

Cost-Effective Solar Cells

Lesson #14: Unique Solar Cell Engineering Report

AUTHOR

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DESCRIPTION

This lesson is designed to be completed in three 80-minute sections. The teacher will have students write their engineering reports with the following sections: Introduction (taken from Lesson #10), Design (incorporating the model from Lesson #10), Methods, Results, and Discussion. The teacher has students design research posters for a hallway display or a poster session, using the engineering report and photos taken throughout the unique solar cell construction and testing.

- Day 1: Engineering Report #1 (Introduction, Design, and Methods)
- Day 2: Engineering Report #2 (Results and Discussion)
- Day 3: Engineering Report #3 (Citations, Acknowledgments, and Poster Formatting)

GRADE LEVEL(S)

9, 10, 11, or 12

SUBJECT AREA(S)

Chemistry, Physics, Solar Panels, Solar Cells, Power, Current, Voltage, Electricity Generation

ACTIVITY LENGTH

3 days X 80 minutes

LEARNING GOAL(S)

1. Students will format solar cell data into tables and graphs
2. Students will draw conclusions based on testing data
3. Students will construct an engineering report in a research poster format

CONTENT BACKGROUND

STUDENT BACKGROUND

- Students participating in this lesson should be familiar with the following scientific practices and concepts:
 - Background research
 - Defining problems – criteria, constraints, and solar cell concepts
 - Planning and Carrying Out Investigations
 - Design Solutions
 - Constructing Data Tables and Graphs
 - Drawing Conclusions
 - Discussing Validity and Reliability
 - Communicating Scientific Information

EDUCATOR BACKGROUND

- Research Posters are very common in academic settings and are frequently displayed at science conferences and workshops. The ideal poster should communicate the researcher's results in 300-800 words, accompanied by effective data tables, graphs, models and photographs. The researcher typically stands by the poster on display, giving short presentations and answering questions for other researchers.

MATERIALS NEEDED

HANDOUTS/PAPER MATERIALS

- Sample Engineering Posters (1 large copy per class or as a handout)

CLASSROOM SUPPLIES

- Large poster paper, trifolds, and/or poster printer

ACTIVITY SUPPLIES (PER GROUP OF 3-4 STUDENTS)

- N/A

LESSON PROGRESSION

PLANNING AND PREP

Students have spent time developing writing around the Introduction, Design, Materials, and Procedure sections of an engineering report. As the project closes, the students are finishing their data tables, graphs, and discussion of results. The teacher can plan on assessing 1) a full engineering report, 2) a research poster, or 3) both. Both products have similar attributes, but focus on different audiences. The 3-day lesson that is described below assumes that the students will be completing both products.

If you are preparing the students for a full engineering report, have the students organize the report with the following sections:

1. Introduction or Background
2. Design and Models
3. Methods (Materials and Procedures)
4. Results (Data Tables and Graphs)
5. Discussion (Conclusions and Comments on Validity)
6. Citations

If you are preparing the students for a research poster, have them prepare the following:

- Design models
- Photographs of the experiment
- Data tables
- Graphs
- Criteria and Constraints
- Brief Introduction section
- Brief Design section
- Summary of Methods
- Brief Conclusions
- Citations

LESSON SEQUENCE

Day 1 Procedure:

1. **(5 minutes)**. Have the students load up their saved copies of the Introduction, Design, and Methods sections. In today's lesson, the students will be re-writing and condensing these sections for a research poster. They should be saving copies of their original, full writing and working on condensed versions in this lesson.
2. **(20-25 minutes)**. Have the students reduce their Introduction down to the most important elements. They should be aiming for 75-150 words in this section. Criteria and constraints should be shortened and bullet-pointed if they are not already.
3. **(25-35 minutes)**. The students need to condense their design section down to describe their initial design (with accompanying design model graphic) and their later designs and re-designs. If the students had many re-designs during the project, they should focus on the later or final designs. The written portion of this section should be 100-250 words.
4. **(10-30 minutes)**. The students will need to re-format their Materials and Procedures into a shorter summary of the methods. Students can include a bullet-point materials list if it is a shorter list. The numbered step-by-step procedure needs to be summarized down into a few sentences describing the general techniques. The written portion of this section should be 75-125 words.

