The DRiVe Inquiry Framework

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Abstract

This article describes the DRiVe (demonstrate, replicate, investigate, variate, evaluate) Inquiry Framework, which provides teachers with specific detailed strategies and graphic organizers to support them in developing their science inquiry practices and in shifting to more open-ended science inquiry. Designed by teachers for teachers, the DRiVe Inquiry Framework has been implemented extensively in classrooms across Canada. This article takes readers through the details of using the framework in a Grade 7/8 combined class in which students tested pop bottle water filters. The part of the activity this article focuses on used the following science practices: asking questions; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations; engaging in argument from evidence; and obtaining, evaluating and communicating information.

Introduction from Ms A

In classrooms across Canada for the past decade or more, within the confines of big ideas in each content area of science, teachers have been encouraged to support their students in engaging in practices of scientific inquiry and engineering that are more open-ended (Alberta Education 1996; British Columbia Ministry of Education 2013; Ontario Ministry of Education 2007). The aim is to encourage students to work collaboratively to develop their own questions and potential solutions to problems, to conduct scientific investigations or technological trials, and to come up with answers or solutions they can defend (Council of Ministers of Education, Canada 2013).

However, it was not until 2011 that I (Ms A) began implementing opportunities for my students to engage in this more open-ended style of scientific inquiry and technological problem solving (Bybee 2011), with my Grade 7/8 combined class. We had always done lots of hands-on science and technology, but I had used a teacher-directed or confirmation style (Bell, Smetana and Binns 2005). In other words, I chose the question to be investigated or the technological problem to be solved, I gave the students the procedure to follow, and the students worked to come up with an answer or a solution that I already knew.

My concern about moving to a more open-ended style for hands-on activities was that I could not see how to implement it successfully with my students. I worked at a school where students had many problems to deal with in real life. I could see that most of them had not yet developed the kind of work skills they would need in order to make use of the opportunities for independent learning that the more open-ended style promoted. I could not see how to manage the transition to the more open-ended style without creating a free-for-all that could result in unsafe situations.

In 2011, I signed up for a series of professional development workshops offered by science curriculum coordinators in my school district. It was this workshop series that turned my classroom practice around. Workshop participants were provided with concrete guidelines, strategies and graphic organizers that we could use with our classes. We took four workshops together over a period of three months. Through a process of practice, trial and error, and discussion, we learned how to organize and guide our classes toward the more open-ended style of science investigation and technological problem solving that we were aiming for. I have written this article along with the curriculum coordinators who ran the workshops and supported me in the classroom, as well as with a researcher who observed my classes, so that I can pass along some of this learning.

In this article, we describe how teachers can use the materials from the workshops (framework, strategies and graphic organizers) to move their classes from confirmation to more open-ended science inquiry. The framework has been developed from an earlier version

(Pardo and Parker 2010) and is now called the DRiVe Inquiry Framework. Here, we share a specific example from my Grade 7/8 class in which my students constructed pop bottle water filters as part of a unit on water. The part of the activity we will focus on used the following science practices:

- asking questions;
- planning and carrying out investigations;
- analyzing and interpreting data;
- using mathematics and computational thinking;
- constructing explanations;
- engaging in argument from evidence; and
- obtaining, evaluating and communicating information.

The DRiVe Inquiry Framework

DRiVe is an acronym that incorporates the following phases of inquiry:

- *D* stands for *demonstrate*. This phase allows the teacher to demonstrate a procedure, so that students acquire the practical skills, tools and safe practices that are important for the particular activity in the specific area of science or technology that is the focus.
- *R* stands for *replicate*. In this phase, students reproduce the teacher's demonstration in an attempt to confirm the teacher's results.
- *i* stands for *investigate*. The lowercase *i* denotes that this phase can happen anywhere in the DRiVe sequence, depending on the needs of the students. The teacher provides access to resources for students to build their background knowledge of the essential concepts and skills at just the right time.
- *V* stands for *variate*. In this phase, students develop testable questions that are the jumping-off point for their own investigations that stem from the teacher's demonstration.
- *e* stands for *evaluate*. The lowercase *e* denotes that evaluation takes place throughout with formative assessment for learning. The final product of the activities is evaluated as summative assessment of learning.

