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Turn the Lights On! Part II: An Online Professional Development Aid for Teaching an Engineering Design-Based Curriculum in 8th Grade (Resource Exchange)

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Tamara J. Moore, Ph.D., is a Professor of Engineering Education, University Faculty Scholar, and the Executive Director of the INSPIRE Research Institute for Pre-College Engineering at Purdue University. Dr. Moore's research is centered on the integration of STEM concepts in K-12 and postsecondary classrooms in order to help students make connections among the STEM disciplines and achieve deep understanding. Her work focuses on defining STEM integration and investigating its power for student learning. She has examined different mechanisms of bringing engineering content and standards into the classrooms that led to a framework for quality K-12 engineering education. Dr. Moore's team has developed several sets of instructional modules for elementary and middle school learners that employ engineering and literacy contexts to integrate STEM and computational thinking content in meaningful and significant ways. In 2012, she received a U.S. Presidential Early Career Award for Scientists and Engineers (PECASE) for her work with urban youth. In 2016, she received Purdue University's Faculty Engagement Scholarship Award for working with teachers and students across the United States on teaching and learning engineering.

Maeve Drummond Oakes (Assistant Director for Education)

Maeve Drummond Oakes is the Associate Director of Education for the NSF Engineering Research Center, CISTAR. She has extensive experience in academic program management at Purdue University, successfully leading programs at undergraduate and graduate education in the School of Civil of Engineering. In Biomedical Engineering she led the creation of new experiential activities for students with industry and through study abroad. As the university coordinator for the Purdue EPICS program she was responsible for the development of a consortium of more than 40 universities, globally. At CISTAR she oversees all of the programming for CISTAR's engineering workforce development pillar.

Allison Godwin (Associate Professor)

Allison Godwin, Ph.D. is an Associate Professor of Engineering Education and of Chemical Engineering at Purdue University. She is also the Engineering Workforce Development Director for CISTAR, the Center for Innovative and Strategic Transformation of Alkane Resources, a National Science Foundation Engineering Research Center. Her research focuses on how identity, among other affective factors, influences diverse students to choose engineering and persist in engineering. She also studies how different experiences within the practice and culture of engineering foster or hinder belonging and identity development. Dr. Godwin graduated from Clemson University with a B.S. in Chemical Engineering and Ph.D. in Engineering and Science Education. Her research earned her a National Science Foundation CAREER Award focused on characterizing latent diversity, which includes diverse attitudes, mindsets, and approaches to learning to understand engineering students' identity development.

Turn the Lights On!

Part II

An Online Professional Development Aid for Teaching an Engineering Design-Based Curriculum in 8th Grade (Resource Exchange)

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Maeve Drummond Oakes, Allison Godwin

Turn the Lights On! is a project in partnership between EngrTEAMS and CISTAR NSF Engineering Research Center (see below for more information) that aims to teach 8th graders about renewable energy resources and sustainability through an engineering design-based STEM integration unit. The project includes the engineering design-based curriculum (Part I) and online professional development aid for teachers interested in implementing this curriculum (Part II).

nanoHUB experience

The course houses all the PD resources which describe the content, pedagogy, and activities in the curriculum.

Videos

The videos introduce teachers to the STEM content in the context of the engineering problem. These video lectures also have tips for customizing the curriculum based on students' needs. Activity videos are included separately, to demonstrate how to perform the experiments or implement the mathematic activities.

Additional resources

The platform offers additional resources such as a quick start guide for those with more extensive experience in integrated STEM teaching, worksheets including answers, a discussion board, and external links that support their learning experience.

The Center for the Innovative and Strategic Transformation of Alkane Resources (CISTAR) is a National Science Foundation (NSF) Engineering Research Center (ERC) focused on shale resources as a bridge to renewable energy. CISTAR Pre-College Education objectives are to stimulate interest in engineering careers at the middle and high school levels and to strengthen pathways to promote the participation of underrepresented students in STEM careers.

EngrTEAMS is a project designed to help teachers develop engineering design-based curricular units for each of the major science topic areas within the Next Generation Science Standards, as well as data analysis and measurement standards for grades 4-8.

