Contrasting Cookbook with Inquiry-Oriented Labs

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Traditional Cookbook Labs	Authentic Inquiry-Oriented Labs
Based on detailed set of instructions.	Based primarily on guiding questions.
Students follow step-by-step directions to conduct experiment.	Students develop own experimental design.
Questions, if present, tend to be leading questions – asking students to confirm an observation or make a calculation.	Many questions included in guidelines; questions are unbiased – asking students to merely report or draw own conclusions from evidence.
Require minimum intellectual involvement.	Require ongoing intellectual engagement.
Lab strongly oriented toward gathering and interpreting numerical data.	Lab strongly oriented toward developing a strong conceptual understanding.
Student activity focuses on verifying information previously communicated in class.	Student activity focuses on discovering new concepts, principles, or empirical relationships.
Confirmatory – follow class presentation of material.	Discovery – serve to lead subsequent class discussion.
Generally little communication, and what exists tends to be one way – from teacher to student.	Discussion driven by a series of intellectually engaging questions.
Rarely incorporates learning cycles (observation, generalization, application).	Engages one or more complete learning cycles.
Students provided data tables with specified ranges for specific types of data.	Students determine what type of data and how much of it to collect.
Tells student what data to collect.	Leaves it up to the students to determine what data to collect.
Students do not design experiment.	Students create experimental design on the basis of discovered principles.
Students communicate results only to course instructor through lab reports.	Students communicate and defend results to other participants in the lab session.
Emphasis on completing task.	Emphasis on achieving conceptual and scientific understanding using empirical data.
Students generally do not provide explanations.	Students asked to provide explanations adhering to rules of evidence.
Students generally do not predict, or predictions based upon known rules or laws.	Students asked to generate predictions based upon deductive processes.
Students generally do not use inductive processes.	Students asked to generate principles on the basis of inductive processes.
Student questioning not encouraged or actively discouraged.	Students, ideally, encouraged to ask questions and find answers to self-identified problems.
Students are told which variables to hold constant, and which to vary, which are independent and which dependent.	Students identify, distinguish, and properly control pertinent independent and dependent variables.
Students provided with a fixed instrumentation set up.	Students provided with a variety of technology and instrumentation but no fixed set up.
Very little interaction between lab instructor and students.	Large amounts of question-drive interaction between lab instructor and students.
Students are directed to solve an instructor-identified problem or problems.	Students identify problems to solved based on observations of unusual phenomena.
Students told precisely how to analyze and interpret data.	Students use their own approaches to analyzing and interpreting data.
Promotes dependency.	Promotes independence of thought and action.
Employs lower-order thinking skills.	Promotes higher-order thinking skills.
Rule-conforming behaviors.	Rule-creating behaviors.
Task often seen as boring.	Task generally seen as engaging.
Focus on piecemeal understanding.	Focus on holistic understanding.
Focus on completing tasks.	Focus on learning science.
Less time on task as students/teaching assistant often spend lots of time going over the instructions.	More time on task as there is a very brief introduction and students create their own instructional design.
Students tend to report "just the facts."	Inquiry questions form basis of lab report.

Experiment unlike the real thing.	Lab approximates the methods of good science
Questions to be investigated decided by the teacher	Questions, ideally, decided by the investigator.
What equipment to use, how to calibrate it, what data to collect, and how to organize data determined by teacher.	Investigators, ideally, have access to a variety of equipment and are responsible for appropriate use to collect pertinent data.
Linear process that does not normally allow for repetition or for advising an experiment.	Nonlinear process that allows for repetition and revision of experimentation.
Conclusion known ahead of time.	Discovery process uses empirical results to draw conclusion.
Restrictive, mechanical, recipe-following, rule-conforming behaviors.	Open-ended, dynamic, procedure-inventing, rule-creating behaviors.
Rarely requires familiarity with concept or principle being investigated.	Requires students to become familiar with the concept or principle being investigated or accounted for.
Lab driven by instructions.	Lab driven by unanswered questions.
Student told which variables to control, manipulate, and observe.	Students identify and control pertinent variables (e.g., dependent, independent, controlled)
Students rarely draw conclusions from evidence.	Students use inductive processes to draw conclusions.
Discourages development of conceptual understanding of propositional and procedural knowledge.	Promotes development of conceptual understanding of propositional and procedural knowledge – a prerequisite for conducting a lab experiment.
Tends to emphasize the quantitative aspects of a physical phenomenon to the exclusion of conceptual and qualitative understanding.	Includes an emphasis on conceptual and qualitative analysis of physical phenomena.
Moves from abstract toward concrete.	Moves from concrete toward abstract.
Assumes understanding.	Constructs meaning.