Getting Started with SLED:
A Primer for Interested Teachers and School Administrators

What is SLED?

SLED stands for Science Learning through Engineering Design. It is a school-university partnership project led by Purdue University and supported by the National Science Foundation (NSF) via its Math Science Partnership (MSP) program[1]. The goal of the SLED partnership is to improve the learning of students in grades 3-6 through the integration of an engineering design-based approach to science teaching and learning. The SLED project has worked to achieve this goal by: (1) developing standards-based and grade-appropriate curricular materials that support the teaching and learning of elementary science through design-based activities, (2) providing professional development to prepare current and future teachers to utilize engineering design as a way to teach inquiry-based science in the classroom, and (3) gathering evidence of how teachers teach and how students learn through this approach.

The SLED partnership began in 2010 and initially involved four academic colleges at Purdue (Education, Engineering, Science, and Technology), other partners at Purdue and in the community, and four participating school districts in Indiana (Lafayette, Plymouth, Taylor, and Tippecanoe). Since its inception, the project has developed a library of more than 30 instructional units that utilize engineering design as a vehicle for the teaching and learning of science in the grades 3-6. The project has also provided professional development for hundreds of in-service and pre-service teachers, and it has expanded its reach to support teachers and schools from districts beyond the original partnership throughout the State of Indiana.

Why Engineering Design?

At both the national and state levels, education standards now call for engineering concepts and practices to be integrated into science education. The national Next Generation Science Standards[2] argue that it is important that “Science and engineering are integrated into science education by raising engineering design to the same level as scientific inquiry in science classroom instruction at all levels and by emphasizing the core ideas of engineering design and technology applications” (p. xiii). In Indiana, engineering design has been integrated into the elementary science education standards since 2010. In 2016, Indiana adopted new science academic standards[3] that retain its vision for engineering design by situating design in the language of “Science and Engineering Process Standards” (SEPS). These new standards are the processes and skills that students are expected to learn and be able to do within the context of the science content. Engineering design, like other project- and problem-based pedagogies, supports students’ development of content knowledge within the context of authentic problems. It encourages students to actively construct solutions to real-world problems using inquiry and cooperative learning processes. Using engineering design, students not only develop new understandings, but they are able to apply them through hands-on and minds-on activities.

