sustainable development and elementary STEM in Japan and the United States

The safety and continuance of our planet is at risk, and it is the students who will live with what is being done today.

Introduction
Sustainable development is “development that meets present needs without compromising the ability of future generations to meet their own needs” (UNESCO, 2009, p. 5). The United Nations Educational, Scientific and Cultural Organization (UNESCO) Associated Schools Project Network was formed in 1953 and has focused on improving the education of children to be global citizens by scaling and disseminating “new educational practices that reinforce the humanistic, ethical and international dimensions of education” (UNESCO, 2009, p. 7). Some of these practices have focused on overpopulation, desertification, indigenous people, HIV and AIDS prevention, and global communication. In 2005, the United Nations Decade of Education for Sustainable Development 2005-2014 was declared, and the UNESCO Associated Schools Project Network began developing and sharing curriculum ideas about teaching sustainable development in schools worldwide. In 2015, the Sustainable Development Goals 2030 (Figure 1) were released and included seventeen fundamental goals (UNESCO, 2018). How are elementary schools in the United States and Japan meeting these goals? How is this being taught in K-6 STEM Centers? The purpose of this article is to introduce sustainable development education and provide guidance to elementary STEM teachers on ways to implement lesson plans in different countries.

Good Practices in Education for Sustainable Development
Anderson and Strecker (2012) state that “the education sector has a critical role to play in imparting the

by
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knowledge and skills that lead to behavior change (and) enable individuals and communities to make informed decisions and take action for climate compatible (and) sustainable development.” (p. 5). The Executive Summary in the Good Practices in Education for Sustainable Development (UNESCO, 2009) lists six factors that contribute to effective sustainable development education. They are:

1. Identifying common denominators for Education for Sustainable Development.
2. Assuming responsibility for contributing to sustainability.
3. Making education more relevant and more meaningful to strengthen the link between school and society.
4. Building partnerships in support of sustainable development.
5. Developing capacity-building both inside and outside the classroom.
6. Improving the teaching/learning process.

In addition to these executive summary statements, education for sustainable development should be locally relevant, stimulate critical thinking, and include use of problem-solving techniques.


<table>
<thead>
<tr>
<th>STL #</th>
<th>Benchmarks 2000/2002/2007 Standards for Technological Literacy</th>
<th>STEL #</th>
<th>Benchmarks 2020 Standards for Technological and Engineering Literacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>STL 1E</td>
<td>Creative thinking and economic and cultural influences shape technological development.</td>
<td>STEL 1I</td>
<td>Explain how solutions to problems are shaped by economic and cultural influences.</td>
</tr>
<tr>
<td>STL 4B</td>
<td>When using technology, results can be good or bad.</td>
<td>STEL 4B</td>
<td>Illustrate helpful and harmful effects of technology.</td>
</tr>
<tr>
<td>STL 4C</td>
<td>The use of technology can have unintended consequences.</td>
<td>STEL 4D</td>
<td>Select ways to reduce, reuse, and recycle resources in daily life.</td>
</tr>
<tr>
<td>STL 5A</td>
<td>Some materials can be reused and/or recycled.</td>
<td>STEL 4H</td>
<td>Classify resources used to create technologies as either renewable or nonrenewable.</td>
</tr>
<tr>
<td>STL 5B</td>
<td>Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.</td>
<td>STEL 4I</td>
<td>Explain why responsible use of technology requires sustainable management of resources.</td>
</tr>
<tr>
<td>STL 5C</td>
<td>The use of technology affects the environment in good and bad ways.</td>
<td>STEL 5E</td>
<td>Explain how technologies are developed or adapted when individual or societal needs and wants change.</td>
</tr>
<tr>
<td>STL 8D</td>
<td>Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.</td>
<td>STEL 6B</td>
<td>Create representations of the tools people made, how they cultivated to provide food, made clothing, and built shelters to protect themselves.</td>
</tr>
<tr>
<td>STL 10D</td>
<td>Invention and innovation are creative ways to turn ideas into real things.</td>
<td>STEL 7E</td>
<td>Recognize there are different solutions to a design and that none are perfect.</td>
</tr>
<tr>
<td>STL 13B</td>
<td>Determine if human use of a product or system creates positive or negative results.</td>
<td>STEL 7K</td>
<td>Interpret how good design improves the human condition.</td>
</tr>
<tr>
<td>STL 13E</td>
<td>Examine the trade-offs of using a product or system and decide when it could be used.</td>
<td>STEL 8G</td>
<td>Examine information to assess the trade-offs of using a product or system.</td>
</tr>
<tr>
<td>STL 14F</td>
<td>Many tools and devices have been designed to help provide clues about health and to provide a safe environment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STL 15E</td>
<td>Most agricultural waste can be recycled.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STL 16B</td>
<td>Energy should not be wasted.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STL 19E</td>
<td>Manufacturing enterprises exist because of a consumption of goods.</td>
<td></td>
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</tr>
</tbody>
</table>
Sustainable Development in the United States

