Inquiry by Design Briefs

by Julia Gooding and Bill Metz

Houston, we have a problem." When those words were spoken by Tom Hanks, in his role as Commander Jim Lovell in the 1995 movie *Apollo 13*, a series of incredible movie events unfolded. As the engineers in Houston gathered around a table they were issued the following challenge: "This is the stuff they have on board. . . we need to make it work!" Looking at the limited materials, the engineers began what some might have called an impossible task. However, those engineers (in the real-life version) made history by working together and creatively solving a difficult problem. Ideas can come from anywhere, and this dramatic movie segment was the impetus for adopting a similar strategy in creating a series of middle school science applications known as *design briefs*—plausible situations in which students are asked to solve problems given limited materials, a specific time frame, and a number of rules and limitations.

It is our contention that the design brief, an established format in technology education, can serve as a unique approach to extend and assess everyday science investigations through the process of application. According to the *National Science Education Standards*, the emphasis of recent research has been on learning for understanding, which means gaining knowledge that can be used and applied to novel situations, to "meet a human need, solve a human problem, or develop a product" (NRC 1996).

Simply put, a design brief exemplifies the process of scientific inquiry, wherein a problem is identified, investigated, and analyzed. During this process, it is expected that students will engage in researching existing ideas, crafting new thoughts, selecting and testing possible solutions, and analyzing data. It is also anticipated that students will evaluate their data-supported outcomes and present their findings in meaningful ways. Classroom teachers will find this methodology an effective approach to scientific inquiry because it places added responsibility onto the shoulders of the learners and describes what is required but not how to get there. Those teachers interested in developing or implementing design briefs should consider that they require

students to apply knowledge. Teachers provide concise guidelines for initially channeling students and provide assessment and project evaluation criteria to students before the investigation starts.

The use of design briefs is most appropriate when students have acquired enough background to apply information in meaningful ways. This strategy can be very open-ended and often runs counter to other forms of instructional delivery because there are no answers provided. Students are expected to apply science concepts, content, and processes in creating solutions to a problem. If their science is sound and their solutions are data driven, their efforts should be considered acceptable. We believe that the process of true inquiry is unique to each individual problem solver or group. While the final outcome may be specific, the means by which that outcome is reached can be as varied as the people searching for it.

Using a design brief

Design briefs are typically structured in a four-part format. They are usually introduced with a *general context statement* (provides a perspective for the investigation); a *scenario* (vignette which sets the stage for the dilemma); and the *challenge* (invites students to solve the problem while being mindful of specific *limitations and rules*). When teachers organize activities in the design-brief format, students are provided with an open-ended structure in which to operate. Thus, teachers should be aware that, as students experience these challenges, there may be a plethora of ways by which they reach acceptable conclusions.

Our recommended approach for solving problems is the *design loop*. Learners can enter the loop at any point because ideas can originate from anywhere (see Figure 1). There are more elaborate and simpler versions of this schematic, but each model directs the learner to isolate a problem and pursue it in a systematic fashion. It should also be noted that there are a myriad of mini-loops within this model. The mini-loop of testing, modification, and retesting is common in most design projects because additional tinkering often becomes necessary as a result of feedback.

For example, if a sixth-grade teacher wanted to develop a design brief for students following a study of liquids, the first step would be to create a factual rationale for the investigation in the form of the *context statement,* such as "Liquids differ in their resistance to flow. The thicker the liquid the slower it moves. This characteristic is known as *viscosity*."

The second segment, the *scenario*, should be a short story that is not only plausible; it should contain a real-life connection or application. "The Gonzo Oil Company uses descriptive terms such as 'thick,' 'very thick,' 'super thick,' and 'super-duper thick' to describe the viscosity of its different oil products. As new products are developed, this system is becoming more confusing and inadequate. The company has decided that it needs a classification system that corresponds to the relative viscosities of the products that it sells."

When creating the *challenge*, the following task might be described: "Your research team has been contacted by the Gonzo Oil Company to help them solve their problem. The company wants you to develop a quantitative viscosity rating system for their product line, one that would assign a number to each product based on its relative viscosity."

The *limitations and rules* sections set forth the conditions and guidelines under which students must work, as well as the criteria for assessing the quality of their efforts. When crafting limitations and rules for