SLED Curricular Materials

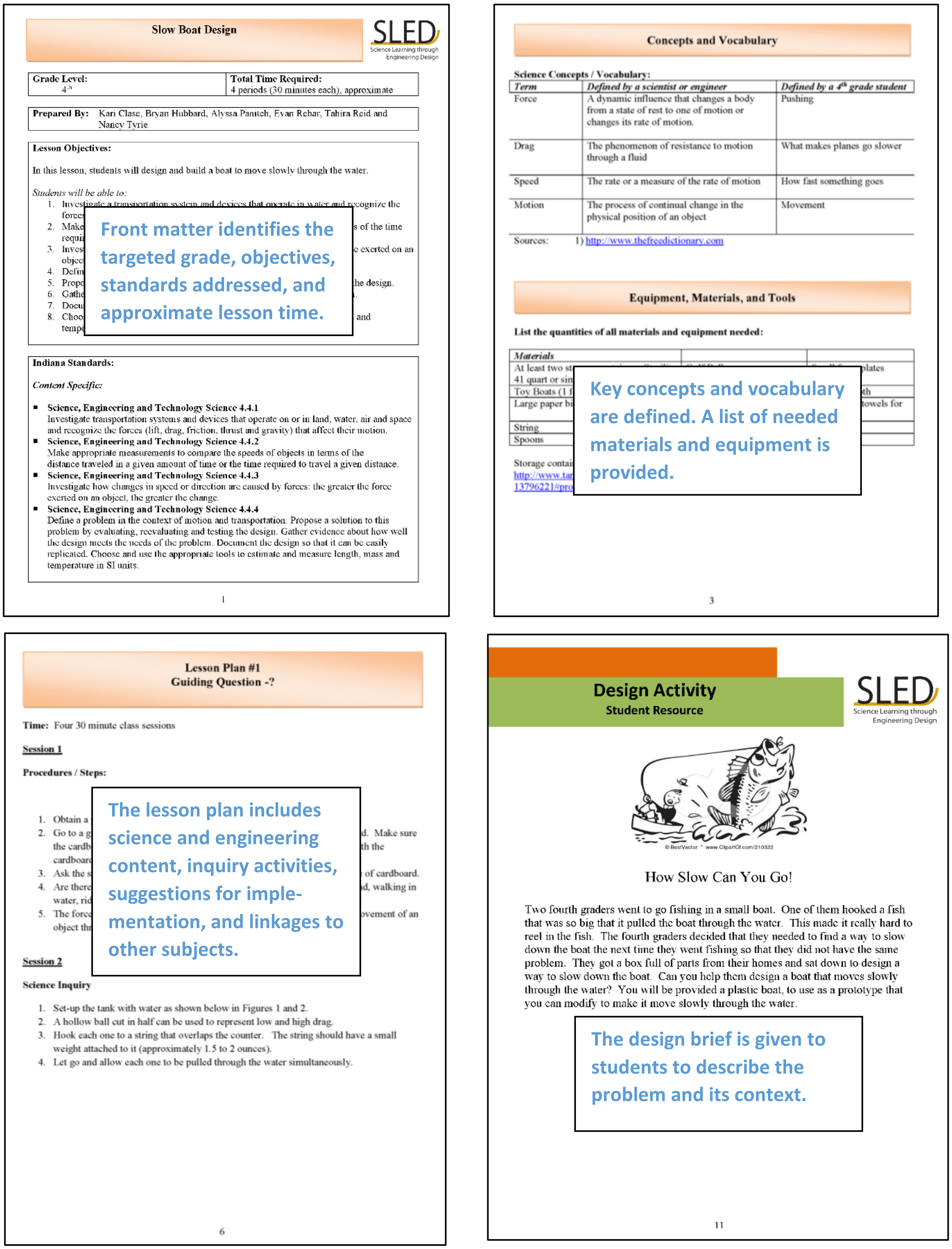
SLED instructional materials are free for teachers and schools to use and can be accessed via SLED's electronic hub at https://stemedhub.org/groups/sled/design_resources. These classroom-tested, standards-based materials were developed by teams of STEM (science, technology, engineering, mathematics) disciplinary faculty from Purdue University working in collaboration with education faculty and with participating classroom teachers. All instructional units are designed to address Indiana and national standards for science and engineering learning, and in most cases they have linkages to math and language arts as well. During development, the instructional units underwent pilot testing by teachers from the targeted grades before being introduced into the classroom for student use. While units were developed for grades 3-6, teachers may be able to adapt the materials for use with students in other grades.

Each SLED unit is anchored by an engineering design task or challenge that is intended to help students learn and/or apply relevant science or mathematics core disciplinary ideas as they design a solution to address a problem. Examples of the design tasks from popular SLED units include: creating a compound machine to safely trap a wolf (Save the Wolf), building an alarm that sounds when a door to a room is opened (Door Alarm), designing a way to make a boat move more slowly through the water (Slow Boat), making a model of a child's prosthetic leg that can kick a ball (Prosthetic Leg), and constructing a model roller coaster with the greatest loop diameter at lowest cost (Roller Coaster).

