An Overview of Novel Engineering in the Classroom

The best way to begin this book is to sketch out what Novel Engineering can look like in a classroom. We've seen the book *Wonder* by R. J. Palacio used in several fifth-grade classrooms and are going to present a composite of these classrooms. Although there is variety among the classrooms and students, there are many similarities. *Wonder* is the story of Auggie, a fifth-grade boy who was born with a severe facial difference and is entering school for the first time. The book begins from his perspective and then switches to include the perspectives of the other characters. The teachers have several learning goals for students that include having students think intensely about the characters and the overarching themes of acceptance and friendship. This requires students to think about multiple characters' perspectives and make inferences about their thoughts and feelings. As the teachers read the book, they pause to give students time to discuss the problems that arose and to discuss, as engineers, how they might solve those problems.

As groups are engaged in discussion, the teacher walks around the room and listens to the discussions. One group wants to address the discomfort that the main character, Auggie, feels while eating in the school cafeteria. Due to his facial structure, Auggie is very messy when he eats and feels embarrassed. As two students, Samuel and Mateo, begin to consider solutions to this problem, it becomes evident that they are drawing on details of the story and making spontaneous inferences, all in service of understanding the design context. For example, they describe how they think Auggie feels, cite specific passages in the text, and infer the reason for those feelings—all of which help them empathize with Auggie about how it might feel to be bullied. They also generate a map of the cafeteria based on setting descriptions, consider the social landscape of an elementary school, and come up with a list of foods that may be easier for him to eat in public.

The following is an excerpt of a conversation between the two students. The conversations throughout this book are numbered so that if teachers are discussing them in groups, they can use the numbers to refer to students' statements.

1. **Samuel:** He doesn't like to eat with everyone.
2. **Mateo:** He could just not eat in the cafeteria, maybe in a classroom with a teacher?
3. **Samuel:** No, he is in school to be with the other kids. We need to make something so he can eat in the cafeteria. What can we ...
4. **Mateo:** He'll be afraid people will look at him.

5. **Samuel:** We can make something that will let him eat and make it less messy.
6. **Mateo:** Okay. How can it be less messy so the food doesn't fall out? Maybe something that catches food but blocks his mouth?
7. **Samuel:** It can be like a fork but hides his mouth.

The following day, the group begins building a device that will help Auggie eat with less mess. As in most Novel Engineering classrooms, the students are provided with a list of available teacher-supplied materials when they begin to plan, which typically include a variety of cheap and recyclable materials such as tape, paper clips, cardboard, string, and cloth. A suggested list of materials is included in Appendix A (p. 223).

Samuel and Mateo propose to test their device using a range of foods, such as a yogurt, apples, and cheese. As they test their device, they are reminded by the teacher to record their findings in an engineering journal so they can share findings with the class and make changes, if needed, the following day. While sharing their findings with their classmates, the students describe their design choices and rationale, the way they tested their design, and how they intend to improve it. Samuel and Mateo want it to look as much like a traditional fork as possible so Auggie will not feel self-conscious. With that in mind, they include a small guard that helps keep food in his mouth.

In many Novel Engineering units, a writing assignment is included as part of a final culminating activity. In Samuel and Mateo's class, students have been instructed to write a journal entry as Auggie, describing how the engineering solution helped him overcome the problem. The pair of boys write about how Auggie felt less fear during lunchtime and is now able to talk to a friend at the lunch table. The students make projections about how their device would help Auggie gain confidence, which in turn would affect his life. In this example, Samuel and Mateo organically worked through an engineering design process (EDP) without being required to follow the process as a checklist; rather, they were allowed to move naturally through the steps. We will discuss the EDP used in Novel Engineering in the next two chapters.

After their first Novel Engineering experience, teachers often say that their students exceeded their expectations. In the previous example, Samuel and Mateo thought deeply about how Auggie might feel in different situations, such as eating in a school cafeteria or meeting new people. They also made inferences from the text and used their knowledge of the characters to project how different scenarios might play out. The teacher spoke with students as they worked, which

provided a strong understanding of what their ideas were around the text, their design choices, and their construction of the final design.

