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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					High
Teacher		Intellectual Sophistication			Student
		Locus of Control			

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.

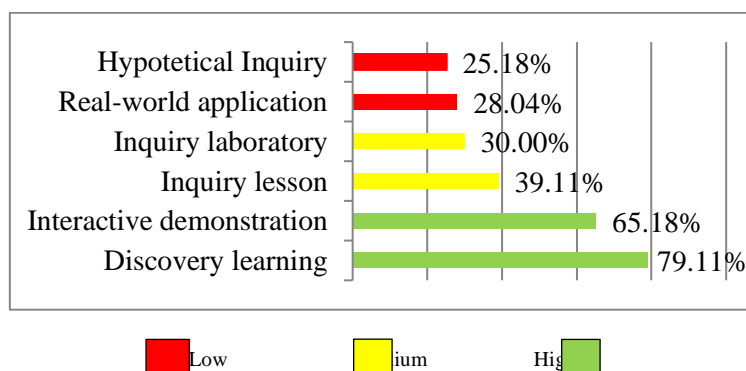
Table 3. Scale of criteria rubric level of inquiry information: Level of Inquiry (LoI).

Scale Value	Category
LoI > 70%	High
$30\% \leq \text{LoI} \leq 70\%$	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**.

**Figure 1.** Result of analysis level of inquiry.

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:

Table4. 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		

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

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.

Table 5. Checklist level of interactive demonstration.

Syntax	Activity	Yes (√)	No (√)
Observation	Observe the demonstration process		
Manipulation	Predict what will happen at the next demonstration		
Generalization	Summing up the results of the demonstration process		
Verification	Proving conclusions with other labs		
Application	Analysing the relationship between the teacher demonstration process and himself		

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.

Table 6. Checklist level of inquiry lesson.

Syntax	Activity	Yes (√)	No (√)
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**.

Table 7. Checklist level of inquiry laboratory.

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.

Table 8. Checklist level of real-world application.

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		

Syntax	Activity	Yes (√)	No (√)
	the design of the practicum that has been designed		
Generalization	Collect data and communicate data in the form of graphical analysis, drawing or tables		
Verification	Present the findings of the observations so that other groups or students are interested in the findings		
Application	Working on an application about the experiments performed (able to link the findings with daily life through the problem)		

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		

At the level of Hypothetical Inquiry can be measured using a checklist in **Table 8**. In the measurement results obtained 25.18% or LoI <30% which means students in the city of Surakarta, Indonesia is not used to using the model so it needs to be trained further in order to achieve that level with the criteria

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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References

- [1] Dewey J 1938 *Logic: The Theory of Inquiry* (New York: Henry Holt and Company)
- [2] Shamsudin N M, Abdullah N & Yaamat N (2013), Strategies of teaching science using an inquiry based science education (IBSE) by novice chemistry teachers. *Procedia-Social and Behavioral Sciences* **90** p 583–592
- [3] Mcnew-birren J & Kieboom LA Van Den. (2017), Exploring the development of core teaching practices in the context of inquiry-based science instruction: An interpretive case study. *Teaching and Teacher Education* **66** p 74–87
- [4] Jonassen DH 2004 Learning to Solve Problems: An Instructional Design Guide p 253.
- [5] Ausebel DP 2000 The acquisition and retention of knowledge: A cognitive view. *Journal of Chemical Information and Modeling* **53**
- [6] Wenning CJ 2011 The Levels of Inquiry Model of Science Teaching. *Journal of Physics Teacher Education Online* **6(2)** Summer p 2-9
- [7] Wenning CJ 2005a Levels of inquiry: Hierarchies of pedagogical practices and inquiry processes. *Journal of Physics Teacher Education Online* **2(3)** p 3-11
- [8] Dewey J 1904 The relation of theory to practice, in The Third Yearbook, Part I, National Society for the Scientific Study of Education
- [9] Wenning CJ & Khan MA 2011 Sample learning sequences based on the Levels of Inquiry Model of Science Teaching. *Journal of Physics Teacher Education Online* **6(2)** p 17-30
- [10] Kitot AKA Ahmad AR, & Seman AA 2010 The effectiveness of inquiry teaching in enhancing students' critical thinking. *Procedia - Social and Behavioral Sciences* **7(C)** p 264–273
- [11] Tritiyatma H, Yuli R & Achmad R 2017, Developing 21st century skill in chemistry classroom: Opportunities and Challenges of STEAM integration. AIP Conference Proceedings, 1868, 030008.
- [12] Trilling B & Fadel C 2009 21st Century Skills: Learning for life in our times (Sanfransisco: Jossey-Bass) p 256
- [13] Wenning CJ 2005b Implementing inquiry-based instruction in the science classroom: A new model for solving the improvement-of-practice problem. *Journal of Physics Teacher Education Online* **2(4)** p 9-15
- [14] Budiyo 2017 *Pengantar Metodologi Penelitian Pendidikan* (Surakarta: UNS Press)