Common features of these design tasks[4] include:

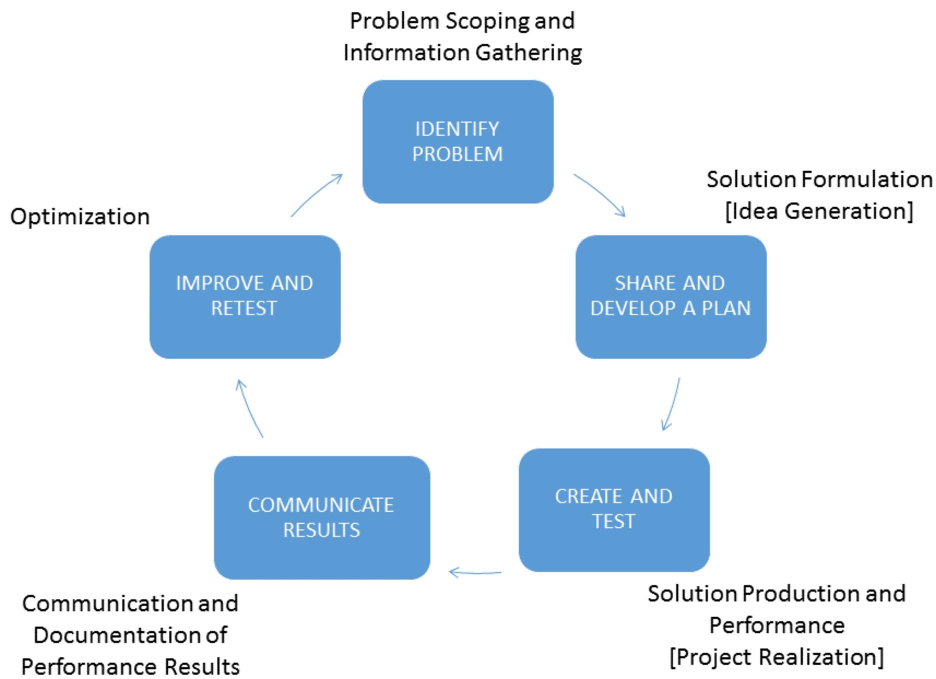
- **Tasks are client-driven and goal-oriented**. Students are challenged to create a solution that helps solve a problem. Typically, there is a client for whom the students develop their design solutions, and there are end users who will make use of whatever product or process is developed.
- **The context is authentic**. Each problem scenario is realistic to promote real-world connections and enhance student interest and engagement.
- **There are constraints**. Students must design their solutions to incorporate necessary features while taking into account limitations such as cost, time, materials, size, etc.
- **Students produce an artifact, such as a model or prototype, or a process**. In most cases, the construction of an artifact to meet the client's needs is the culmination of the design process.
- **Multiple solutions are possible**. In engineering design, different design solutions can effectively address the problem, so students can be successful in many ways.
- **The process involves teamwork and collaboration**. This reflects the real working environment of engineers, and it helps to build students' skills for working with others.
- **The process utilizes familiar and easily accessible materials, resources, and tools**. SLED units make use of common classroom tools (scissors, rulers, scales) as well as materials that, in most cases, can be readily obtained at low cost from common retail vendors. Many teachers ask parents to help contribute supplies for design activities to minimize cost.

Teachers interested in using SLED instructional materials can download the units from the website given above. Each unit includes information for teachers, such as the objectives, standards addressed, materials needed, assessments, etc. in addition to materials for use with students, such as the design brief. The figure below shows excerpts from one unit, Slow Boat, showing some of the key elements of each SLED curricular unit.



SLED Design Model

SLED utilizes a simple model of engineering design based on the cycle of activities students engage in when solving an engineering design problem. The five interactive phases, shown in blue below, represent steps in an iterative process in which students identify the problem, develop a plan for its solution, create and test a solution, gather data and communicate the results, and then seek to improve the solution through redesign. The terms engineers often use for these activities are shown adjacent to each phase.



The SLED Engineering Design Model[4]

Identify Problem. Students first work in teams to identify the problem. The context of each design task is laid out for students in the form of a design brief, a short description of the design task. Teachers pass out copies of the design brief to their students and ask a student to read it aloud to the whole class. During this initial phase, students seek to understand: what is the end goal of the design activity, who is the client and end user, and what are the criteria and constraints for the design?