Only 51 schools in the U.S. are listed in the Associated Schools Project Network website. Most are private, not public schools. The U.S. Department of State announced in October 2017 that the U.S was withdrawing its membership in UNESCO in December 2018. While these two points may seem discouraging to advocates for sustainable development in the U.S., the work towards the Sustainable Development Goals 2030 goes on unimpeded by individual schools, principals, and teachers. This is because they see the value of sustainable development in the education of their students. Students benefit from being global citizens through a shared sense of belonging to the global community (UNESCO, 2016).

The beginnings of a national focus on sustainability started with the environmental movement in the 1960s in conjunction with the passing of the Clean Air Act of 1963 and Clean Water Act of 1972. This led to the creation at the national level of the Environmental Protection Agency, National Oceanic and Atmospheric Administration, and the National Science Foundation (Hopkins, 2013). Young people across the country demonstrated for a cleaner environment, and support remains strong among the population despite pressure from industries for relaxed environmental regulations. Environmental Studies became and is still a popular undergraduate degree at universities.

The National Council on Science and the Environment (NCSE, n.d.) and the University Leaders for a Sustainable Future (ULSF, n.d.) linked 600 partners and 50 collaborators through meetings, training workshops, events, and a website to advance Education for Sustainable Development in the U.S. The new focus was on unsustainable human activity in the areas of resources, overconsumption, biodiversity loss, climate change, water and air quality, and disaster risk reduction. The release of Next Generation Science Standards (NGSS Lead States, 2013) included multiple ESD-oriented standards on interdependence in ecosystems, biodiversity and humans, human impacts on earth systems, and global climate change.

Table 2. Glenallan STEM Academy Activities and Goals 2030.

<table>
<thead>
<tr>
<th>Goal #</th>
<th>UNESCO Goal</th>
<th>Glenallan Elementary STEM Academy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Poverty</td>
<td>School Energy &amp; Recycling Team (SERT) Outdoor Classroom</td>
</tr>
<tr>
<td>2</td>
<td>Zero Hunger</td>
<td>Girls in STEM After-School Club</td>
</tr>
<tr>
<td>3</td>
<td>Good Health and Well-Being</td>
<td>1st Grade: Design Water Filters lesson</td>
</tr>
<tr>
<td>4</td>
<td>Quality Education</td>
<td>2nd Grade: MP3 Durable Packaging lesson</td>
</tr>
<tr>
<td>5</td>
<td>Gender Equality</td>
<td>3rd Grade: Designing Structures (paper chair activity)</td>
</tr>
<tr>
<td>6</td>
<td>Clean Water and Sanitation</td>
<td>4th Grade: Cleaning Oil Spills lesson</td>
</tr>
<tr>
<td>7</td>
<td>Affordable and Clean Energy</td>
<td>Kindergarten: Earthworms lesson</td>
</tr>
<tr>
<td>8</td>
<td>Decent Work and Economic Growth</td>
<td>Peace, Justice, and Strong Institutions</td>
</tr>
<tr>
<td>9</td>
<td>Industry, Innovation, and Infrastructure</td>
<td>Partnerships for the Goals</td>
</tr>
<tr>
<td>10</td>
<td>Reduced Inequalities</td>
<td>Sustainable Cities and Communities</td>
</tr>
<tr>
<td>11</td>
<td>Sustainable Cities and Communities</td>
<td>Responsible Consumption and Production</td>
</tr>
<tr>
<td>12</td>
<td>Climate Action</td>
<td>Climate Action</td>
</tr>
<tr>
<td>13</td>
<td>Life Below Water</td>
<td>Climate Action</td>
</tr>
<tr>
<td>14</td>
<td>Life on Land</td>
<td>Life Below Water</td>
</tr>
<tr>
<td>15</td>
<td>Peace, Justice, and Strong Institutions</td>
<td>Life on Land</td>
</tr>
<tr>
<td>16</td>
<td>Partnerships for the Goals</td>
<td>Peace, Justice, and Strong Institutions</td>
</tr>
</tbody>
</table>

