Investigating the Students' Experimental Design Ability toward Guided Inquiry Based Learning in the Physics Laboratory Course

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ABSTRACT
The goals of this advanced physics laboratory course emphasized not only to improve students' physics knowledge but also spectrum scientific abilities in particular for preparing their future-ready competencies. One of those scientific abilities was initiated to study that was "the ability to design experiment". It was the fundamental ability in help enhance students' higher order thinking in solving problems and self-operating their own labs scientifically. Besides, this corresponds to a crucial national policy of Thailand. There has been promoted innovative thinking skills to step onward driving the Thailand economy. This study was a preliminary report on the students' experimental design ability towards the students' learning engagement in a guided inquiry lab which involved to the physics concept of heat transfer. To investigate the ability, 18 senior-physics students enrolled the course were required to work in three groups of 4to 6. In the investigation, a guided-inquiry lab set and worksheets were substantially designed and validated by three physics university lecturers who had teaching experiences for over 10 years. The guided worksheets were straightforwardly structured by considering five sub-abilities dealing with the ability to design experiment. Those worksheets were viewed as a lab report and also used as a main research tool to help follow and collect data about the students' experimental design ability. The key format of the worksheets was that guided inquiry questions and black spaces were contained. This aimed to actively engage the students in the experiment since (1) linking physics concept, (2) defining measurement variables, (3) clarifying an experimental procedure, (4) selecting equipment and materials, and (5) minimizing errors. In each of the five abilities, the students had to individually investigate the answers of guided-inquiry questions and then shared ideas with their groups till they could solve the main problem of the lab. Additionally, video recordings were collected to triangulate qualitative data of the students' learning engagement. From observation, we found that the students spent about 6 hours in total (3 hours for designing the experiment by working on answering the guided-inquiry questions and 3 hours for doing the experiment) to complete the experimentation. The most time-consuming (about an hour) was in the step of linking physics knowledge to formulate a situation in order to solve the problem. The result found that there were no students who could design the experiment to solve the problem correctly but all of them were able to formulate the situations relating to the solving problem. All experiments designed could be practical. The main difficulty was from the students' misunderstanding of heat transfer. They did not determine the heat transfer from all objects in the closed system. This was the most difficult point in enhancing this ability. Moreover, there were many unexpected sub-abilities: basic measurements, using scientific equipment, and also identifying variables. Besides, the students were required to self-assess their proficiency on a 4-point rubric test. The first-two lowest average scores were in items relating to the sub-abilities to link physics knowledge and to clarify an experimental procedure.

INTRODUCTION
The several goals of physics laboratory courses are to develop students' understanding underlying physics principles, laws, or conceptions together with spectrum basic skills which involve to the art of experimentation—carrying out experiments and designing investigations to solve problems, data analysis—interpretations, and collaborative learning—social exchanges and expansion of ideas (AAPT, 1998; Hofstein & Lunetta, 2004). Such those skills are viewed as scientific practice. These are processes or methods that scientists use when they