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The Scientific Graphic Organizer for Lab Work

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Secondary school students frequently engage in lab work. Often, they are asked to write a report afterwards. But if we just want to know whether they did what they were supposed to do and learned what was intended, is it then necessary to have students write an extensive lab report? Writing consumes a lot of time, and with a report we mostly assess students' ability to communicate clearly.[1,2] To formatively assess both aspects of lab work (doing the practical and learning from it) without increasing the teacher's workload (reports piling up), I developed the Scientific Graphic Organizer (SGO).[3,4] The SGO can be regarded as a prestructured but simplified lab journal suited for quantitative physics inquiry (QPI) in which a quantitative relation between variables is sought.[5] In the SGO, all essential information is provided to produce a fair judgement of students' doing and learning in and from lab work. In this paper, I present the SGO and its features, along with my personal experience in using the SGO for lab work.

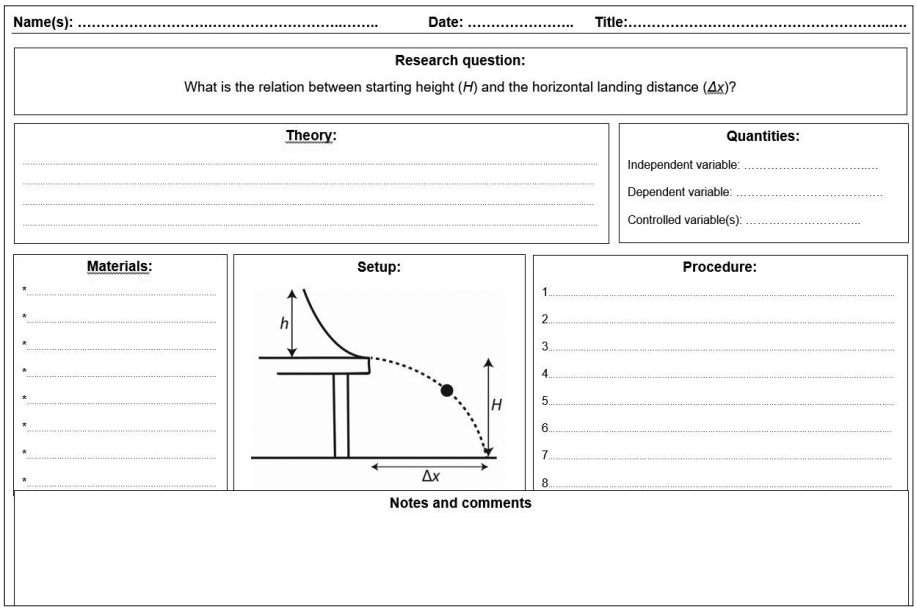

Fig. 1. The front of the SGO covers the planning of the lab, where elements can be provided by the teacher and the blanks are to be filled in by the students.

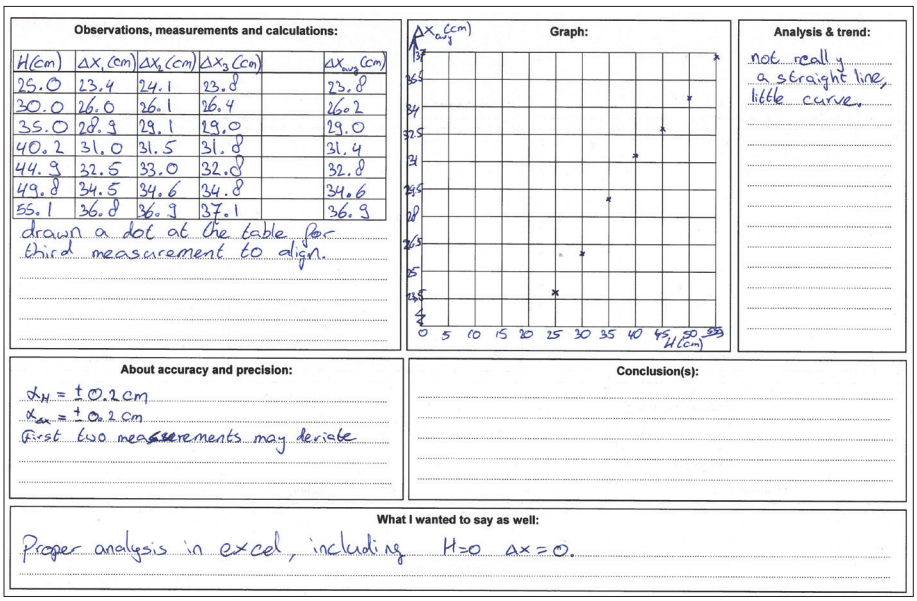

Fig. 2. The back of the SGO covers the collection and processing of the data, including a tentative conclusion and room for additional remarks. The conclusion has not yet been drawn, as it required a more thorough data analysis, which the SGO does not allow for.

