
| Manipulation    | Determine the relationship of phenomenal objects observed |
Measuring the level of discovery learning can use the level of inquiry discovery learning checklist as in Table 4. The results of the checklist in the content by the students than in the presentations in statistics to determine the extent to which the level of students on discovery learning. In discovery learning students focus on active involvement to build knowledge [19]. The teacher can use the discovery learning model if the student has reached this level well or Level of Inquiry (LoI) > 30% and according to the material characteristics to be taught.

3.2. Interactive Demonstration
The interactive demonstration is the level of basic skills of inquiry, in the interactive learning demonstration model is generally a teacher manipulate (demonstrating) a tool that then the teacher gives some questions related to the demonstration of the tool that demonstrated to know about the cause or how it can happen [6,20]. The students' cognitive and problem-solving abilities can evolve through questions provided by the teacher on the basis of the demonstrated tools since the teacher's learning model determines students' cognitive abilities and thinking skills [19, 21]. Interactive demonstration level of students can be known by giving questions about learning activities that have been done or used by teachers in everyday learning.

| Syntax | Activity | Yes | No |
|--------|----------|-----|----|
| Generalization | Conclude the relationship in the tentative conclusion | (✓) | (✓) |
| Verification | Make verification of observations together | (✓) | (✓) |
| Application | Apply in everyday life | (✓) | (✓) |

Measuring an interactive demonstration level can use checklist activity in Table 5. Based on student experience, whether students are used or not using syntax at interactive demonstration level by means of statistical analysis of how much students ability in that level. At this level obtained results of 65.18%, which means that the middle school students Surakarta is feasible or accustomed to using interactive learning demonstration model. In the interactive demonstration the teacher starts to move the locus of control slowly from teacher to student through prediction done by the student, then from the prediction of the student is drawn conclusion based on the experiment done [19]. In the interactive demonstration model the inquiry framework is provided by teachers tailored to the student's intellectual level and students' cognitive abilities [7, 22] because teaching on the elementary school will certainly be different from senior high school, therefore teachers must adjust to the ability of their students.
3.3. Inquiry Lesson

Pedagogy inquiry lesson is based on activities that are still dominated by teachers, but gradually teachers provide guidance to guide students in achieving the correct concept [19], in inquiry lesson teachers encourage students to act scientifically in the investigation of a phenomenon just like a scientist, in inquiry lesson students are required to control and manipulate activities in order to achieve learning objectives [13, 15, 23], so that students will indirectly play an important role in the investigation.

Learning using inquiry lesson is almost similar to an interactive demonstration, but in the inquiry lesson teachers guide but only ask questions that lead learners to the investigation that will be done, so that learners will unwittingly discover and understand the lesson without direct assistance from the teacher [20], learners are required to think hard to find the purpose of learning with scientific inquiry and gather information as much as possible to be drawn conclusions [15] and directed to be applicable in everyday life [6].

Inquiry lesson study emphasizes thinking through scientific inquiry, in accordance with John Dewey's opinion if a child is given a problem then unwittingly the child will think to solve his problem through the project of inquiry or information search [24], teachers can maximize this opportunity to guide learners on the move to find out learning objectives [25] and naturally learners will understand the learning objectives with their own discoveries [26].

Inquiry lesson can be measured using a checklist that contains learning activities that have been done by students in solving problems and finding concepts.

| Syntax     | Activity                                                                 |
|------------|--------------------------------------------------------------------------|
| Observation| Identify and formulate problems                                          |
| Manipulation| Plan, execute experiments and analyse data                               |
| Generalization| Summing up the experimental results                                      |
| Verification| Predict a problem according to the concept found previously             |
| Application| Use the concept to do other experiments                                   |

Table 6 is a way used to know the extent of the activities ever or commonly done by students in learning, the more often done it can be said that the level of inquiry of students in inquiry lesson categorized well. In the measurements done got 39.11% results which means that the ability of students already meets the criteria of intermediate skills, so that teachers can use inquiry lesson in accordance with the character of the material to be taught. In the lesson inquiry paradigm suitable if the student holds an important role to find the concept and in accordance with the demands of the 21st century.