Technology Education and Elementary STEM

Technology education and STEM teachers have historically included content and practices of resource conservation and the environmental impacts of technologies. The International Technology Education Association (ITEA/ITEEA, 2000/2002/2007) released Standards for Technological Literacy: Content for the Study of Technology (STL), which included fourteen specific sustainable development benchmarks for the nation’s elementary STEM teachers to address. They are listed in Table 1 for Grades K-2 or 3-5. Technology or STEM educators design hands-on projects in order to teach these benchmarks to their students.

Many technology education projects begin with critical-thinking questions, discussion, and brainstorming about the impacts of

Zulay Joa, STEM Academy teacher at Glenallan Elementary, explains the Water Filter project.
technology. Assessment of student understanding is normal in technology education. STEM education at the elementary level exposes students to a variety of science, engineering, and computer-based concepts. Through this experience, students in Grades K-5 learn about real-life problems faced by many people in different parts of the world. Elementary students begin to learn the necessary tools that will allow them to become twenty-first century problem solvers. For example, they develop models on how to filter contaminated water, develop solutions for cleaning oil spills, and they learn computer-based coding. Through early exposure to STEM-related challenges, students are motivated and excited to continue to explore the world of science, technology, engineering, and mathematics.

Sustainable Development in Elementary STEM Academy

Glenallan Elementary School in Montgomery County, Maryland, serves a low-to middle-income diverse population in a Washington, DC suburb. There are 717 students attending who are 43% Hispanic, 34.6% African American, 10.6% Asian and 8.6% white. For 27% of the student body, English is not their primary language. Fifty-six percent of the students receive free and reduced-price lunch, an indicator of low income. The school is not an official member of the American ASPNet schools but does work effectively on sustainable development goals school-wide and in a specific class called the STEM Academy.

The school has a School Energy & Recycling Team (SERT) run by students to promote recycling, efficient use of water, and saving energy by turning off lights. The school is a LEEDS Green Roof building with plantings on the school roof. There are gardens in areas for stormwater runoff, a butterfly garden outside, and other outside teaching areas. These school-wide activities meet UNESCO Goal #4, Quality Education.

Every two weeks, the STEM Academy teacher sees all 717 students in the school in class sessions that last about 50 minutes. There are scheduled lesson plans for grade levels that meet five sustainability development goals (Table 2). They are:

- Kindergarten: Earthworms lesson meets SD Goal #15, Life on Land
- 1st Grade: Designing water filters meets Goal #6, Clean Water and Sanitation
- 2nd Grade: Durable packaging lesson meets Goal #12, Responsible Consumption and Production
- 3rd Grade: Designing structures meets Goal #9, Industry, Innovation, and Infrastructure
- 4th Grade: Cleaning oil spills meets Goal #14, Life Below Water

The earthworms project for kindergarteners was developed from a Teaching STEM in the Early Years book (Moomsaw, 2013). The student scientists dig in an outside area and study the earthworms they find using a magnifying glass. Later they will each build a see-through earthworm habitat to study in the classroom. The 4th graders develop a project to clean oil spills. Given red wool, cotton balls, a spoon, and a rubber band, they must work as a team to remove vegetable oil from a container with blue water. The order in which they use these items makes a difference in how much oil is removed. For example, the rubber band is used to skim the surface oil off like a boom used in a real-life oil spill. This lesson was developed from the Science Museum of Boston—Engineering is Elementary curriculum.

