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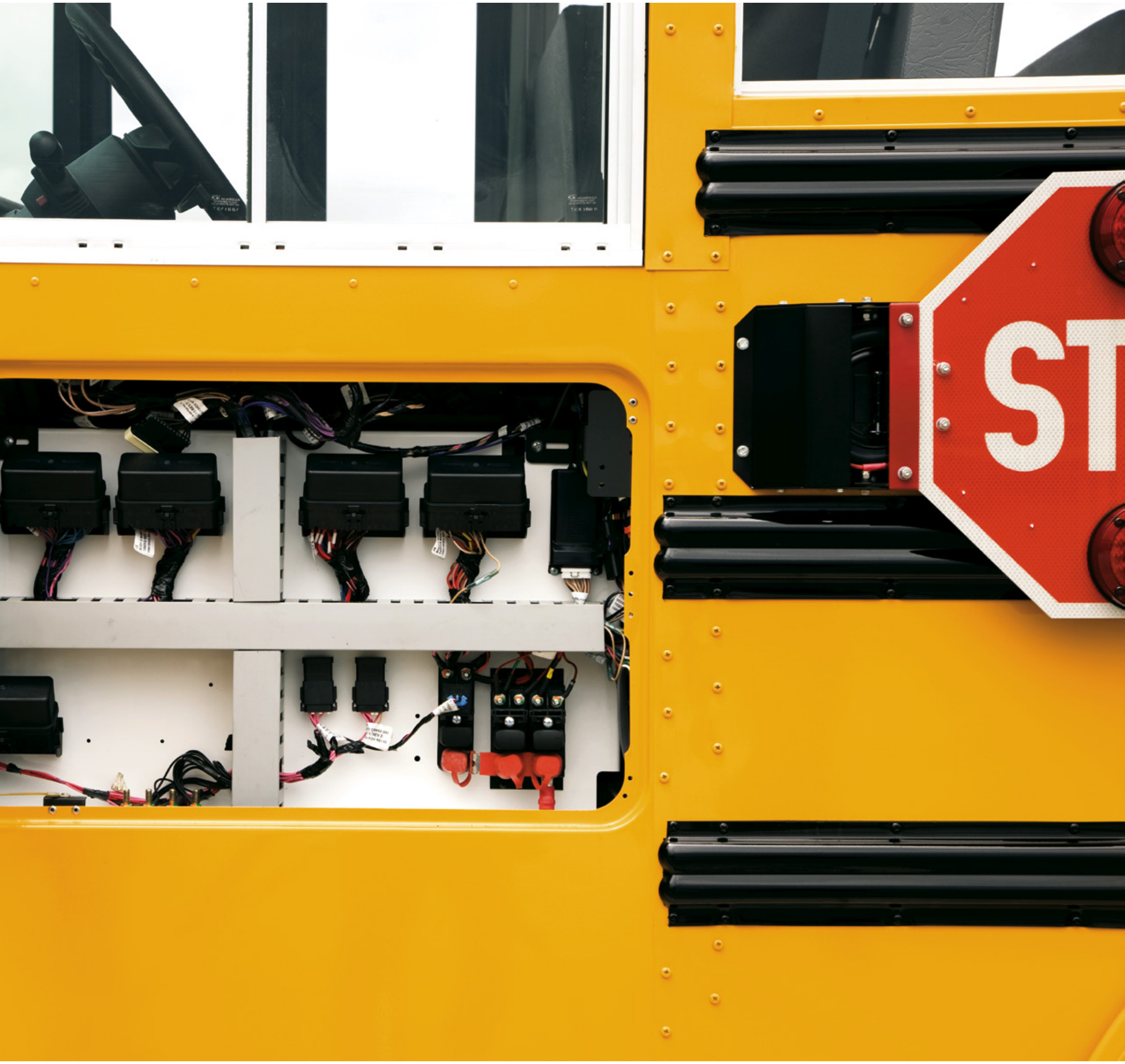

5-E CLASSROOM STEM ACTIVITY:
THE SCHOOL BUS OF THE FUTURE!

