A School-University Partnership for Preparing Teachers to Integrate Engineering Design for Science Learning

2014 AACTE Conference

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SLED
Science Learning through Engineering Design

This project is supported by the National Science Foundation, Grant #0962840

NSF

National Focus on STEM Education

- Science, technology, engineering, and mathematics (STEM) education is viewed as critical to U.S. innovation and economic competitiveness
- Major national reports have focused on the need to strengthen STEM education in U.S. schools, and a number of new initiatives are underway

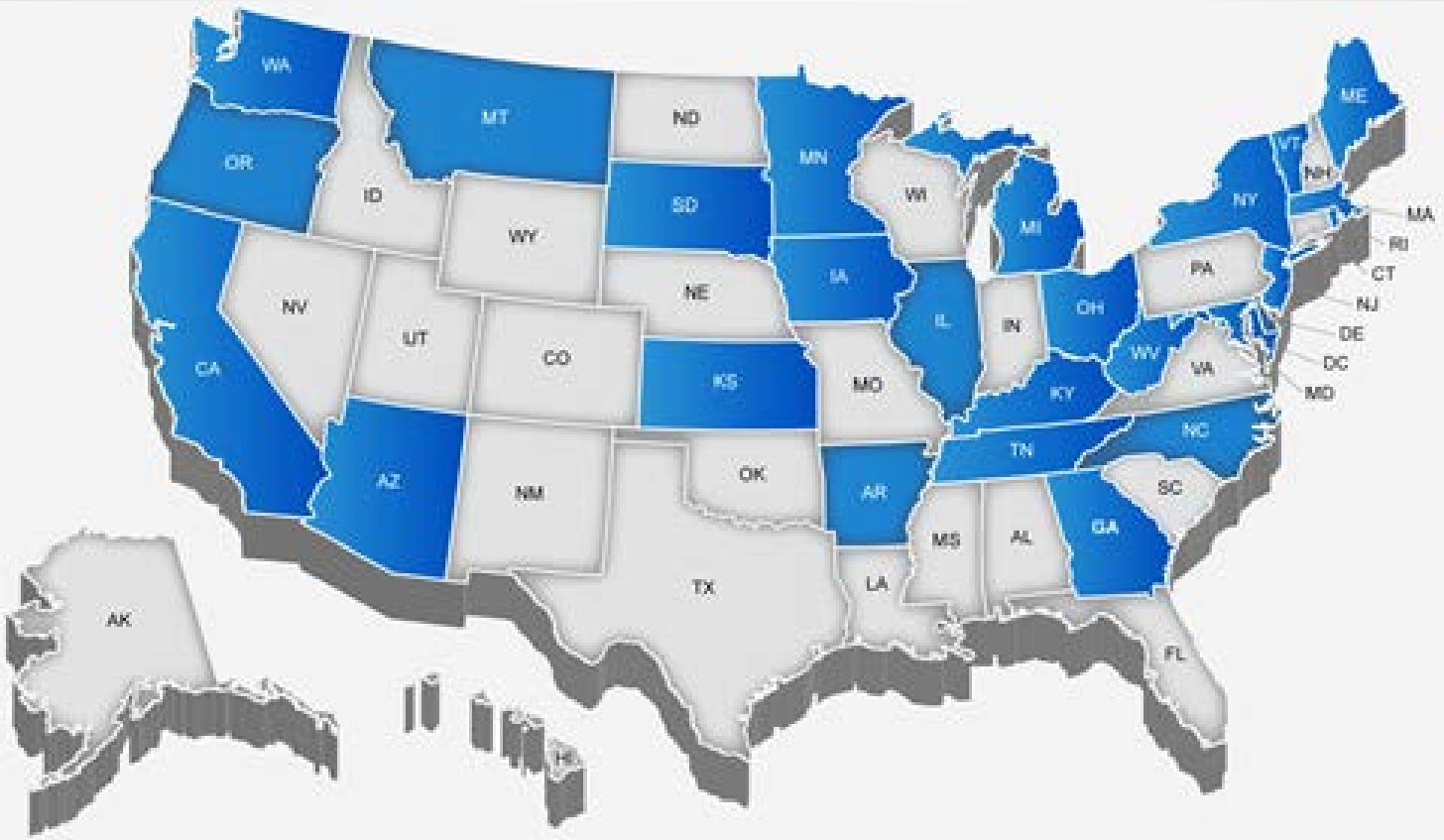
Next Generation of Science Standards
(NGSS Lead States, 2013)

Science education in grades K-12 should be built around three major dimensions:

- Scientific and engineering practices
- Crosscutting concepts that unify the study of science and engineering through their common application across fields, and
- Core ideas in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science.