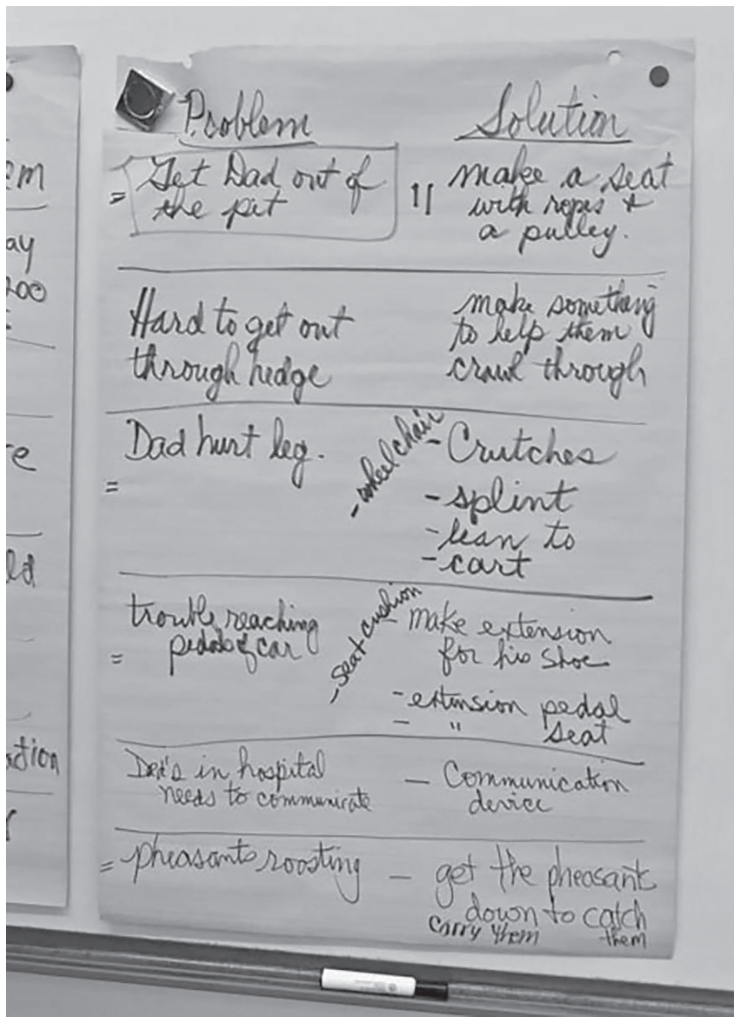
In addition to meeting ELA goals, students worked collaboratively with partners or group members, communicating their ideas and supporting one another in the process. Most surprising to teachers, however, is the way their students act like young engineers. When engaged with the *Wonder* unit, students think critically about their designs, present evidence to support their design decisions, test their ideas, evaluate those ideas, and then iterate to improve their designs.

This example mirrors the experiences of hundreds of teachers with whom we have worked. Teachers consistently indicate that the integration of engineering and literacy is synergistic and powerful. Stories provide complex settings (engineering design contexts) and characters (clients) with real problems and needs, and the students' desire to help those characters by designing functional engineering solutions motivates a deeper reading and understanding of the texts. Most important, students become excited about what they are reading, writing, designing, and building! This excitement in turn helps them make strides in both engineering and literacy, as well as in their abilities to work together, think creatively and analytically, and communicate their ideas.

Novel Engineering provides a structure for students to do engineering while simultaneously working in the content areas. Books, short stories, and nonfiction texts can offer a broad context for engineering design problems that are complete with built-in constraints and criteria. In Novel Engineering, students read and identify engineering problems in the books or other texts, consider characters as clients, and then use details from the story to build functional solutions to address the characters' problems. An example of student-generated problems based on students' work with the book *Danny the Champion of the World* can be seen in Figure 1.2 (p. 8).

Books can range from picture books appropriate for kindergarteners to more complex novels for older students (see Table 1.1, p. 9). Although we will talk about the literacy and engineering portions of Novel Engineering as distinct tasks, students actually see them as part of the same task and bounce back and forth between them minute by minute. Including a hands-on piece is more time consuming, but one of the benefits of Novel Engineering is that it allows teachers to use some of their ELA blocks for these projects and provide time for students to interact with the text.

Figure 1.2: List of student-generated problems from *Danny the Champion of the World* by Roald Dahl



Guiding Principles of Novel Engineering

From our work at Tufts University, we've seen that students are capable of jumping into engineering projects with little guidance and that teachers can use Novel Engineering as an entry point to meet classroom goals. We've also seen that Novel Engineering provides teachers with a concrete way to attend to and respond to student thinking. These observations—along with our belief in the abilities of students and teachers—helped us formulate our guiding principles.