Grade three is working on structural designs like model bridges and paper chairs. The paper-chair activity allowed teams of three students to select ten items from a variety of types of paper. They then design and build a paper chair that can hold “Glen” (a stuffed animal) for 20 seconds without collapsing. The lesson focus is on stability, strength, and durability. The first graders work
on a clean water project by constructing a filter system to remove debris from a water container. Students were given coffee filters and cotton balls to work with. This activity was linked to storm water restoration that the school does in real life.

Additionally, the instructor manages the Girls in STEM Club. This after-school club is for fifth-grade girls to prepare them for middle school and does monthly STEM challenges to build the girls’ sense of accomplishment in STEM. Successful women engineers are invited as guest speakers. The club participates in the Hour of Code, a national computer coding event, and in the U.S. Science and Engineering Festival. The goal of these efforts meets UNESCO Goal #5 Gender Equality and Goals 2024 to increase the percent of girls selecting careers in STEM. Successful women engineers are invited as guest speakers. This activity was linked to storm water restoration that the school does in real life. This is a problem that the instructor is trying to correct.

Sustainable Development in Japanese Elementary Schools

The UNESCO Associated Schools Project Network has 10,000 schools worldwide in 170 countries. According to ASPNet (2018), there are 1,058 Japanese schools in the network, or approximately ten percent of the total schools worldwide. The Japanese National Commission for UNESCO (2014) reported that the Committee of UNESCO Schools for Promotion of ESD were proposing to promote educational activities based on the idea of Education for Sustainable Development (ESD) and utilize and develop the UNESCO School network.

In a 2015 study by Miyakawa, Isobe, and Masuda, Japanese schools were studied to find out how sustainable development was taught. Eleven kindergarten (61.1%) and 174 elementary schools (47.8%) responded to a survey. Content was taught overwhelmingly during Integrated Study Period and within an environmental theme. The primary reasons why schools linked to the sustainable development were to:

- Enhance school activities (114 responses).
- Sympathize with UNESCO School philosophy (102).
- Strengthen relationship with local community (98).
- Inter-school exchange/association (36).

At the elementary school level, teachers indicated that the following abilities were designed to be developed in students through ESD activities: thinking power, expressiveness, discerning power, multi-aspect thinking, thoughtfulness, cooperativeness, and respect for nature.

Inclusion of sustainable development activities in elementary schools was reported to have benefited the schools by building stronger relationships with the local community, expansion of hands-on activities, improved awareness of teachers, improved quality of education, and improved academic motivation and

Table 3. Chubu Elementary Multicultural Coexistence by Grade Level.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Program Name</th>
<th>Term</th>
<th>How to Work on Programs</th>
<th>Learning Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Make friends with many people at school.</td>
<td>year</td>
<td>Prepare questions. Make use of activities through all grades Then, write letters.</td>
<td>15 hours</td>
</tr>
<tr>
<td>2nd</td>
<td>Know people in school district.</td>
<td>year</td>
<td>Teach how to interview beforehand. Then, write letters.</td>
<td>15 hours</td>
</tr>
<tr>
<td>3rd</td>
<td>Make friends with people outside school.</td>
<td>year</td>
<td>Study the characteristics of wards in Nagoya City beforehand. Make newspapers in conclusion.</td>
<td>20 hours</td>
</tr>
<tr>
<td>4th</td>
<td>Learn the characteristics of Aichi prefecture.</td>
<td>year</td>
<td>Learn Aichi prefecture in social studies class, exchange with schools in unique areas, and communicate by newspapers.</td>
<td>20 hours</td>
</tr>
<tr>
<td>5th</td>
<td>Learn different lifestyles of people outside Aichi prefecture.</td>
<td>year</td>
<td>In experiencing rice farming, report differences of growth caused by different climate and natural features. Then, communicate by newspapers.</td>
<td>30 hours</td>
</tr>
<tr>
<td>6th</td>
<td>Think about Japan and welfare in the world.</td>
<td>year</td>
<td>Learn Japanese trend in the world and enhance interests in other countries. Communicate by simple foreign languages and picture compositions.</td>
<td>30 hours</td>
</tr>
</tbody>
</table>
academic abilities of students. Obstacles to success included gaps in teacher enthusiasm, funding for activities, lack of time, continuity of activities, and concerns about evaluation (Miyakawa, Isobe, and Masuda, 2015). One aspect of the challenge of time was that most materials used for sustainable development activities were developed locally, not received from UNESCO resources.