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BUILD A BETTER SCHOOL BUS

DESIGNING CARS IS FUN, BUT MAKING THAT SCHOOL BUS YOU'RE RIDING ON BETTER AND SAFER IS IMPACTFUL.

BY MIA DEANGELIS

TED WERNER USES HIS ENGINEERING DEGREE TO DESIGN SCHOOL BUSES.

It's 7 a.m. on a Monday. You're probably on a school bus or waiting for one. Eventually, you're on your way to another day of geometry, calculus, etc. You may start to think, who needs these classes? Do I really need to know how to calculate angles or the circumference of a circle?

But maybe you sit back and your mind begins to wander, and you take notice of that bus you're riding on. You ask yourself, who created this bus? Is it safe? How do we know it's safe? Who said it is? Is that somebody's job to say it's safe? Who even has a job making school buses?

Well, Ted Werner does. And so does David Harris. Werner and Harris are both engineers for Thomas Built Buses, which is a division of Daimler. Yes, that's the same company that makes those sweet Mercedes cars and trucks. The engineers at Thomas have a pretty awesome job themselves: making your "big yellow taxi" come to life!

Harris is a mechatronics engineer. He makes sure all of the integrated electronics on new buses work together. Werner is a mechanical engineer, also known as a design engineer.

Werner got his job when he was still fresh out of college. He graduated with a mechanical engineering degree from North Carolina State in December 2012, and two weeks later started his employment with Thomas. "I've known I wanted to be an engineer since fourth grade," he explains. "I've always been into design, whether it's been playing with LEGOs and going off script, building whatever came to mind."

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Now he gets to design school buses

every day, loving the work he does. In today's world, designing buses is a pretty high-tech business. "It's pretty cool getting to see something that you designed on a computer in real life all over the United States," Werner says.

Werner and Harris spend their days making their designs come to life with 3D CAD modeling. But don't think they are sitting in front of a computer all day! It is a balance of on-the-floor and computer work that makes this job more hands-on than what many think of engineering jobs.

And for a young engineer, Werner notes that this is no ordinary job, "especially for someone like me coming right out of college; it's unusual to have a job where they allow me freedom to design something and have it built and put on a bus," he says. "I think that's just awesome that you can say you designed it and see it roll down the road with kids on it."

After talking with Werner, we asked Harris what he enjoys most about his job, and he said he likes the collaboration he can have with his co-workers. Harris always works to "better his product." "You're able to be creative in your own way and look at new ways to do things," he says.

And if you're still wondering about how safe your bus is, these guys got you covered. The difference between designing school buses and designing cars is that each group of buses in each state is subject to different regulations. "We're basically building a customized bus every time," Werner points out. Harris adds, "There is a more robust structure. These buses feature padding, more joint strength, and a steel structure."

Automotive engineering, in general, is an exciting field, especially for those who are into building things. But to get there, you're going to need an engineering degree, something which Werner says sounds more intimidating than it is. "Pursuing engineering is worth it in the end," he says. "If you have any interest in engineering, don't let course work get in your way. A lot of my friends looked at my engineering classes and thought, 'that's tough.' It is hard, but it leads to a lot of rewards."

Harris points out that automotive engineering-based companies such as Daimler and Thomas offer a lot of opportunities for young engineers in many other fields as well. "All over the country, anything you want to do, you can do it here."

So next time you're sitting on the bus and dreading your next calculus exam, imagine yourself fresh out of college, building buses, doing what you love, with STEM.

DAVID HARRIS IS A MECHATRONICS ENGINEER AT THOMAS BUILT BUSES.

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Here are some ideas for how teachers of grades 9-10 could use this story as a launching point for integrated STEM learning. Our activities follow the 5-E Learning Cycle Model, and the activity below is intended to last two to three 1-hour class periods (although portions of the activity could be used in shorter time periods).

Part 1: Engage

Have your students read the article on page 36, and then pose the following questions:

1. What do you think are some important considerations and tradeoffs when engineers design school buses? (e.g., safety, fuel efficiency, durability, cost, noise, seating capacity – write these on the board)
2. What different school bus designs have you seen?
3. How do the designs of school buses differ from the designs of other transit or city buses? Why do you think there are these differences?
4. What skills and resources do you think an engineer would need to design a new bus that would take into account all the different considerations?

