# Students’ Scientific Practices in Advanced Lab

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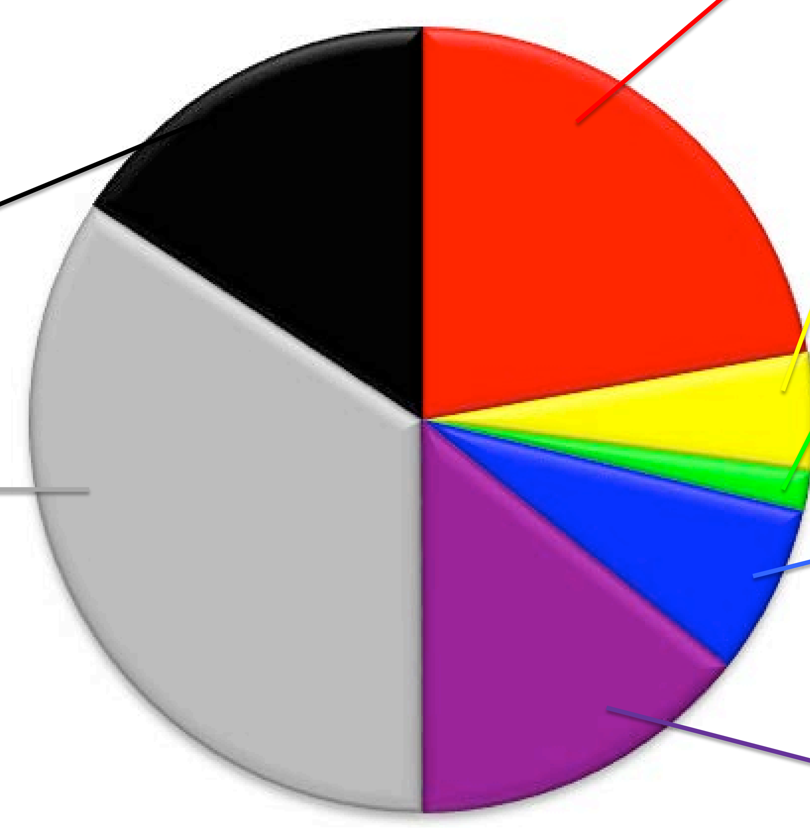
**Off Task:** Students are not doing things relevant to the experiment they need to finish.

**Off SP (Scientific Practice):** Students are doing the experiment but are not engaging in SP. They may read the handout to find the experiment procedure; follow the instructor's or handout's instructions verbatim; write or read silently. There is no clear evidence indicating students are completing scientific practice at the moment.



**Investigation:** The phenomenon which would be categorized as “investigation” is a student’s sense that there is a problem needing to be solved (such as: we need to calibrate equipment, we need to know how to produce the data we want, we need to figure out what’s going on here). The question can either be originated from students’ internal ideas or external sources. But students should have at least an implicate predication or plan of what would happen and make an explicit reflection and adjustment. The idea or motivation may come from the instructor, handout, or textbook.

**Computational Thinking:** It is very easy to identify student behavior of “do math”. However, not all the behavior of “doing math” would be put into this category. Only when students discuss data processing, error propagation, or the physics meaning of the calculation, will their behavior be coded in this category.

**Explanation:** Students need to be able to apply their physics knowledge to interpret the situation in which they are engaging. They need to be able to “see through” the apparatus in front of them to understand the data they are collecting. In order to better support their explanations, they may use multiple representations: the experimental equipment, the diagram from book/handout, or even their body language. The main purpose to have such behavior is to clarify the theoretical confusion.