FIGURE 1 Design loop

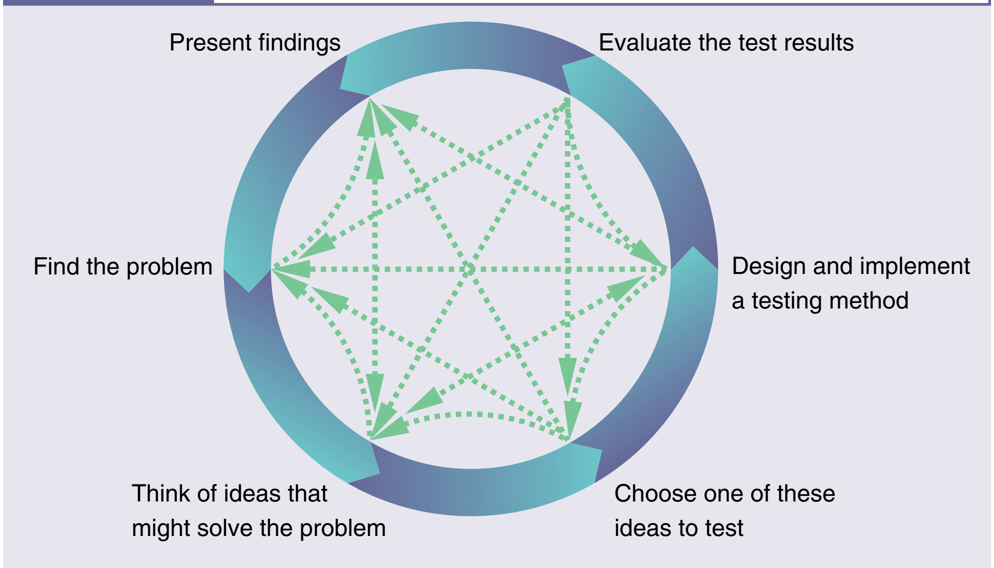

FIGURE 2 Two sample design beliefs

Suspicious saline

The context

Forensic science techniques and procedures are generally used in the search for answers to crime-related questions.

The scenario

Inspector Goodling of the Maine CSI Unit was called to the Ocean Point Municipal Building early on a Sunday morning. Outside the rear entrance, in a tidal pool not far from the building, lay Bob Guessberg, the president of Ocean Point's Municipal Union and an avid scuba diver. Bob was dressed in his diving outfit, complete with tanks, flippers, spear gun, and mask...and dead as a doornail.

Inspector Goodling was immediately suspicious, since Bob never went diving alone. She ordered a complete investigation including an autopsy, which the medical examiner began as soon as the body was delivered to the morgue. The cause of death was determined to be drowning, since water was found in Guessberg's lungs. What kind of water was it?

The challenge

Inspector Goodling was suspicious and suspected foul play since inside the Municipal Building were three large tanks containing brine (salt solution) for use on the county roads during the winter season. Each tank contained a different brine concentration. Samples of ocean water, brine (three different concentrations), and water from Guessberg's lungs were sent to your CSI lab. Inspector Goodling is relying on your expertise to provide help with this investigation.

The limitations

- Each team will be allowed two class periods to complete this challenge at the discretion of the teacher.
- Each team will have access to the five different solutions collected at the crime scene as well as distilled or bottled spring water.
- Each team will have access to all science equipment.
- Each team must craft a "fair test" procedure, and have that procedure approved, prior to gathering materials.
- Each team must develop appropriate data displays to communicate its findings.

The rules

- Each team must present its "fair test" procedure and findings to the other CSI teams.
- Students should refer to the Team Presentation Rubric as they design their presentations.
- Each team member must write a brief data-supported report to Inspector Goodling that contains a review of the research, the results of the laboratory investigation, and a probable cause of death.
- Each team must speculate about what additional tests might be done to develop stronger evidence.
- Students will be expected to wear appropriate eye protection during this investigation. Care should be taken when using any chemical.

Limitations

The context

The environmental factors of light, moisture, and temperature generally determine the species of organisms that can survive in a particular area.

The scenario

Seed companies are always searching for new varieties of seeds to expand their product lines. The new seeds, however, must be thoroughly tested so that the company can determine the optimum conditions under which these plants will grow in order to market them properly. The Green Valley Company (GVC) recently received a shipment of grass seeds from its field operation in Alabama. GVC needs help in creating and conducting the tests for this new variety of seeds.

The challenge

Your research facility has been approached to test the seeds. Due to the time constraints placed on you by GVC, this challenge will require the help of every research team available. The Green Valley Company is interested in determining the best conditions for germinating the seeds.

The limitations

- Each team will have three weeks to complete this project. The amount of actual class time will be at the discretion of the teacher.
- Each team will randomly select the variable its team will test.
- Each team may only use the seeds supplied by the Green Valley Company.
- The criteria for evaluating the plants at the end of the testing

FIGURE 2 Two sample design briefs, continued

cycle must be established before testing begins.

- Each team must submit a "fair test" action plan for approval prior to starting any experimentation, including a list of the conditions (variables) that will be held constant.
- Each team will have access to the general planting and standard laboratory equipment.
- Each team may supply additional materials if so desired.
- Each team must create a way to collect and display its data.

The rules

- Each team member must submit a detailed data-supported report of its findings.
- Each team must create a poster that shows a thumbnail review (the steps) of its entire project.
- Individual class members will be responsible for using the data compiled from all posters to craft a set of consumer instructions for the back of the seed package.