- [15] Wenning CJ 2012 Levels of Inquiry Model of Science Teaching: The Buoyancy Learning Sequence Levels of Inquiry Method of Science Teaching. *Journal of Physics Teacher Education Online*.
- [16] Ryzal P & Rattu BR 2018 Enhancing students' cognitive outcome in chemistry by guided inquiry learning models. *International journal of sciences: Basic and applied research* **37** (3) p 41-51
- [17] Wenning CJ2005c Whiteboarding and Socratic dialogues: Questions and answers. *Journal of Physics Teacher Education Online* **3**(1) p 3-10
- [18] Ratu BR & Ryzal P 2018, Enhancing higher-order thinking skills using discovery learning model's acid-base pH material. *AIP conference proceeding*, 020108
- [19] Wenning CJ 2010 Levels of inquiry: Using inquiry spectrum learning sequences to teach science. *Journal of Physics Teacher Education Online*, **5**(4) Summer 2010 p 11-19
- [20] Wenning CJ 2006 A framework for teaching the nature of science. *Journal of Physics Teacher Education Online* **3**(3) March p 3-10
- [21] Siti NA 2017 Educational effectiveness research as the knowledge base of improving education. *Pertanika J. Soc. Sci. & Hum.* **25** (3) p 1019 - 1038
- [22] Wenning CJ 2007 A physics teacher candidate knowledge base, *Journal of Physics Teacher Education Online* **4**(3) p 13-16
- [23] Chen L 2017 Understanding critical thinking in Chinese sociocultural contexts: A case study in a Chinese college. *Thinking Skills and Creativity* **24** p 140–151
- [24] Dewey J 1910 *Science as subject-matter and a method*, in *Experience and Education*, taken from John Dewey on Education: Selected Writings, Reginald D. Archambault (ed.) (New York: Random House).
- [25] Vygotsky LS 1978 *Mind in Society: The Development of Higher Psychological Processes* (London: Harvard University Press)
- [26] Flick & Lederman (Ed) 2006 *Scientific inquiry and Nature of Science* (Dordrecht: Springer)
- [27] Wenning CJ & Wenning RM 2006 A generic model for inquiry-oriented labs in postsecondary introductory physics. *Journal of Physics Teacher Education Online* **3**(3) p 24-33
- [28] Widowati A, Atun S, Suryadarma IGP, Setuju, Widodo E, Nurohman S, & Yuneivi REK (2018), The development of blog with Nos Within Inquiry Laboratory an Approach for developing scientific literacy of the student in junior high school. *International Journal of Engineering & Technology* **7**(3.2) p 756-759
- [29] Bloom BS 1956 *Taxonomy of Educational Objective* (New York: David.M)
- [30] Susan MB 2010 *How to Asses Higher-Order Thinking Skills in Your Classroom* (New York: ASCD)
- [31] Gambrell E & Gibbs L 2009 *Critical Thinking for Helping Professional* (Madison Avenue: OXFORD University Press)
- [32] Facione NC & Facione PA 2001 Analyzing Explanations for Seemingly Irrational Choices: Linking Argument Analysis and Cognitive Science. *International Journal of Applied Philosophy* **15**(2) p 267–286
- [33] Zulfa A, Rita D, Fazri Z, Yusri W, Hendra H, & Joni A 2018 Developing instruments to measure students' logical, critical, and creative thinking competences for bung hatta university students. *International Journal of Engineering & Technology* **7** (49)