To access the PD on nanoHUB you can scan the QR code above or use the following link: https://nanohub.org/courses/CISTAR

The PD includes

- Turn the Lights On! Curriculum
- A quick start guide
- Lesson overview videos
- Activity videos
- PowerPoint presentations from the videos for references and note taking
- Printable worksheets from the curriculum
- Discussion boards for interaction

CISTAR
NSF Engineering Research Center
Center for Innovative and Strategic Transformation of Alkane Resources

EngrTEAMS

Part II

Turn the Lights On!

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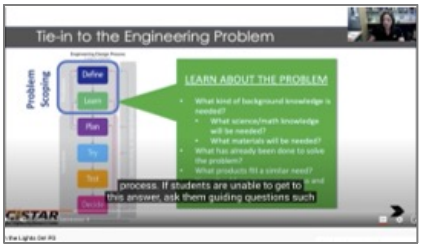
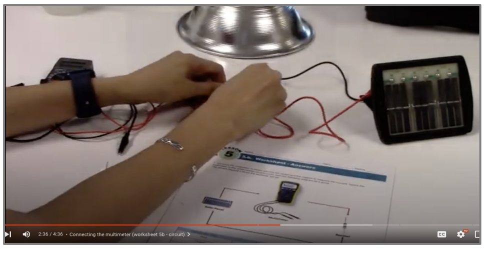
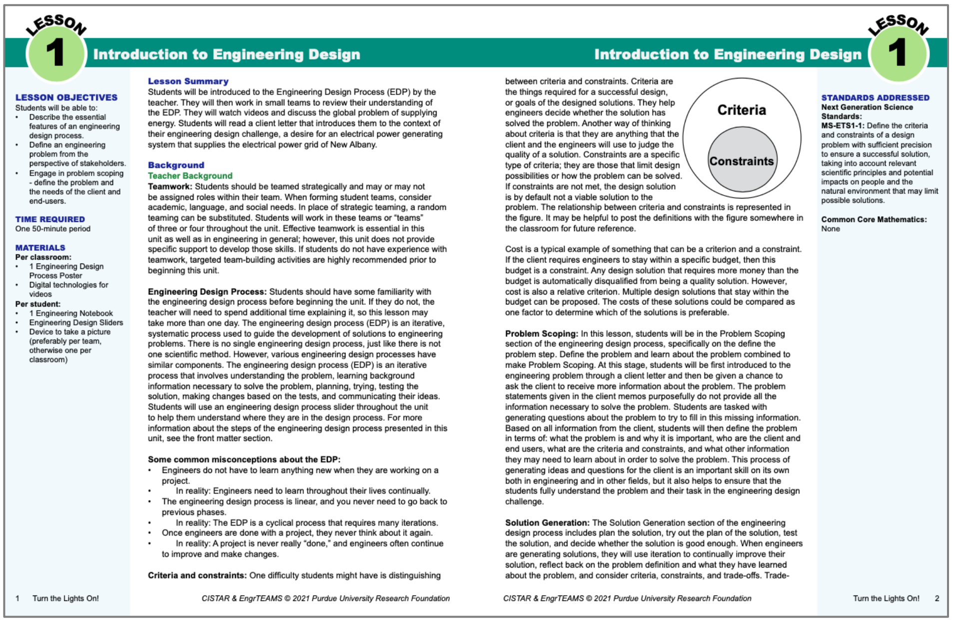
The Turn the Lights On! curriculum has nine lessons, and each lesson includes guidelines for the teacher. These guidelines are composed of (1) lesson objectives, (2) time required, (3) the resources needed, and (4) the NGSS standards and Common Core Mathematics addressed. Additionally, we offer a lesson summary with background information on the specific topic covered in the lesson, specific vocabulary, information about the material, and educational resources that the teacher needs to prepare before the activity. We also provide a script for classroom instruction, guidance on how the teacher should conduct the activity, and how to wrap-up. We also added illustrations when necessary to clarify items discussed in the lesson. The online PD contains further information on how teachers should use these guidelines in the curriculum through videos for every lesson.



Video Lecture introducing teachers to the lesson content



Video activity demonstrating how to conduct an experiment



LESSON 1 — Introduction to Engineering Design

LESSON OBJECTIVES
Students will be able to:
- Describe the essential features of an engineering design process.
- Define an engineering problem from the perspective of stakeholders.
- Engage in problem scoping - define the problem and the needs of the client and end-users.