Teacher notes

Suggested materials

Any variety of grass seeds will be appropriate for this investigation. Transfer the seeds to plain bags or containers so students do not get any clues regarding the type of seed or the recommended planting/cultivating conditions. Other materials may include plant pots or planting flats; crushed aspirin and baking soda for adjusting the pH of the soil; sand, clay, and topsoil for making different planting media; plant fertilizer; thermometers; centimeter rulers; graduated cylinders; and a supply of paper towels.

Suggested use

As students progress through most units on plants they will usually be asked to investigate the effects of changing environmental factors on the growth of plants. Such is the case with this design brief. However, unlike the traditional lessons, this challenge requires students to work in a variety of different-sized groups, from full-class involvement to individualized assignments. The focus of this design brief is for students to develop and implement a procedure for testing one of the environmental factors that might affect the growth of grass plants. Students are then expected to conduct their investigations and share their data with others. Processing this data will be the responsibility of individual students as they are then required to craft a data-supported investigation overview in the form of a letter. Team responsibilities then continue with the creation of a data-driven information label for their grass seeds. This challenge could be extended to test the use of commercial fertilizer or naturally occurring fertilizer.

Ties to content

An ecosystem can be defined as the interaction of the abiotic and biotic factors in the environment. Basically, abiotic factors are nonliving factors that affect the plants, whereas biotic factors are living factors that affect the plants. Abiotic factors include light, temperature, sunlight, and availability of nutrients. They can determine the growth rate and condition of plants, as well as if plants are able to live in a certain environment. Plants have a range of conditions under which they will survive and this range can vary for each species of plant. The focus of this design brief is to determine the optimum environmental conditions for common grass seeds.

Possible procedures(s)

Students will be expected to craft a "fair test" investigation for one of the abiotic variables that might affect the growth of grass seeds. These proposals need to be reviewed and approved prior to students gathering materials. Each research team will be asked to design and conduct a different test, the data from which can be combined as a final "company proposal." Some conditions may include depth of planting, distribution (crowded or uncrowded conditions), optimum amount of water, optimum amount of sunlight, optimum range of temperature at soil surface, optimum range of temperature below soil surface, type of soil, pH of the soil, and so on. As the investigation progresses, students will need to collect and record accurate data for processing, displaying, and interpreting. The final segments of this challenge include a data-supported overview and the creation of data-based planting instructions.

Safety issues

Students will be expected to wear appropriate eye protection during this investigation. Care should be taken when using any chemical. Check the MSDS sheet for each chemical prior to use.

a design brief the teacher should consider some of the following factors:

Time

- How much time will students be given to complete this challenge?
- Will the time be broken into segments?
- Are there penalties associated with exceeding the time limit or benefits for staying under?

Materials

- Will all research teams be supplied with the same materials?
- Are there limits to the materials?
- Will there be fictitious material costs that students have to consider?
- If materials are supplied, do teams need to use everything?

Data

- Will students be held responsible for creating their own tables, graphs, and charts?
- How do you expect students to use the collected data?

Presentation of results

- What form will student presentations take?
- Will the entire team be involved in the presentation?
- Will students evaluate each others' projects? If so, how?

Procedural issues

- Will students be permitted to make procedural changes without a rationale?
- Will students be expected to develop their own testing procedures?
- Will there be a minimum number of trials required for a procedure to be considered valid?
- Will it be necessary for students to submit their procedures, or action plans?
- Will detailed sketches or illustrations be required?
- Upon completion, will students have to craft additional investigable questions about their projects?
- Will students be expected to research and include a real-life example/application of the challenge?

Static and working models

- If a working model is associated with the project, how well does it have to work?
- Will modifications be permitted to working models at all times?
- Will there be size or weight limitations associated with the model?

Assessment concerns

- Will a rubric be provided for student and/or project assessment?
- Must students meet all rule and limitation requirements prior to being assessed?
- How will individual student assessments be conducted?
- Will there be a variety of ways by which students can demonstrate that they have successfully completed the project?
- Will students be required to critically evaluate their own projects?

Figure 2 shows two examples of design briefs. The first focuses on the analysis and interpretation of crime scene data. This challenge was crafted as an application for a unit on solutions, specifically the concept of concentration. In the second, student research teams try to determine the optimum conditions under which new varieties of grass seed will flourish. As with many design briefs, these challenges could also be considered a performance assessment.

Conclusion

We invite teachers to consider using the design-brief strategy as an additional means of differentiating the delivery of their instruction. The structure of the design brief motivates students through its plausible scenarios and challenges them to chart their own course of action while applying science content and process in resolving problems. This strategy is also beneficial to teachers as it contains an integrated assessment in the form of limitations and rules that provide opportunities for teachers to gain insights as to how their students interpret and process information. ■

References

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Resources

For further information about design briefs, visit *www.inquirybydesign.net.*

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