Multicultural Coexistence Project at Chubu Elementary

Chubu Elementary School in Miyoshi City in Aichi, Japan was founded in 1873 and serves a suburban zone outside of Nagoya, the third largest city in Japan. The school has 545 Japanese students from Grades 1 through 6 with fewer than two percent designated as special needs. One of the sustainable development goals this UNESCO Associated School promotes is multicultural coexistence. According to Miyakawa (2019), “Multicultural coexistence is to accept different cultures between countries and to establish the equal relationship.” This project is designed to help all students learn to communicate effectively with many diverse people including from different cultures and countries. All grade levels are involved (Table 3).

Evaluation of the effectiveness of the project lesson plan is addressed by the teachers answering questions about their students. Were students able to:

- 1st grade: Get used to and enjoy their school life in exchanges with other graders.
- 2nd grade: Make use of what they learn to promote activities through exchanges with workers in their school district and children in nursery and kindergarten.
- 3rd grade: Enhance their understanding toward the school district through district exploration and interviews; whether they learn the characteristics of other regions through exchanges with other schools.
- 4th grade: Understand the characteristics of their region and partner schools through exchanges with schools in different environments.
- 5th grade: Tell their own good points and characteristics through exchanges with regions of different climate and natural features.
- 6th grade: Enhance the ability to collect and process information through collecting and analyzing various information from international and welfare points of view.

(Miyakawa, 2019)

Joint STEM Elementary Lesson Plan

Educators in the Maryland (U.S.) and Aichi (Japan) schools are working together to create sustainable development lesson plans to be taught in STEM classrooms worldwide. On page 8 is a sample lesson plan, the Special Needs Mobility Challenge. This lesson is linked to standards in ITEEA’s Standards for Technological Literacy (2000/2002/2007), Next Generation Science Standards, Common Core, Maryland STEM, and the UNESCO ESD. It will be piloted by the Girls in STEM Club at Glenallan Elementary. If you decide to try this lesson in your classroom, we would be interested in the results. In fact, plans are underway to research the effectiveness of transnational ESD lesson plans in the coming years.

Summary

Schools and teachers across the U.S. are working diligently to teach American students how to be global citizens who protect resources and the environment. School projects are hands-on and engage students at all levels and in multiple content fields in critical thinking and problem solving to make the learning memorable and long lasting. Schools in Japan teach sustainable development through the UNESCO ESD Network and report many benefits to students, teachers, and schools. The safety and continuance of our planet is at risk, and it is the students who will live with what is being done today.

References

ACT. (2017). STEM education in the U.S.: Where we are and what we can do. Iowa City, IA: Author.


Sustainable packaging created by Japanese high school students in Arita.

This is a refereed article.
Lesson Description/Learner Characteristics: State the approximate time frame for this lesson. List the primary content area for this lesson. List the beginning and ending grade levels for which this lesson is appropriate. Must identify characteristics of learner (i.e. academic ability, socioeconomic etc. What is the relevance of these characteristics to the lesson? (1e: Designing Coherent Instruction)

Glenallan Elementary School STEM Academy
5th Grade STEM Club
“Special Needs Mobility Challenge”

Lesson Description: Over the course of three meetings of the Girls in STEM program, fifth grade girls will be given a scenario of a mobility-challenged student’s access to classrooms and resources at Glenallan Elementary. Given a set number of cardboard boxes, student teams will design and test a personal vehicle to be able to move a thirty pound (13.6 kg) object through a class door and into the STEM Academy, ensuring their equal access to all school resources. Upon completion of this activity, the student teams will develop and present a short PowerPoint presentation to the club about their solution, difficulties with the challenge, and how they analyzed their design through data.

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Objective/Outcomes: What will students know and be able to do as it is related to the state and national standards? Outcomes should be written in the form of student learning and suggest viable methods of assessment. Include the criterion level expected. For teachers of English language learners: What language objectives will be addressed? (1c: Setting Instructional Outcomes; 3a: Communicating with Students)

- Students will demonstrate understanding of factors impacting special needs students with mobility issues in school settings.
- Students will demonstrate the practice of engineering design to solve a societal problem through analysis of criteria and constraints, modeling, and data analysis.
- Students will effectively communicate their solutions to an audience.