Day 2 Procedures:

1. **(30-40 minutes).** Using Microsoft Excel, Google Sheets, or similar apps, guide the students through the construction of a data table for their results. From that data, have students generate appropriate graphs. The data tables and graphs should have the following attributes:
 - **Appropriate Title**
 - **Rows and Columns (X and Y axes) are labeled, with units**
 - **Summary data and/or calculations are included**
 - **Appropriate Graph Types are chosen**
 - **Intervals and Scale on the graph are appropriate**
 - **Key, Legend, or description of mathematical operations are included if necessary**
2. **(30-35 minutes).** The students should be writing a Discussion section. Encourage the students to write a full discussion with the following attributes:
 - **Conclusions**
 - i. **Did the design solution(s) meet the criteria and constraints defined in the Introduction (CLAIM).**
 - ii. **Use data from the solar cells to support the claim above (EVIDENCE).**
 - iii. **Explain how the data is consistent with the claim and how it reflects the science concepts behind solar cells (REASONING).**
 - **Comments on Validity**
 - i. **Include comments on how well your model represented a real-world solution.**
 - ii. **What did you do to ensure validity and reliability in your procedure?**
 - iii. **What did you do to ensure validity and reliability in your testing of the cell?**
 - iv. **What errors may have or did occur during the investigation?**
 - v. **What changes would you make in future solar cells?**
3. **(5-10 minutes).** Have the students save their longer versions of the Discussion. Then, have them condense down their writing into a shorter version for the research poster. This section should be 50 – 200 words in length.

Day 3 Procedures:

1. **(5-10 minutes).** Have the students brainstorm any people (teachers, peers, volunteers, guest speakers, etc.) or organizations that they worked with on the project. The students should acknowledge these entities in a list that prioritizes the people or organizations that helped out the most on the project. List them in order of most helpful first.
2. **(10-15 minutes).** Have the students format any sources and references into a “Citations,” “Works Cited,” or “Bibliography” section. Students should include all sources from the longer version of their engineering reports in APA format. Apps such as EasyBib or Citations Manager can assist in this process.
3. **(55-65 minutes).** Have the students begin assembling their poster layouts in Microsoft PowerPoint, Publisher, Google Slides, Adobe Illustrator, or any Multimedia presentation software. The research poster dimensions are typically 36” x 48” in a landscape format. The following attributes should be included:
 - Design models
 - Photographs of the experiment
 - Data tables
 - Graphs
 - Criteria and Constraints
 - Brief Introduction section
 - Brief Design section

LESSON PLAN

- Summary of Methods
- Brief Conclusions
- Citations

Resources for Research Posters can be found here:

- Designs, Examples, PowerPoint Templates and Presentation Tips: <https://www.craftofscientificposters.com/>
- UMBC Undergraduate Poster Examples: <https://ur.umbc.edu/poster-presentation-examples/>
- Google Slides and PowerPoint Creative Commons Templates: <https://www.free-power-point-templates.com/presentation-poster-templates/>

Student sample posters can be found here:

- Poster #1: <https://drive.google.com/file/d/1vi15tuKKO7LYX0OU3K9kcF0lCehfQAYN/view?usp=sharing>
- Poster #2: <https://drive.google.com/file/d/1QtIhAC-QmxTdMzu8VqM4-ULMnYaoGuhH/view?usp=sharing>
- Poster #3: <https://drive.google.com/file/d/1WbVMYOKSkSxuww87m3RObeMajPlvFwdF/view?usp=sharing>

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENT

N/A

SUMMATIVE ASSESSMENT

As the final part of the unit, the engineering report and/or design poster serve as the key summative assessment for the entire unit, especially lessons 10-14. IN their reports and presentations, students should be able to demonstrate understanding of the following concepts:

- Electricity basics: current, voltage, conductance, circuits
- The photovoltaic effect, as understood at a molecular level
- Engineering design, including proper documentation of problem definition, materials, procedures, and results representation and analysis
- Proper laboratory procedures
- Real-life implications of solar PV technologies

Students will be assessed on the following standards while developing their engineering reports and posters.

- NGSS SEP1
Defining Problems
- NGSS SEP3
Planning and Carrying Out Investigations

LESSON PLAN

- NGSS SEP6
Design Solutions
- NGSS HS-PS2-6:
Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed material
- NGSS HS-PS3-3:
Design, build, and refine a device that works within given constraints to convert one form of energy into another.
- NGSS SEP4
Analyzing and Interpreting Data
- NGSS SEP5
Using Mathematics and Computational Thinking
- NGSS SEP7
Engaging in Argument from Evidence
- NGSS SEP8
Obtaining, Evaluating, and Communicating Scientific Information
 - “Obtaining”: Use of sources, in-text citations, and bibliography
 - “Evaluating”: Incorporation of sources, Comments on Validity
 - “Communicating”: Engineering Report and/or Research Poster

LESSON EXTENSIONS

A public demonstration of learning is recommended for students to showcase their hard work. This can be set up within the school or in a public setting as a poster session. Have students display their research posters and explain their work to guests who walk by. Students can prepare for the presentations by developing the following:

- A 30 second summary of the project that ends with, “Would you like to hear more about my project?”
- A 3-5 minute detailed talk on the project
- Answers to common questions. Have the students ask each other questions about the project during a dress rehearsal in-class before the formal presentation.