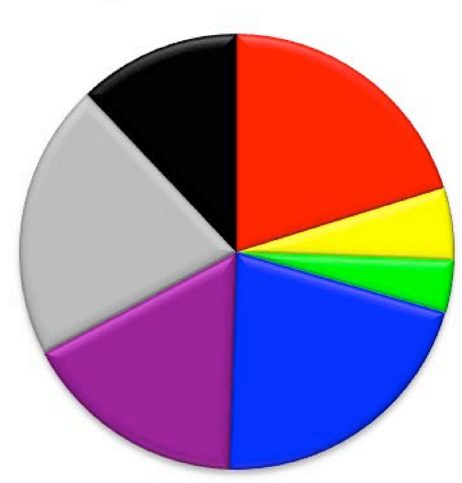
**Argument:** This practice is described as the production of knowledge is dependent on a process of reasoning that requires a scientist to make a justified claim about the world. In response, other scientists attempt to identify the claim’s weaknesses and limitations. It would be translated as two students, who both have reasonable but different explanations, arguing with each other in the lab course.

**Information:** Communicating information could be two ways: obtaining external information or generating internal information. It happens when students are looking for extra support from a handout, textbook, or relevant website. Moreover, students like to talk to an instructor, teaching assistant, or their peers about the experiment content. In this case, they are not only getting information, but also giving their own information to others.

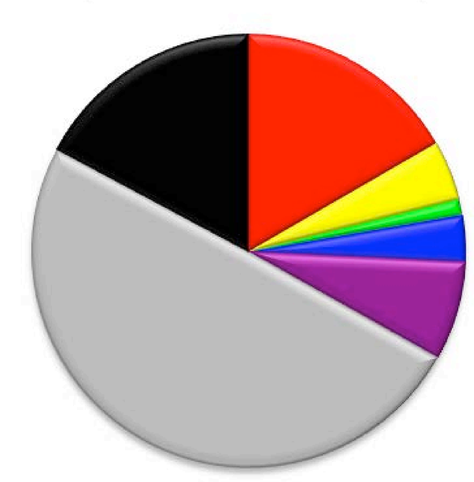
**Students do different experiments differently**

Group 1 spent a relatively long time on scientific practices in conducting the Zeeman Effect lab. The reasons might be the group members or the nature of the experiment itself. Group 1 was a very active and vocal group. They preferred to seek out the physics meaning and carry out the investigation to test their theoretical understanding. When they sensed they had problems, they preferred to talk things out and sought external information. Additionally, the Zeeman Effect itself is an experiment that needs in-depth physics and mathematics understanding. Students are not required to spend a long time taking data. Those features help to promote student scientific practice activation. But experiments such as Microwave Optics, Millikan, or NMR, require students to spend most of their time in lab collecting data and analyzing errors. This means students normally will not focus on the physics meaning of these experiments. For students, these “advanced labs” are merely cookbook experiments with advanced apparatus.