Maryland College and Career Ready Standards/Next Generation Science Standard(s): For example: (MCCRS) 4.NBT.3 Use place value understanding to round multi-digit whole numbers to any place. Content area teachers should include appropriate English Language Arts Common Core Standards for Content Areas, if appropriate, in addition to content standards. State standards are identified in plan, assessments, and extensions. (1c: Setting Instructional Outcomes)

- UNESCO ESD Goals 2030 #4. Quality Education.
- ITEEA STL #14F. Many tools and devices have been designed to help provide clues about health and to provide a safe environment.
- MSDE STEM Standards of Practice Framework Grades K-5: A. Demonstrate an understanding of science, technology, engineering, and mathematics content. Essential Skill: “Write a plan using the engineering design process when engaged in STEM activities.”
- NGSS 3-5-ET-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- MSDE STEM Standards of Practice Framework Grades K-5: F. Communicate effectively and precisely with others. Essential skill: Share information in an appropriate format for written, oral, sound, and/or visual presentations.
- Common Core State Standard SL.5.4. Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
**Technologies and Other Materials /Resources:** List all materials, handouts, resources, and technology tools that are needed by the student or the teacher to execute the lesson. Technologies may include hardware, software, and websites, etc. Materials and resources may include physical resources (e.g. books, manipulatives, supplies, equipment, etc.) and/or people resources (e.g. guest speakers, librarian, etc.). Identify how they enhance student learning.  

### Consumables per team:
Cardboard boxes, tape, scissors, box cutters, wheels  

### Testing equipment:
Weight scale, stopwatch

### Online Resources:

### Academic Language:
**What key terms are essential to this content? What terms are essential to develop and extend students’ vocabulary? How will academic language be taught?**

**Mobility:** A student’s inability to move through classroom space due to physical limitations in their lower body, upper body, or both.  
**Special Needs:** An individual with a mental, emotional, or physical disability. An individual with special needs may need help with communication, movement, self-care, or decision-making.  
**Engineering Design:** The systematic and creative application of scientific and mathematical principles to practical ends such as design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.  
**Testing:** A method of collecting data or procedure for critical evaluation.  
**Friction:** A force that acts against motion when two surfaces are in contact with each other.  
**Load:** Constant and temporary weight a structure needs to support.  
**Comprehension:** Weight or load pressing down on a structure.

This academic language will be presented to students during the Day 1 Instructor modeling. It will be reinforced through critical-thinking questions throughout the lesson.

### Diversity of Teaching and Learning:
Describe how you will differentiate instruction for a variety of learners, including students with special needs, English Language Learners, and gifted & talented/highly able learners to ensure that all students have access to and are able to engage appropriately in this lesson. Be specific: (ACCOMMODATIONS, TIER 1, TIER 2, TIER 3, ELL, Gifted)

**Students will be placed in teams of three to ensure that students from different learning backgrounds can exchange ideas and work together.**

**Visual aids will be provided (sample box, 30-pound object) for students to be able to clearly understand the challenges as well as materials available.**

**Students will be given the opportunity to show/express their ideas through drawings.**

**Throughout the learning exploration, students will be able to make self-to-world connections, as related to the class challenge.**

**The instructor will meet one-on-one with students who might need extra guidance.**

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Explicit Lesson Procedures: The procedures should clearly describe the sequence of learning activities and should identify where and how all materials, technology tools and student-created technology products, and reproducible materials/handouts are utilized in the lesson. Describe the lesson sequence: (I DO-TEACHER MODEL); (WE DO-GUIDED PRACTICE); (YOU DO-INDEPENDENT PRACTICE)

• How will the lesson launch?
• How will the material be presented?
• How and when will the teacher model?
• What opportunities will there be for guided practice, group work, and individual practice?
• What questions will be posed to the students? What are the expected responses?
• How and when will you monitor student understanding throughout the lesson?
• What opportunities will there be for reflection and closure?

Include approximate time allocations for each portion of the lesson. Be very precise when explaining the teacher and student tasks during the learning activities.