Table 1 outlines the phases of the DRiVe Inquiry Framework.

The Inquiry Activity

Demonstrate Phase

In the demonstrate phase, Ms A builds the pop bottle water filter. First, she takes a retort stand and fixes a ring in place. After cutting a pop bottle in half, she places the top of the bottle upside down in the ring. She then adds a coffee filter. She measures out the required amounts of clean sand and stones and adds them in order. She places a beaker beneath the

Table 1. Phases of the DRiVe Inquiry Framework

	Description	**Inquiry level**
Demonstrate (D)	Teacher models investigation behaviour and the desired outcome, and specifies the task (diagnostic assessment)	
Replicate (R)	Students reproduce the teacher's investigation to verify skills or to accomplish the task (diagnostic—formative assessment)	Confirmation
Investigate (i)	Teachers and students gain further knowledge they might need (formative assessment)	
Variate (V)	Students investigate a testable question they developed (formative assessment)	Open
Evaluate (e)	Formative assessment for learning—teacher, peer and self—in all preceding activities Summative assessment of learning—using criteria for success	

open end of the bottle and pours tap water through the bottle. Finally, she pours in the pond water to be cleaned. The water passes through the filter and collects in the beaker.

During this demonstration, students take notes and ask clarification questions. Here is an example of a student's question and the teacher's response:

Student. What's one of those . . . ? What's that called again?

Ms A. What's which called? (*Points to stand.*) This part? (*Points to ring.*) Or this part?

Student. The circle part.

Ms A. This is called a ring. OK?

In the second part of the demonstrate phase, Ms A prompts the students to look at their notes and tell her what they have observed her doing and what happened to the pond water that she poured through the filter. She writes each step that students tell her on a separate sticky note—pink for what the scientist did and green for what happened to the pond water. She attaches the sticky notes to Poster 1 (see Figure 1).

Below is an example of an exchange between Ms A and a student about what she (the scientist) did:

Ms A. And then what did I do? After I touched the retort stand, what did I have to do?

Student. Put in the ring clamp. I added a ring clamp good (*writing this step on a pink sticky note and attaching it to the poster*).

As the class goes through this recounting, students make any changes they need to their notes so that by the end they have a procedure to follow for the replicate phase.

Replicate Phase

Ms A introduces the replicate phase of the pop bottle water filter activity as follows:

Ms A. I now have a control. This is what mine looks like (*holding up the filtered water sample*). My challenge to you is to make a filter that produces this.

In the replicate phase, students work in pairs, using their notes as their procedure and replicating step by step and as closely as possible what Ms A did in the demonstrate phase when she built her pop bottle water filter. When they have their filters built, they pour in the pond water sample and collect the filtered water.

Ms A asks students to place their samples under the document reader so that everyone can see all the samples together. As a whole class, they discuss what aspect of the samples they can measure to compare