Share and Develop a Plan. Once the problem is understood, students begin to design a solution. First, students individually (without consulting others) generate ideas for a solution based on what they know about the problem and relevant science concepts. Individual students sketch their ideas for solutions in their design notebooks. Then, students get together in small groups, typically 3 or 4 students each. Each group discusses group members' ideas and comes to consensus on a group design. The group design could be one person's design that everyone agrees is best, or elements

from different individuals' designs may be combined to create a composite design. All group members then record the agreed-upon group design in their design notebooks.

Create and Test. After agreeing on a solution, students work together in their teams to construct their prototype or process using available materials. During the hands-on construction phase, students are encouraged to remain faithful to their group's design when constructing their product, and, should modifications prove necessary, to record any changes in their design notebooks. Once students have constructed their solutions, they can test them to ensure that they meet the needs of the client and satisfy the design criteria. During this phase, data may be collected and analyzed, and students are encouraged to use their scientific knowledge to explain the results.

Communicate Results. After completing and testing their designs, students share their designs and results with other teams and/or the whole class. This process helps students develop communication skills, allows students to observe different problem solutions, and again encourages students to utilize scientific knowledge to explain what worked well and what could be improved.

Improve and Retest. Through the communication process, student teams gather feedback about their designs. This feedback can inform a redesign process to make improvements to the designs. While time constraints in the classroom may limit how much actual redesign can be done, students should at least be given the opportunity to consider how they might redesign their solutions to make improvements. If time permits, students can construct their revised designs and retest them to see how well the redesigned solutions work.

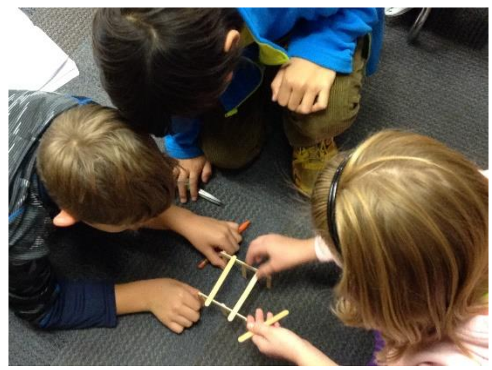
Integrating SLED in Your Classroom and Curriculum

How should you integrate SLED activities in your curriculum? There is no one right answer to that question. Teachers who use SLED materials adapt them to align with their specific goals/objectives, academic calendars, and teaching styles. Different approaches can and do work. Use the materials to best support what you do in the classroom.

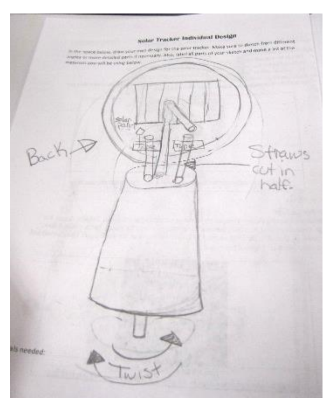
Using SLED activities. Many teachers begin the school year by using a simple design activity as a way to introduce students to the engineering design process; design tasks such as Lifeguard Chair, Candy Bag, and Take a Stand are good for this purpose. After students develop a basic understanding of the engineering design process, some teachers use a SLED activity as a way to introduce a science concept and then provide additional instruction about the science content after the activity. For example, teachers have used the Compost Column task as a way to introduce the idea of decomposers when teaching about ecosystems. In other cases, teachers use a SLED activity to reinforce students' learning of an already-introduced science concept or as a culminating activity of a science unit of instruction. For example, teachers have used the Door Alarm task as the final activity of a unit on electricity and electric circuits or the Slow Boat task as a way to reinforce students' learning about forces and motion.

Curriculum mapping. To get started, map the existing curriculum for your grade level. What are the big science ideas that you address during the school year? When and how do you usually teach particular topics? Then, examine the SLED library of activities. Are there particular activities that would complement what you are already doing? Where might you be able to use those activities to support your instruction? Think about starting with just one or two SLED activities during the school year as a way to introduce your students to engineering design. Then, as you become more comfortable with the approach, consider adding additional activities that can support your curricular goals. Some schools using SLED materials now integrate multiple design activities within grades and across grade levels. SLED materials can address many of your science standards while also allowing you to make linkages to other disciplinary areas such as mathematics and language arts.