Day #1 Teacher Model:
Present scenario to club. Possibly have a mobility-challenged student or adult discuss with the girls the obstacles they face in moving around schools and having access to the same resources as everyone else. Ask critical-thinking questions.

Discuss the resources the students have access to for their design. Present criteria and constraints (set amount of box material per team). Release teams to start their designs.

Day #2: Construction Day:
Student teams work on constructing their mobility vehicle.
Teams need someone to take notes, document the processes used.
Try out device with 30-pound object and classroom obstacle course. Goal is to go to five stations in the shortest amount of time with the vehicle staying intact.

Day #3 Class presentations on solutions via PowerPoint:
PPT must show process of design, data results, and photo of apparatus.

Questioning: 3b: Using Questioning and Discussion Techniques: Create higher order and critical-thinking questions to engage your students in learning.

Day #1
• Why is it important for all students to have access to a free public education?
• What are some ideas about how to go around obstacles the mobility-challenged students face?
• Can resources be moved to a more accessible location?
• How could you measure the success of your design mathematically?

Day #2
• Why did you pick the design you did?
• How does your vehicle account for friction?
• How did you decide the height of the vehicle and the height for the passenger?
• What measurement tools will you use and for what purpose?

Day #3
• Was your vehicle successful? Why or why not?
• What would you improve in your design?
• Would your vehicle be helpful to a student with special needs and mobility issues?
Assessment Criteria for Success:
- How and when will you assess student learning throughout the lesson (formative)?
- How will you and your students know if they have successfully met the outcomes?
- What is the criteria for mastery of the lesson outcome(s)?
- Describe any (formative and summative) assessments to be used.

(1f: Designing Student Assessments; 3d: Using Assessment in Instruction)

Use of a four-level rubric. Criteria include:
- Design process documented
- Team cooperation and focus during design
- Safe practices during construction
- Physical apparatus created
- Movement through obstacle course
- Effective communication through presentation that covers factors impacting mobility, team-based engineering design demonstrating analysis of criteria and constraints, modeling, and data analysis.

Extended Lesson Activities and/or Home Assignments: Describe your student’s current levels of understanding of the content related to the outcome for this lesson. What are some of the indicators that let you know these outcomes and the lesson activities represent the appropriate amount of cognitive challenge for all students? How are extensions differentiated for individual students?

(1f: Designing Student Assessments)

As students complete the challenge, they reflect on the importance of making educational spaces accessible to others. Students also become aware that we are not all mobile in the same way. As a whole, this challenge activity provides the Girls in STEM with the opportunity to utilize their mathematical skills, and it encourages them to work in collaborative teams. The following indicators can be used to assess student learning:
- Common Core State Standard SL.5.4. Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
- NGSS 3-5-ET-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

The PowerPoint presentation from Day 3 provides a venue for students to express what they have learned verbally and through visual aids. At the end of the presentation students are welcome to answer any questions and reflect on their team performance.

Extensions of Lesson: Students can conduct a library or Internet search on issues of mobility in schools or on laws specific to special needs students in education.

Reflect on all 5E Components: Did you design an activity that Engaged students? Did lesson activity allow student Exploration of the Engineering Design Process? Did students provide an Explanation to assess understanding? Was a lesson Extension provided to research STEM careers? Were students provided chance to Elaborate on design activity? (What are Instructional Next Steps?)

(4a: Reflecting on Teaching)

Engage: Students analyze and identify ways in which students with special needs can have access to free education. Students discuss and plan for different ways in which a given object can avoid a series of obstacles. Students record and share ideas.

Exploration: Students follow the Engineering Design Process in order to complete their team challenge. Students design and test their models. Students make final improvements at the end of day two.

Explanation: Throughout the learning process students assess their understanding by exchanging ideas and creating a plan. Later, students create and deliver a PowerPoint presentation to show their learning process.

Extension: At the beginning of the challenge students explore how mechanical engineers, bioengineers, and civil engineers are involved in the creation of technologies and spaces that make free education accessible to all.

Elaborate: In this three-session activity, students are given the opportunity to design and test their model vehicle at least twice (within time constrains.) During this time students are also encouraged to think about what other features they can add to their vehicle to minimize friction but also to make it as safe as possible.

Lesson developed by Dr. Thomas Loveland and Zulay Joa (June 2019)