Next Generation of Science Standards (NGSS Lead States, 2013)

26 Lead Partner States



Challenge for Teacher Education

- How can we effectively prepare teachers, many of whom have had little or no experience with engineering, to develop the knowledge and skills necessary to integrate engineering concepts and practices within their science teaching?

The SLED Partnership

SLED, Science Learning through Engineering Design, is a school-university partnership project designed to help improve students' science learning in grades 3-6 through the integration of engineering design as a vehicle for science teaching and learning.

The SLED project is supported by the National Science Foundation through its Math Science Partnership program.

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SLED Partners

- Purdue University
  - Colleges of Education, Engineering, Science, and Technology
  - Discovery Learning Research Center
- School Districts
  - Lafayette Schools
  - Plymouth Community Schools
  - Taylor Community Schools
  - Tippecanoe Schools
- Community Partners

SLED's working hypothesis

If elementary school teachers are given the necessary tools, resources, and support, they will implement, and possibly innovate and invent, their own instructional ideas for integrating the engineering design process in diverse ways, giving priority to different pedagogical or conceptual features (e.g., subject matter, academic standards, and processes).

Foundational Ideas

- Community of practice (Lave & Wenger, 1991) involving university STEM faculty members, teacher educators, and teachers and administrators from partner schools
- Development of teachers' content and pedagogy for effective classroom science teaching (Abell & Lederman, 2007)
- Use of the engineering design process as a means to foster student learning through an integration of science and engineering (Fortus, Dershimer, Krajcik, & Marx, 2004; McRobbie, Stein, & Ginn, 2001)

SLED Components

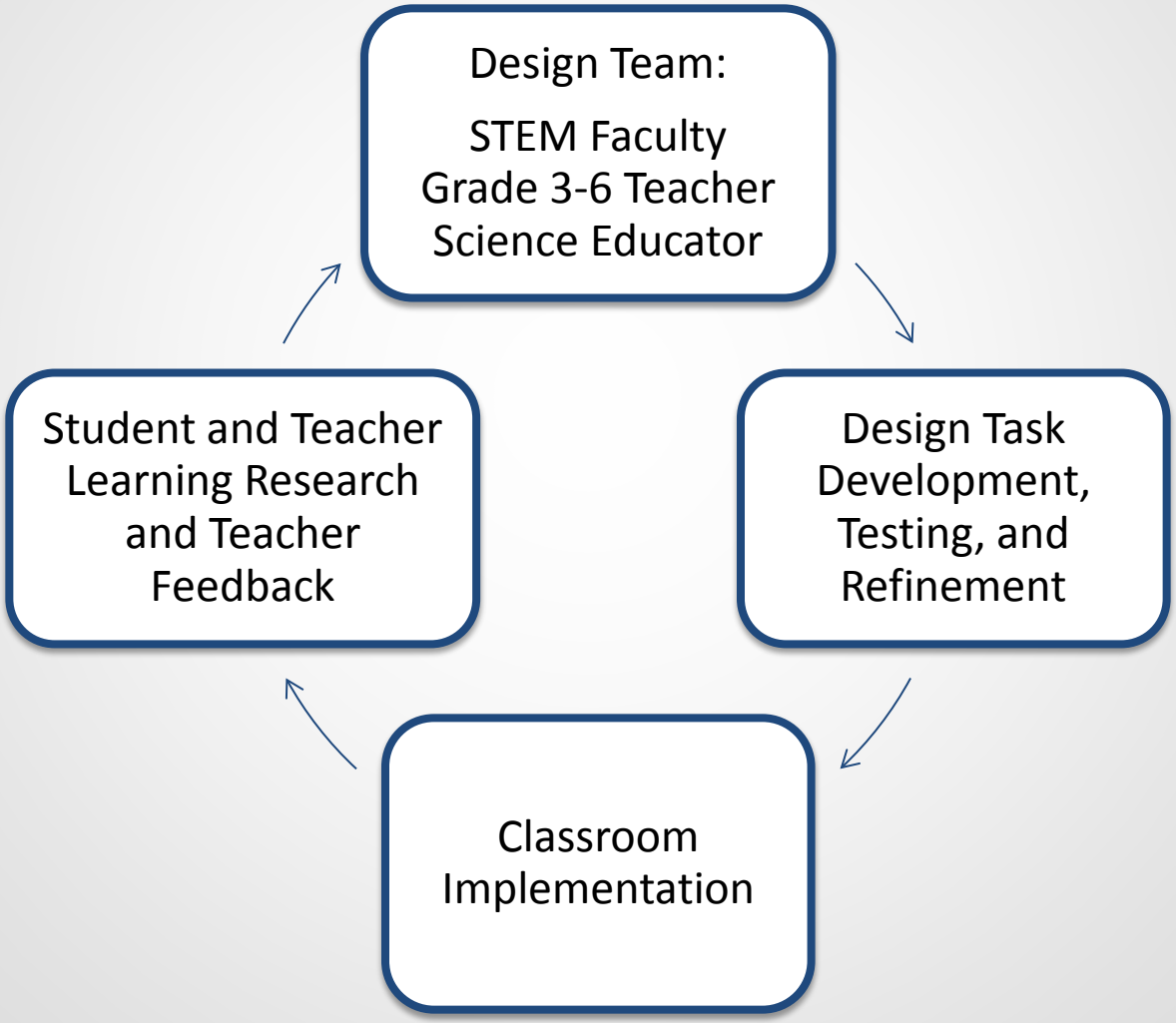
1. Design and development of curricular materials/ tasks that support the teaching of elementary science through authentic, inquiry-based, design projects
2. In-service teacher professional development focused on the use of engineering design in the elementary science classroom
3. Pre-service teacher preparation that is integrally linked to partnership schools and teachers

