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ARTICLE

Problem Scoping

Design Thinking & Close Reading

Makerspaces in the School Library

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Makerspaces, collaborative workspaces stocked with materials and tools for creating, building, designing, and learning, are becoming more and more common in schools and, in particular, in school libraries. These educational makerspaces "harness the same intellectual playground concept for the purpose of inspiring deeper learning through deep questioning" (Kurti, Kurti, and Fleming 2014, 8). By letting students ask questions, dig for answers, and work through solutions, making deepens learning and understanding (Kurti, Kurti, and Fleming 2014).

Makerspaces in the school library allow for connections between making and literacy. Indeed, such connections are authentic and natural as real-world engineers practice multiple forms of literacy (Wilson-Lopez and Minichiello 2017, 7). In the makerspace, before building students might write proposals. Students can also write reflections on the process or write their own instructional pieces. Angela Stockman has even encouraged teachers to turn the writing process into a making process, linking the two together (2016). To design and build new creations, students might do research or read how-to guides. However, perhaps the greatest advantage to hosting the makerspace in the school library is the collection of high-quality children's literature. As the researchers at the Tufts University Center for Engineering have shown, children's literature can inspire making. Their Novel Engineering project has studied the way that young student engineers work through the design process when making is tied to literacy. In particular, students use children's literature as part of the design process, particularly in the problem-scoping stage. (For more about the project at Tufts, go to <www.novelengineering.org>.)

Problem Scoping: The Research

Problem scoping is part of the problem-definition phase of the design process. The design process starts with problem definition, followed by brainstorming, designing, building, testing (repeated as necessary), and is finalized by showcasing or sharing work. As described by Amy Wilson-Lopez and Angela Minichiello, the processes of defining problems, generating and evaluating solutions, testing and optimizing solutions, and communicating solutions do not happen linearly, but rather simultaneously (2017). However, for the purposes of understanding and teaching these processes, it makes sense to look at them as discrete.

Problem scoping is the process by which student designers "figure out" the problem that they need to solve (Watkins, Spencer, and Hammer 2014). It is the process by which the problem is defined. Students identify the key elements or factors to which they need to attend, and also consider the context of the problem (Watkins, Spencer, and Hammer 2014). Engineers work within a system of limitations and constraints. It is easy to confuse these two terms. Limitations are the requirements that solutions must meet, while constraints are restrictions on possible solutions, such as time or access to materials (Wilson-Lopez and Minichiello 2017, 8).

Researchers in the Novel Engineering program posit that real-world engineers and designers start with complex and poorly designed problems. The first step of design is thus to scope the problem (Watkins, Spencer, and Hammer 2014). Literature replicates the complex and poorly defined problems of real-world designers and, thus, can spark the design process for school-aged engineers (McCormick and Hynes 2012). When given a literary context (specifically, E. L. Konigsberg's middle-grade novel *From the Mixed-Up Files of Mrs. Basil E. Frankweiler*), students exhibited extensive problem scoping and

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used problem scoping to decide amongst the problems and design a solution (McCormick and Hynes 2012). One qualitative research study used observations of two fourth-grade boys to document how students decided which problem of the novel to solve. In describing the process, the fictional context of the book was described as a catalyst for engagement, and Mary McCormick and Morgan Hynes concluded that the literary context provides the complex, poorly structured problems necessary for authentic design (2012).

Problem Scoping in Practice

Children's Literature as a Scaffold

In my work with students I have found the problem-definition step to be a challenging one. Students can readily identify a group they might want to help (e.g., animals) or something they want to make (e.g., a fidget spinner), but have more trouble clearly identifying a problem that needs a solution. While making can take the form of recreating or tinkering, if we want students to more deeply practice their critical-thinking and problem-solving skills, they need to master the skill of problem scoping. Using children's literature is a way to scaffold this process.

Connecting making and literacy has the potential for inviting students to engage with the text in new and deeper ways. Effective problem scoping from a literary work asks students to dig more deeply into the text to find relevant details. I support this work through whole-class brainstorming and guided practice with problem-scoping worksheets.

Whole-Class Brainstorming as an Introduction

Whole-class brainstorming is a good way to introduce the idea of problem scoping to students. In one lesson, fourth-graders who were reading *The Young Man and the Sea* by Rodman Philbrick were challenged to make boats for the main character, Skiff. The kids explained Skiff's problem: to raise money and help his family, he needs to catch a tuna. As each student spoke, I added the student's comments to a piece of chart paper. To get more details, I asked a clarifying question: "Will he need to pull the tuna up into the boat, or will he drag it behind?" They told me he'd be dragging it. Therefore, we knew that any boat they would design would need to be able to go out into the water, and then pick up the tuna and drag it back. This would be considered a limitation. The tuna, in our case, would be a blue clothespin with a rock glued to it.