Part 2: Explore

1. Discuss with students the three types of school buses that are being used - Type A, B, and C school buses – you can use *http://www.stnonline.com/faqs*
2. Pose the following problem to your students:

Working in groups of 3-4, design a sketch of your own "school bus of the future." The sketch(es) of your design can be orthographic projections, perspective drawings, and/or section views, and they should include the scale if appropriate and identification of any relevant materials. Use the internet to research important considerations to be taken account when designing your bus, using the list the class generated as a starting point. You should not cover all of these considerations, but your design should cover at least 1-2 well. You may want to research scientific information like force, drag, velocity, strength, weight, and emissions, and mathematical information like efficiency ratios, material and maintenance costs, etc. Remember that engineers use an engineering design cycle where they first understand the problem and the goals, then brainstorm different designs, and then select a design and make a plan.

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Part 3: Explain

Each student group should present their final design sketch to the class, making sure they discuss the scientific/mathematical principles they incorporated into their design based on their research. They should also discuss their process to arrive at the design – how their group worked together, decided on an idea, and revised and improved their initial plans. As student groups present, they should pose questions to each other about the priorities and trade-offs inherent in each design, and the teacher should especially highlight considerations related to fuel efficiency and aerodynamics, as this will be the next topic discussed.

Part 4: Elaborate

(Refresh your own memory by reading: http://auto.howstuffworks.com/fuel-efficiency/fuel-economy/aerodynamics.htm)

1. Pose the following questions to the class:
   - **a.** One consideration when designing a school bus was fuel economy. What factors make a bus more or less fuel efficient? (e.g., the weight, the speed it travels at, its shape and how aerodynamic it is)
   - **b.** What characteristics of the shape of a vehicle makes it more or less aerodynamic? (curved/ streamlined without sharp edges, fastback "tail" on rear, front/rear spoilers, roof rack/side mirrors slow down)
   - **c.** How did the buses your groups designed take into account aerodynamics? Do you think current school buses designed with aerodynamics in mind? Why or why not? What is "drag" and what does a vehicle's "drag coefficient" mean? How is drag calculated? (students may need time to research these ideas)
2. Pose the following problem to your students:

Working in groups of 3-4, investigate the formula for the drag force that an object experiences when moving through a fluid. Recall the equation for drag force (FD) is:

FD = (1/2)(pv2CDA)

Where p is the density of the fluid (for objects moving through air, this is 1.2 kg/m3) and v is the velocity the object is moving at. CD is the drag coefficient, which for a school bus is approximately 0.55, and A is the frontal area of the object, which for a school bus is about 85 ft2. Create a visual that shows how the drag force changes for different velocities, and write at least 4 observations about how the variables in the above equation are related to each other and what this means for the fuel efficiency of the bus.

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Part 5: Evaluate

1. Show the class the following video of middle school student Jonny Cohen's "Green Shield" invention to improve the fuel efficiency of school buses: *http://abcnews.go.com/GMA/video/green-shield-fuel-efficient-school-buses-10434183*
2. Students respond to the following prompt individually in their math/science journals: How do you think the values in the equation for drag force would change once the green shield is put on the bus? What do you think are the important engineering tradeoffs to consider when evaluating Jonny's design?
3. Students can also solve additional problems based on the quantitative information given about the "Green Shield" in this article: *http://knowledge.allianz.com/mobility/transportation_safety/?2064/How-one-schoolboy-could-cut-18m-tons-of-CO2*

Standards:

Next Generation Science Standards

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

(Depending on which considerations groups decide to focus on, this activity could also involve: HS-PS2-3, HS-PS2-6, HS-ESS3-2, HS-ESS3-4)

Common Core State Standards – Mathematics

CCSS.Math.Content.HSA.SSE.A.1. Interpret expressions that represent a quantity in terms of its context.

CCSS.Math.Content.HSF.IF.C.7. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

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