Component:
Design and Development of Design-Based Curricular Materials

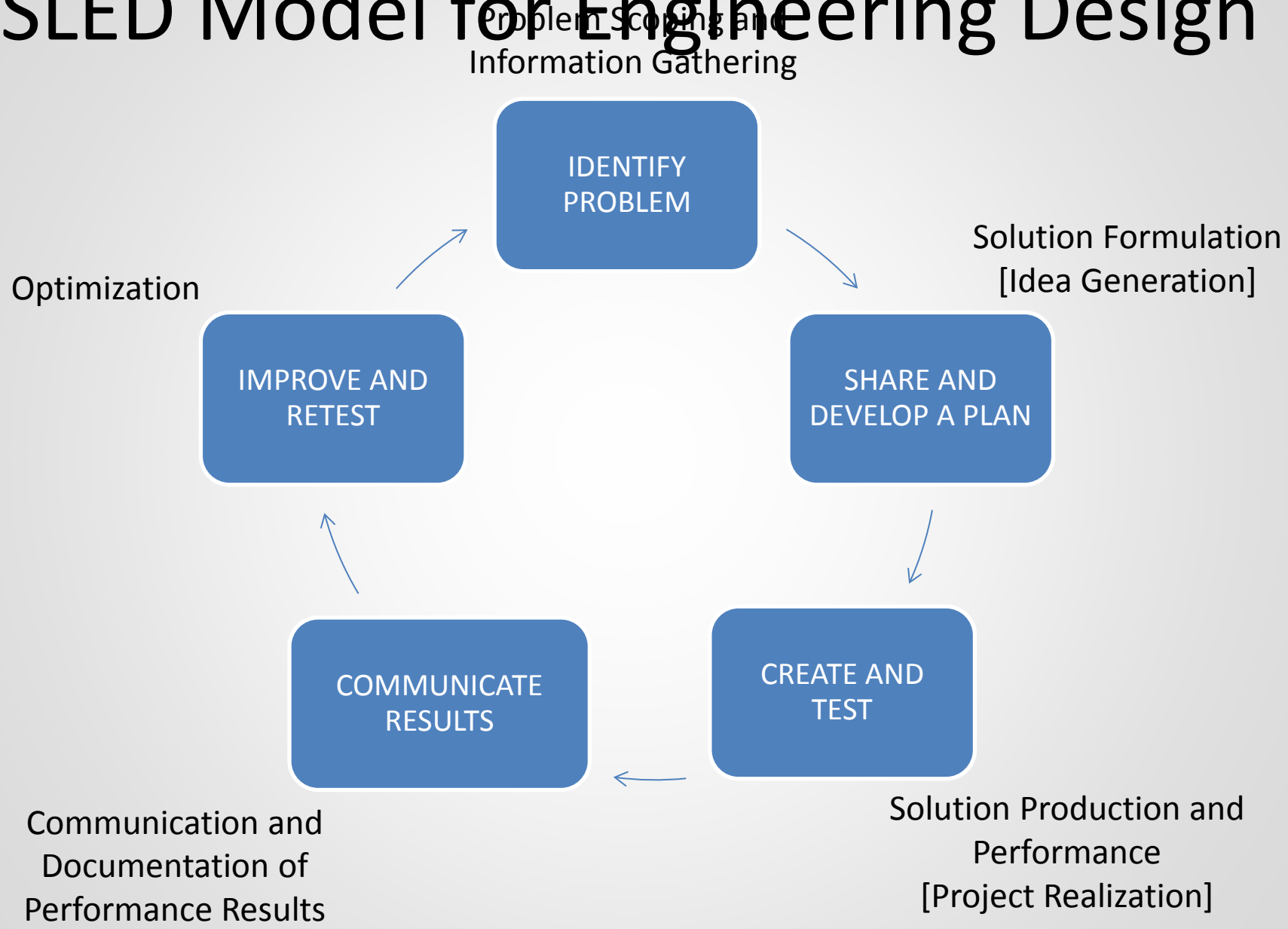
SLED Design Teams

- Design teams, consisting of STEM faculty and a classroom teacher, develop standards- and design-based curricular materials that use engineering design activities to anchor students' learning of science
- Shared understanding of the instructional and curricular problems, mutual interest in innovation, and collective creation of shared instructional products (Morris & Hiebert, 2011)

SLED Activity Creation Cycle



SLED Model for Engineering Design



Essential Features of Design Briefs

1. Is client-driven and goal-oriented
2. Provides an authentic context
3. Includes constraints
4. Use of materials, tools, and equipment that are familiar to students