Features

The basic SGO provides a two-page schematic for the essentials of the lab work. As shown in Fig. 1, the front of the SGO covers the planning of the QPI. Depending on the openness of the task,[6,7] information in sections can be provided or intentionally left blank. For instance, in the SGO of Figs. 1 and 2, the research question and basic setup is given for a QPI in which horizontal projectile motion is investigated (see Fig. 3), but the precise method is left open for the students to complete.

The back of the SGO (Fig. 2) covers the collection and processing of data, including a few lines in which students can pose their (provisional) conclusion. In the given example, students could not yet state a conclusion, as it required a more thorough data analysis requiring additional (software) tools. A summary of such an analysis can be stated in the section "Analysis & trend."

Working with the SGO

It takes some time to familiarize students with the SGO. For example, students need some practice to write a concise but clear procedure, but it also helps them to think about what information is essential to do the experiment. I consider that spending time to familiarize grade-9 students with the SGO is worth the effort, as it is still applicable in later years with more complex or open-ended experiments. Moreover, it provides a stepping stone to more formal lab journals as used at university level.

In contrast to students' notebooks where information is often scattered, the SGO's structure quickly provides the

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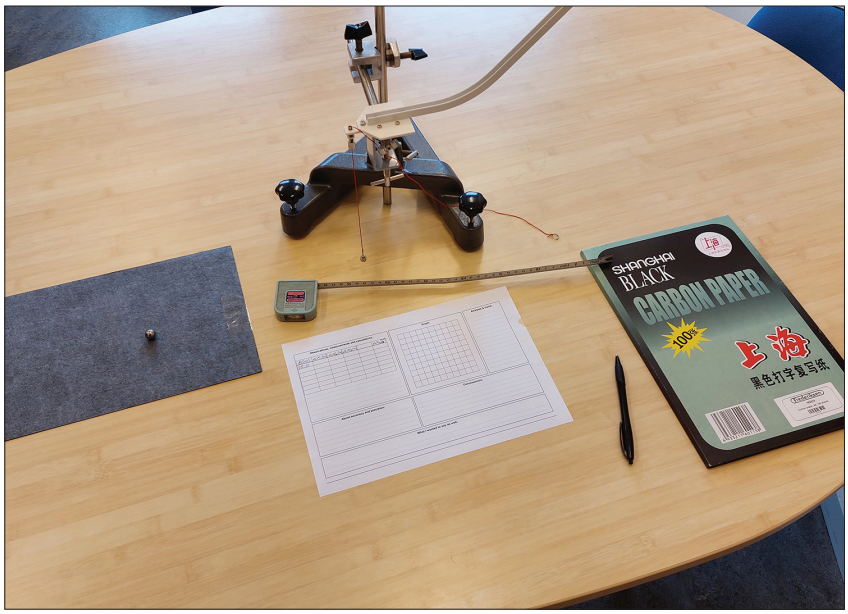

Fig. 3. The SGO is used for a horizontal projectile motion experiment.

teacher insights into what students are doing and whether they are on the right track. For instance, a glimpse of the SGO elicits what values for *H* are chosen and how many repeated measurements are taken, and thus allows the teacher to provide instant feedback.

Once handed in, the SGO allows the teacher to verify whether the intended outcomes have been realized and the learning goals met. The SGO allows the teacher to fairly judge students' doing and learning in and from lab work as it provides the information on the research decisions they took and the conclusions they drew based on their data. Based on this information, the instructor can formulate follow-up questions to elicit students' knowledge of doing inquiry,[5] such as *"Do you consider the chosen range adequate and, if so, why?"*

Perceived merits and limitations

In my experience, the SGO has several benefits. The time normally spent on writing reports, or grading them, can be spent on more cognitively demanding tasks such as data analysis.[8,9] In a recent study, the SGO was applied in a chemistry lab activity.[10] It was found that the SGO helped students to focus on specific parts of the experiment. An additional section on safety was included, requiring the students to identify potential safety issues and to come up with precautions to minimize risks. The open-source basic SGO[3] can be easily adapted and extended, while the idea of a concise format can still be present.

Although the SGO might discard the need for writing a report for many lab activities, writing a proper report is an essential skill that needs to be taught.[11] The SGO is a useful aid for this as well, as its structure resembles that of a scientific report, and students have already identified all essential information that needs to be reported. But more importantly, by diminishing the cognitive load[12]—i.e., reducing distracting noise that create barriers to learning[13]—the SGO has the potential to support student thinking about experimental physics and reflection on their method.

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