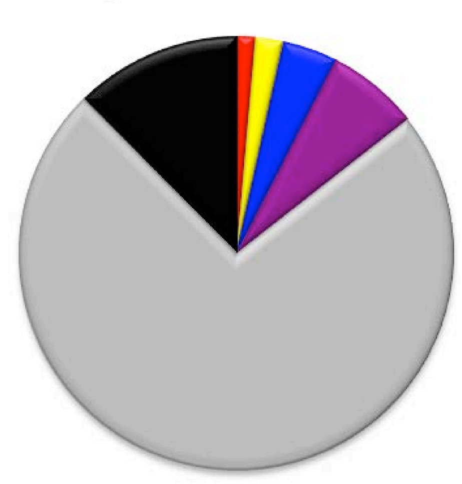
**Group 1's Zeeman Effect**



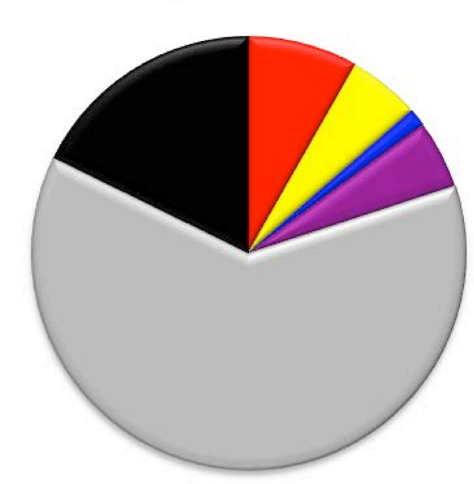
**Group 1's Microwave Optics**



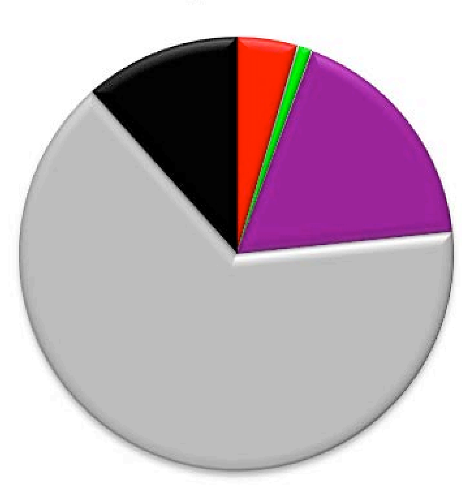
**Group 2's Zeeman Effect**



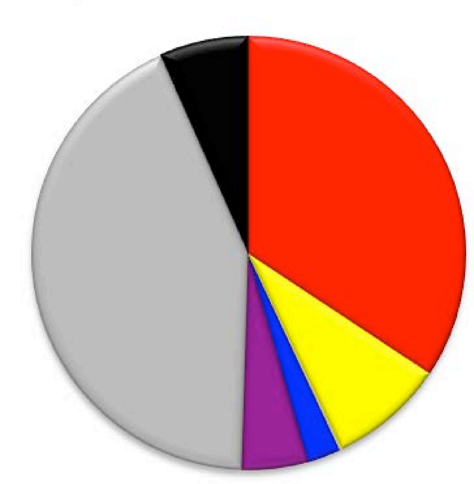
**Group 2's Millikan**



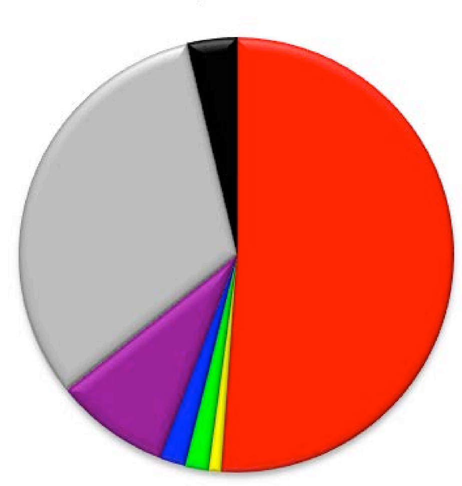
**Group 3's NMR**



**Group 3's Torsional Oscillator**



**Group 4's STM**



**Group 4's Torsional Oscillator**

**Student personality would affect experiment performance**

However, the features of the experiment cannot guarantee student scientific practice activation. By comparing two groups working with Torsional Oscillator, it is obvious that group 3 spent lots of time on the investigation while group 4 treated it as another cookbook experiment. Torsional Oscillator is an experiment with relatively easy apparatus and heavy data collection load. Easy apparatus provides the opportunity for students to understand the physics of this experiment easily; while the heavy data collection load may force students to stick with the repetitive data collection process. Our data show that different students work on these two different ways in doing this experiment, which suggests that students need proper guidance for such an experiment to activate scientific practices more frequently.

## Conclusion

The main purpose of this study was to understand physics undergraduates’ behavior in an advanced lab course. The unique features of the advanced lab course include sophisticated equipment, extended design projects, and small class size, which prepare students for authentic research. Therefore, the question “How do students do scientific practices in lab courses” needed to be answered.

## Further Research

Our current data shows that the personality of students and the nature of experiment are all playing very important roles in scientific practice activation. But the conclusion is limited by the amount of data we’ve processed. The suggested next step could be coding more video recordings to look for consistent trends within the results, or in-depth focusing on one or two typical groups and experiments to conduct a case study determining which factors plays what roles in students’ scientific practice activation.