5. Yields a product that is either an artifact (prototype) or process
6. Yields multiple solutions
7. Requires team work

(Capobianco, Nyquist, and Tyrie, 2013)

Examples of SLED Design Tasks

Task	Grade	Concepts
Drink Holder	3	Light absorption, light energy
Musical Instrument	3	Sound waves, loudness and pitch
Slow Boat	4	Drag force, forces affecting motion
Door Alarm	4	Electrical circuits
Are you UV safe?	5	Introduction to engineering design
Compost Column	5	Decomposition
Prosthetic Limb	5	Movable joints, mass, volume, density
CO_2 Device	5	Properties of liquids and gases, mass
Yucky Water	6	Volume, water filtration
Solar Tracker	6	Four seasons, direct and indirect rays

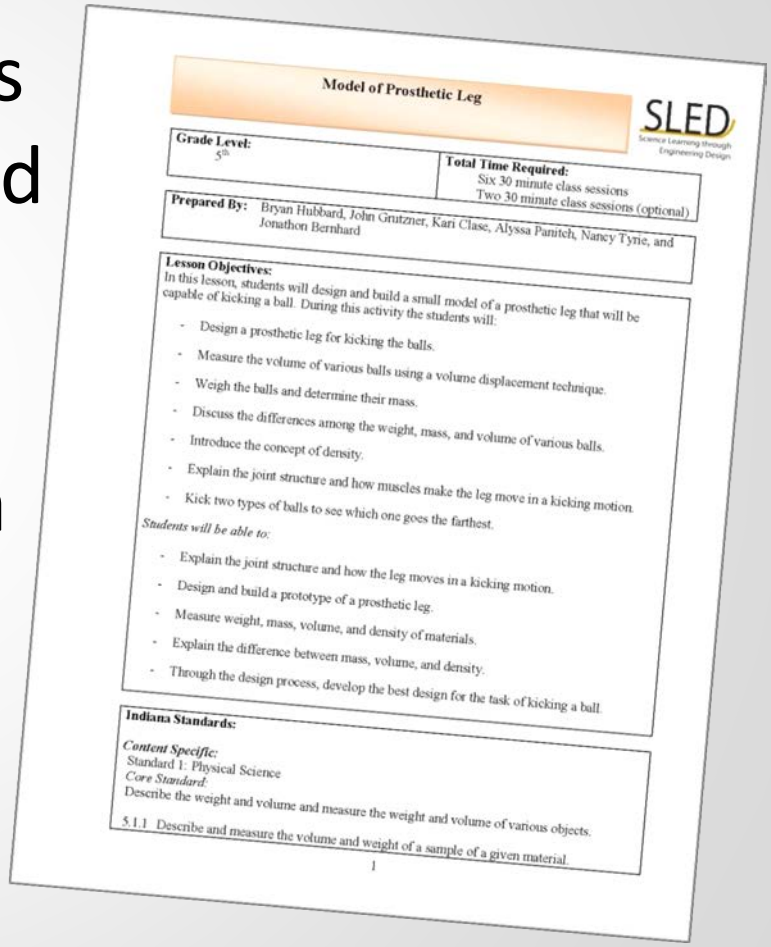
Example of a SLED Design Task: *Prosthetic Limb*