I also ask kids to think about constraints. Constraints might come from the story, or they might come from the context in which the making is taking place. In this case, I told learners that they would have one class to design and build, and the following class we would do finishing details, and then motor our boats in a kiddie pool. I also gave them the requirement that the boat had to be powered by a Sphero, a robotic sphere. For materials, I put out some scrap wood and told students they had to use the wood as is (no cutting). I also gave them cardboard, craft sticks, mini dowels, straws, corks, and empty water bottles. They could use LEGO bricks as well. Together we had effectively identified the parameters of the problem, and the students were ready to design and build.

Small-Group Projects as Further Practice in Problem Scoping

Problem scoping can be more independent as students have more practice. Fifth-grade teachers used the novel *Out of My Mind* by Sharon M. Draper as an all-class read aloud. This novel lends itself very well to a maker project and to problem scoping in particular. In this book, the main character Melody loves music, fast food, and trivia. She is smart and is working hard to make the school's quiz bowl team. She also has cerebral palsy and is severely limited in motion and communication. The students were given the task of designing a product for Melody. The challenge was purposefully left open so students could think of it as something she wanted, something she needed, or something to help her with her day-to-day life. I wanted students to realize that Melody was more than her disability and that their products could be unrelated to her cerebral palsy but would need to be devised with her physical challenges in mind.

The process started with students being put into groups. They were asked to complete a worksheet that asked students to record Melody's likes, wants, and limitations. Some of the worksheets were filled out on a fairly simple level, but others had quite lengthy lists. For example, under "What does Melody like?" groups included Melody's favorite subjects (math and history), her friend Rose, and even her love of McDonald's fast food. Similarly, while many groups made assumptions about Melody's wants ("a voice," "legs that work," "to walk"), some groups more deeply mined the text and included joining the Whiz Kids team (the quiz bowl team Melody wants to join) and a computer. While all students were exhibiting some degree of textual analysis to problem scope, they did so at varying levels. In this way, the problem-scoping worksheet serves as a formative assessment. Feedback helps students see that in both reading and problem scoping, understanding a character is not about assumptions but requires close attention to the text.

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This attention to the text continued as students worked on their designs. I overhead one student ask, "You know how it's hard for her to get out of her chair?" referencing moments in the book that focused on the difficulty Melody and her family faced in getting her from her wheelchair to her bed. In another class, a group focused on her troubles eating, and discussed the idea of making a chewing machine. In these instances, students took details from the book—Melody's needs and limitations—to define a problem that their design would solve.

Hybrid Approach to Problem Scoping

Another instruction model is a hybrid of whole-class and small-group problem scoping. Third-grade students study theme, which makes fables a nice literary genre to incorporate into making. For two years I have used the "Engineering Solutions to Aesop's Fables" lesson from littleBits (available at <http://littlebits.cc/lessons/engineering-solutions-to-aesop-s-fables>). After I've read three fables to the students, we make a chart on the whiteboard, identifying clients and their problems (see table 1). In the story of the fox and the grapes, the students readily identify the fox as a potential client, but take some prodding to find the other character: the grapes (or, perhaps, the farmer). For each character, we identify the general problem. In "The Belling of the Cat" the mice don't want to be eaten by the cat. The cat, in turn, would like to catch the mice. The peacock can't fly, according to the fable, because his tail is too heavy. From there, students work in groups to choose a client and do further problem scoping. These fables work well for the younger students because the details they need to mine are clearly stated.

Literature as an Authentic Framework

Problem scoping is an essential skill not only because it defines the parameters of the problem, but also because a clearly defined problem leads to new design ideas. Rather than simply recreating something they have seen, when students complete the full design process they come up with novel ideas. Moreover, they can articulate how their invention solves the problem, thus demonstrating their problem-solving skills. Using the children's literature that is readily available in the school library offers an authentic framework in which design thinking can occur.

FABLE	CLIENT: CHARACTER	PROBLEM
The Fox and the Grapes	The Fox	Wants the grapes but can't reach them.
The Fox and the Grapes	The Grapes (or The Farmer)	Do not want to be eaten.
The Belling of the Cat	The Mice	Can't get to food without being chased by cat.
The Belling of the Cat	The Cat	Wants to catch the mice.
The Peacock	The Peacock	Now that his feathers are so beautiful, he can no longer fly.
The Peacock	The Eagle	Plain looking.

Table 1. Fables, characters, and problems.

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