Cross-curricular connections. SLED materials, while focused specifically on science and engineering, were designed to support connections to other disciplines. Most SLED units support connections to mathematics. A few SLED activities (e.g., Reindeer Habitat) have an overt focus on mathematics, and many teachers integrate mathematics into other SLED activities. For example, teachers often assign costs to the different materials that students use to construct their design prototypes, and students are challenged to use math to calculate the cost of their designs and to try to come up with a design solution at the lowest cost. In addition, SLED activities often involve data collection as part of preliminary inquiry activities or when testing design solutions. This offers an opportunity for students to practice creating data tables, calculating sums and averages, creating graphs from data, and interpreting the results of their design tests. Language arts can also be incorporated into SLED units. Suggestions for relevant readings and other extension activities are provided in many of the units. In addition, teachers sometimes incorporate language arts by having students write a persuasive letter to the client about their design, create an advertisement for their design, or make an oral presentation to explain the benefits of their design.



Notebooking. Notebooking is an integral part of the engineering design process. Professional engineers often use notebooks as a way to document their design processes and design ideas. By using a notebook in the classroom, students model the practices of working engineers and develop the habit of keeping good records of their work. Each time a new design activity is conducted in the classroom, teachers should encourage students to record in their notebooks the problem, client, end user, and goal of the design challenge. As they begin to work on the design, students should record and label their individual and group design sketches. They should note any changes made during the design process; many teachers instruct students to make changes in a different color so that they are easy to identify. The design notebook is also the place for students to keep track of design ideas, background research, notes about discussions, materials used, the results of any labs or tests, and reflections. Students' notebooks provide a place for them to keep all of the information about each design activity.



For elementary school teachers, literacy education plays a central role in their instruction. The notebook provides an interactive platform for teachers to integrate and extend students' literacy skills, including vocabulary development. SLED teachers have used the design notebook to include different graphic organizers and Foldables© that introduce and reinforce new vocabulary terms throughout the design learning experience.

Assessment. Of course, assessment is a key aspect of any classroom activity, and SLED activities are no different. How do you assess your students when they do an engineering design activity? Students' success has less to do with the final end product than with how well they engage in the design process. Most teachers use multiple forms of assessment to gauge their students' performance throughout the design process. Collecting and grading students' design notebooks is one form of assessment used by most teachers. Have students correctly identified the problem, the client, the end user, and the goal of the design activity? Do they have clearly labeled individual and group design sketches? Have they recorded results of any testing of the design and used science vocabulary terms appropriately to explain any results? Many teachers utilize rubrics aligned with the phases of the design process to judge their students' performance throughout the unit. For example, some teachers assess students' collaboration and contributions to group work during the planning and construction phases of a design activity. Teachers often assess students' presentations of their designs to the class and their use of science concepts to explain why their designs did or did not work well. Teachers can also assess ancillary products created as part of the unit, such as a persuasive letter students are asked to write to the client about why they think their design is the best. Of course, teachers also use traditional assessments, such as quizzes and tests, which address the content related to the design activity. Suggestions for assessment are provided in each of the SLED curricular units.

For More Information

For more information about SLED, please visit our electronic hub at https://stemedhub.org/groups/sled (or just sledhub.org). SLED-developed curricular resources can be accessed without a login and are free of charge. If you would like to join the SLED hub site, which provides access to additional features and materials, you can do so free of charge.

End Notes/References

[1] The SLED project is supported by the National Science Foundation, Award #0962840. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
[2]NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: The National Academies Press.
[3] *Indiana Academic Science Standards* (2016). http://www.doe.in.gov/standards/science-computer-science.
[4]Capobianco, B. M., Nyquist, C. & Tyrie, N. (2013). Shedding light on engineering design. *Science and Children*, *50*(5), 58-64.