TIME REQUIRED
One 50-minute period

MATERIALS
Per classroom:
- 1 Engineering Design Process Poster
- Digital technologies for videos

Per student:
- 1 Engineering Notebook
- Engineering Design Sliders
- Device to take a picture (preferably per team, otherwise one per classroom)

Lesson Summary
Students will be introduced to the Engineering Design Process (EDP) by the teacher. They will then work in small teams to review their understanding of the EDP. They will watch videos and discuss the global problem of supplying energy. Students will read a client letter that introduces them to the context of their engineering design challenge, a desire for an electrical power generating system that supplies the electrical power grid of New Albany.

Background
Teacher Background
Teamwork: Students should be teamed strategically and may or may not be assigned roles within their team. When forming student teams, consider academic, language, and social needs. In place of strategic teaming, a random teaming can be substituted. Students will work in these teams or "teams" of three or four throughout the unit. Effective teamwork is essential in this unit as well as in engineering in general; however, this unit does not provide specific support to develop those skills. If students do not have experience with teamwork, targeted team-building activities are highly recommended prior to beginning this unit.

Engineering Design Process: Students should have some familiarity with the engineering design process before beginning the unit. If they do not, the teacher will need to spend additional time explaining it, so this lesson may take more than one day. The engineering design process (EDP) is an iterative, systematic process used to guide the development of solutions to engineering problems. There is no single engineering design process, just like there is not one scientific method. However, various engineering design processes have similar components. The engineering design process (EDP) is an iterative process that involves understanding the problem, learning background information necessary to solve the problem, planning, trying, testing the solution, making changes based on the tests, and communicating their ideas. Students will use an engineering design process slider throughout the unit to help them understand where they are in the design process. For more information about the steps of the engineering design process presented in this unit, see the front matter section.

Some common misconceptions about the EDP:
- Engineers do not have to learn anything new when they are working on a project.
- In reality: Engineers need to learn throughout their lives continually.
- The engineering design process is linear, and you never need to go back to previous phases.
- In reality: The EDP is a cyclical process that requires many iterations.
- Once engineers are done with a project, they never think about it again.
- In reality: A project is never really "done," and engineers often continue to improve and make changes.

Criteria and constraints: One difficulty students might have is distinguishing between criteria and constraints. Criteria are the things required for a successful design, or goals of the designed solutions. They help engineers decide whether the solution has solved the problem. Another way of thinking about criteria is that they are anything that the client and the engineers will use to judge the quality of a solution. Constraints are a specific type of criteria; they are those that limit design possibilities or how the problem can be solved. If constraints are not met, the design solution is by default not a viable solution to the problem. The relationship between criteria and constraints is represented in the figure. It may be helpful to post the definitions with the figure somewhere in the classroom for future reference.

Criteria
Constraints

Cost is a typical example of something that can be a criterion and a constraint. If the client requires engineers to stay within a specific budget, then this budget is a constraint. Any design solution that requires more money than the budget is automatically disqualified from being a quality solution. However, cost is also a relative criterion. Multiple design solutions that stay within the budget can be proposed. The costs of these solutions could be compared as one factor to determine which of the solutions is preferable.

Problem Scoping: In this lesson, students will be in the Problem Scoping section of the engineering design process, specifically on the define the problem step. Define the problem and learn about the problem combined to make Problem Scoping. At this stage, students will be first introduced to the engineering problem through a client letter and then be given a chance to ask the client to receive more information about the problem. The problem statements given in the client memos purposefully do not provide all the information necessary to solve the problem. Students are tasked with generating questions about the problem to try to fill in this missing information. Based on all information from the client, students will then define the problem in terms of: what the problem is and why it is important, who are the client and end users, what are the criteria and constraints, and what other information they may need to learn about in order to solve the problem. This process of generating ideas and questions for the client is an important skill on its own both in engineering and in other fields, but it also helps to ensure that the students fully understand the problem and their task in the engineering design challenge.

Solution Generation: The Solution Generation section of the engineering design process includes plan the solution, try out the plan of the solution, test the solution, and decide whether the solution is good enough. When engineers are generating solutions, they will use iteration to continually improve their solution, reflect back on the problem definition and what they have learned about the problem, and consider criteria, constraints, and trade-offs. Trade-

STANDARDS ADDRESSED
Next Generation Science Standards:
MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Common Core Mathematics:
None

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An example of lesson in the curriculum