3.4. Inquiry Laboratory

Inquiry laboratory generally consists of students who are more independent in designing and developing experiments and can analyze data in accordance with the investigation [19]. The data obtained by students is then analyzed to find the law or theory appropriate to the investigation, in this case, the teacher plays a role to assist students’ difficulties in designing experiments and collect data using technology but to communicate the results obtained is the responsibility of students [27].
Laboratory investigations here not only mean learning in the laboratory but rather emphasize how students can relate concepts they already know to the results of their investigations. In laboratory inquiry, students are faced with complex problems that require high mental processes [28]. Problems will lead individual students to take the action and action that will be done in the learning process, students are said to have learned if able to solve the problem so that in laboratory inquiry students are required to become an active [4,17]. The independent level of students in the inquiry is higher than the level below so that in this case the teacher acts as a controller of the steps undertaken by students in order to achieve the goal of learning [6]. Inquiry laboratory can be measured using a checklist which contains learning activity ever done by a student, a checklist can be seen in Table 7.

| Syntax        | Activity                                                                 | Yes   | No   |
|---------------|--------------------------------------------------------------------------|-------|------|
| Observation   | Establish experiments through prelab activities (group discussions) and/or guiding questions | ✔     | ✗    |
| Manipulation  | Experiment                                                               | ✔     | ✗    |
| Generalization| Conduct observations, record experimental results and communicate results to other groups or other students | ✔     | ✗    |
| Verification  | Presenting the findings to other groups or students interested in the findings | ✔     | ✗    |
| Application   | Working on the application about the experiment                           | ✔     | ✗    |

Results obtained by measuring the level of inquiry laboratory using a checklist in Table 6. Showing 30% of students in high school in Surakarta city have criteria that are or equal with integrated skills. The purpose of pedagogy in laboratory inquiry can be to establish the appropriate law or theory based on the investigation of the problem [18].

3.5. Real-world Application
Real-World application is a level that requires a high level of skill in its implementation, because at this level students are required to solve real-world problems, real-world applications are similar to project-based solutions [15, 18]. In real-world application locus of control almost fully played by the students, because students organize and manipulate the activities individually, while the role of teachers here as an indirect guide to direct students. "Example: if the student asks the teacher what to do to solve the project then the teacher only answers as necessary and does not give an answer that directly directs the student to do what and how".
Real-world application level can be measured using checklist questions about habits or learning steps that have been done.

| Syntax        | Activity                                                                 | Yes   | No   |
|---------------|--------------------------------------------------------------------------|-------|------|
| Observation   | Presenting a problem, designing experiments and prelab activities and laboratory safety directions as well as the use of laboratory equipment and teacher leader questioning | ✔     | ✗    |
| Manipulation  | Conduct experiments, observe objects through scientific investigations and observations based on | ✔     | ✗    |
At real-world application level can be measured using the checklist at Table 8. The result of measurement is 28.04% or LoI <30% which means that students are not used to using real-world application model so that it still needs to be trained further in order to reach that level. At this level is the same as applying from the realm of C5 (Synthesis) which is interpreted as the ability to produce and combine elements to form a structure that combines various sciences with theories and experimental results themselves [18, 27].

3.6. Hypothetical inquiry

Hypothetical Inquiry is the highest level of the Wenling level of inquiry spectrum, at an advanced level students are required to conduct a pure investigation which means that the investigation is conducted to acquire new knowledge for oneself rather than a focus for general knowledge [18]. At this level, the teacher acts as a companion and the locus of control is fully held by the students because students at this level are students who have a high cognitive level. At the level of hypothetical inquiry the student has reached the sphere of C6 (Evaluation) in which the student acts as a decision maker and policy and evaluates the existing information [28-30].

Measuring whether students are already on good criteria or not at the real-world application level can use a checklist that contains learning activities based on the students' experience whether they have been or have not been accustomed to using them in daily learning can be seen in Table 9.

Table 9. Checklist level of hypothetical inquiry.

| Syntax | Activity | Yes (✓) | No (✗) |
|--------|----------|---------|--------|
| Observation | Observe problems, identify problems, design experiments, and prelab activities | ✓ | □ |
| Manipulation | Conduct experiments, collect data information to construct hypotheses | ✓ | □ |
| Generalization | Investigate observations, record experimental results and communicate to other groups or students | ✓ | □ |
| Verification | Present the findings of the observations so that other groups or students are interested in the findings | ✓ | □ |
| Application | Analyze the research process to obtain more effective procedures, working on application problems about the experiments performed | ✓ | □ |
better. This needs to be done so that students accustomed to thinking high level because by accustomed to thinking high level then students will have a high cognitive ability [31,32,33].

4. Conclusion
Based on the measurement of Level of Inquiry (LoI) on 560 students MA Surakarta City obtained high criteria results on; discovery learning (79.11%), criteria being on; interactive demonstration (65.18%); inquiry lesson (39.11%); inquiry laboratory (30%) and low criterion on; real-world application (28.04%); Hypothetical inquiry (25.18%). Based on these results, the teacher can choose the inquiry model that is in high level and medium to be applied in the learning because if the low criteria applied to the students will experience confusion at the time of learning, but the teacher can use the level of inquiry at a low level based on the needs and characteristics of the material to be studied. Teachers can trace the inquiry model continuously until students reach the advanced skills level to improve their cognitive and independence in learning.

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