Boiler BioTech, a company in Warsaw, Indiana, needs assistance in designing a prosthetic leg for a young child so he/she can kick a soccer ball. Your team is responsible for designing and testing a prototype of a prosthetic leg that mimics the same movement of a hinge joint.

See sledhub.org for more examples.

Prosthetic Limb Task

- Addresses science standards related to mass, volume, and density as well as the movement of joints.
- Addresses a specific Indiana engineering standard to design a prototype that replaces the function of a body part.



Model of Prosthetic Leg

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Grade Level: 5th

Total Time Required:
Six 30 minute class sessions
Two 30 minute class sessions (optional)

Prepared By: Bryan Hubbard, John Grutzner, Kari Clase, Alyssa Panitch, Nancy Tyrie, and Jonathon Bernhard

Lesson Objectives:
In this lesson, students will design and build a small model of a prosthetic leg that will be capable of kicking a ball. During this activity the students will:

- Design a prosthetic leg for kicking the balls.
- Measure the volume of various balls using a volume displacement technique.
- Weigh the balls and determine their mass.
- Discuss the differences among the weight, mass, and volume of various balls.
- Introduce the concept of density.
- Explain the joint structure and how muscles make the leg move in a kicking motion.
- Kick two types of balls to see which one goes the farthest.

Students will be able to:

- Explain the joint structure and how the leg moves in a kicking motion.
- Design and build a prototype of a prosthetic leg.
- Measure weight, mass, volume, and density of materials.
- Explain the difference between mass, volume, and density.
- Through the design process, develop the best design for the task of kicking a ball.

Indiana Standards:

Content Specific:
Standard 1: Physical Science
Core Standard:
Describe the weight and volume and measure the weight and volume of various objects.

5.1.1 Describe and measure the volume and weight of a sample of a given material.

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Component:
In-Service Teacher Professional Development

In-Service Teacher Professional Development

- Teacher professional development is anchored by a two-week summer institute designed to introduce teachers to engineering design as a way to teach science.
- Teachers work with design teams and test design tasks, visit a community partner to engineering in action, develop skills through mini-workshops, map curriculum, and develop personal lesson implementation plans.

In-Service Teacher Professional Development

- Follow-up activities during the school year include progress reports and reflection sessions.
- Online activities on content and pedagogy are available via the project's electronic hub (sledhub.org).

Component: Pre-Service Teacher Preparation

Pre-Service Teacher Component

Selected pre-service teachers:

- Participate in the SLED summer institute
- Enroll in EDCI 36500 *Teaching Science through Engineering Design in the Elementary School*
- Are paired with SLED in-service teachers to co-develop, implement, and assess their implementations of SLED task during an 8 week field experience

Course Activities/Assignments

- Engage in engineering design- and inquiry-based tasks
- Maintain an engineering design notebook (i.e., evidence design/inquiry work; reflections; sketches)
- Conduct a learner profile (i.e., children's conceptions of scientists, engineers, and abilities to solve problems)
- Develop assessment plans
- Develop and implement lesson plans that integrate STEM
- Field experience (8 weeks of co-teaching in STEM classroom)

SLED Research

Partnership Development

- Support implementation
- Promote sustainability
- Impact on all partners, including STEM faculty

Teacher Learning

- Implementation
- Effectiveness
- Challenges

Student Learning

- Children's conceptualizations
- New science content knowledge
- Transfer of learning

Lessons Learned

- **Partnership**
  - Shared vision and the development of a common understanding of engineering design have been critically important to project success
- **In-service teachers**
  - Have embraced design as a classroom pedagogy
  - Demonstrate shifts from first-order to second-order barriers as they gain experience with design

Lessons Learned

- **Pre-service teachers**
  - Have developed expertise in engineering design for teaching science that has translated into success in acquiring teaching positions
- **Students**
  - Have shown clear gains in their knowledge of engineering design
  - Have shown achievement gains as a result of participation in SLED design activities

For more information

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- Or visit sledhub.org

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