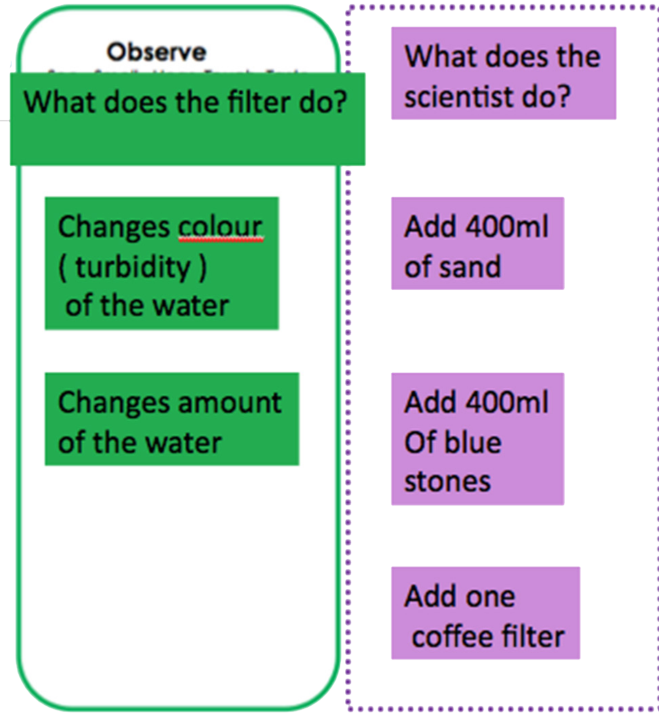

Figure 1. Poster 1, with students' observations on sticky notes.

them. A student suggests arranging the samples according to colour, and the class does so. Ms A then introduces the class to the concept of turbidity and explains that it can be measured using a turbidity probe.

Investigate Phase

Ms A arranges for Mr P, a science curriculum coordinator, to come to her class with a turbidity probe and demonstrate how to use it. Ms A and Mr P support students in learning to use the turbidity probe to measure the turbidity of their filtered water samples. Here is an example of Mr P sharing his expertise:

Mr P. So when you handle the sample holder, handle it by the lid. OK? Now where's the . . . ? See the little arrow? See the little arrow thing? The white arrow? You have to line that arrow up with this arrow.

Variate Phase

The class decides on turbidity of the water as the dependent variable that they will measure. On a green sticky note (colour consistent with Poster 1), Ms A writes, "What will happen to the turbidity of the water?" She places the sticky note on the brain graphic on Poster 2 (see Figure 2).

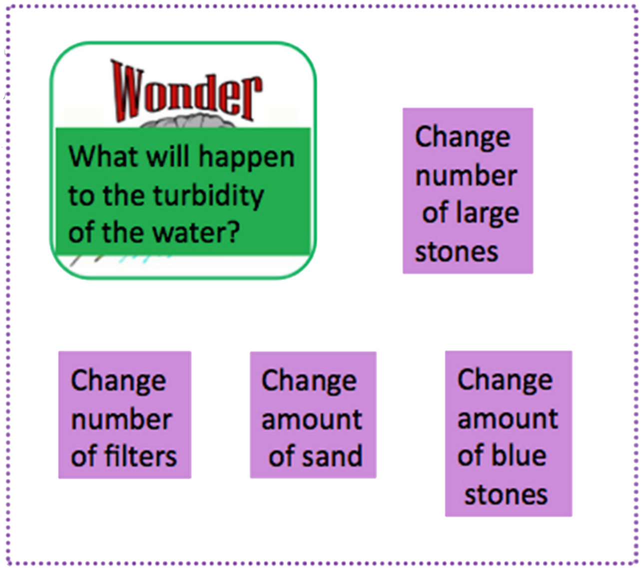

Figure 2. Poster 2, with students' ideas on sticky notes.

The class looks at the pink sticky notes on Poster 1 for variables in the pop bottle water filter that could affect the turbidity of the water. On pink sticky notes, Ms A writes every idea the students provide and attaches them to Poster 2.

She takes from Poster 2 the green sticky note with "Turbidity of water" and places it on Poster 3 (see Figure 3) at the head of the fishbone organizer, in the DV (dependent variable) position. Then, from Poster 2, she chooses one variable (number of coffee filters) to change and moves that pink sticky note to the IV (independent variable) position on the fishbone, to the left of the DV, on Poster 3. Then, she moves all remaining variables written on pink sticky notes to the CV

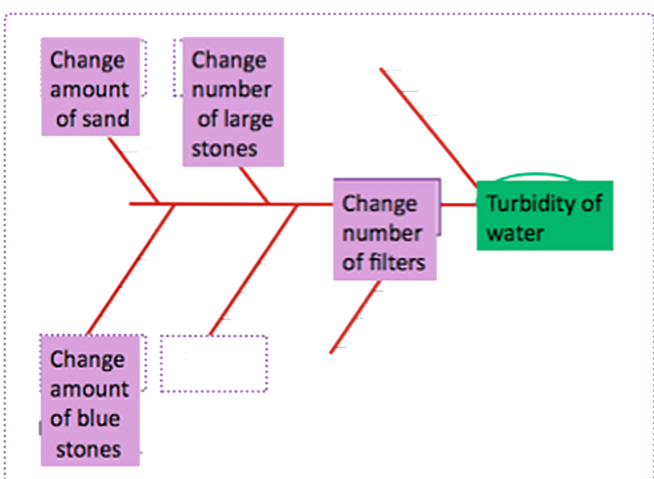

Figure 3. Poster 3, with students' ideas on sticky notes.

(controlled variables) positions on the spines of the fishbone. Then, she phrases the testable question: "If I change the number of coffee filters, what will happen to the turbidity of the water?"

Next, in pairs, students choose a variable to change and design their own experiment. In all cases, their DV is the turbidity of the water. After the following introduction from Ms A, the students go on to perform their experiments, collect their filtered water samples and measure the turbidity:

Ms A. Remember, what is your question, what is the one thing you are going to change? Remember, you need to keep everything else exactly the same. You know where the equipment is, so you can begin.

After they have completed their experiments, the students add their turbidity results to the class chart, and the class looks at all the results together to find out the impact of each variable on the turbidity of the water.

Evaluate Phase

In Ms A's class, many students have writing challenges. Ms A has designed a foldable that can be used as part of the evaluation process, along with the notes she has collected. On the foldable, students can privately write their predictions, reasoning, findings and explanations. Ms A uses the success criteria shown in Appendix A to evaluate students' work on their foldables.

Conclusion from Ms A

I have used the DRiVe Inquiry Framework in my classroom since 2011. I find that my students are more engaged, and over the school year they develop their ability to use the practices of science to conduct more open-ended science investigations. What I particularly like is how the DRiVe approach scaffolds me and the students as we gradually shift from the confirmation style they are familiar with to the more open-ended style of science inquiry we are aiming for.

This model has provided my students with a voice, they see themselves as scientists, and they have become more confident in their academic abilities all around. As they become more confident, they demand more from themselves and their peers. This model has changed the way I think about teaching and how my students feel about learning.

Appendix A: Success Criteria for Summative Evaluation

Success Criteria and Feedback—Lab Report

Success Criteria

What are the features of an effective lab report?

Introduction

- ☐ I have clearly stated my prediction (“If . . . , then . . . .”)
- ☐ I have logical and reasonable support for my prediction.
- ☐ I have included personal connections and background knowledge to support my prediction.
- ☐ I have used research (theories, models, insights) to support my prediction.

Methods

- ☐ I decided on evidence to collect and measurements to collect.
- ☐ I have outlined plans to test my prediction.
- ☐ I have outlined procedures to manipulate and control my variables.

Results

- ☐ I have collected and recorded my measurements in a clear and organized way.
- ☐ I have recorded additional observations using measurements and senses.
- ☐ I have collected and displayed my observations in a clear and organized way.

Discussion

- ☐ I have outlined trends shown in my data.
- ☐ I have made connections to scientific concepts in my explanations.
- ☐ I have compared my observations to my prediction.
- ☐ I have a valid conclusion based on my data.
- ☐ My conclusion relates to my question.
- ☐ I have evaluated my procedure and identified experimental errors.

Overall

- ☐ I have organized my reasons in my explanations.
- ☐ I have used appropriate scientific vocabulary.
- ☐ I have used clearly labelled diagrams that clarify my thinking.

Self-Reflection

Analyze your lab report using criteria.

Two things I did well:

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Something to think about for my next inquiry:

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Teacher Feedback

Use the success criteria to provide feedback about two things done well and one suggestion for improvement.

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