Bringing STEM to Life: Essentials for Elementary Education

EQUITY IN ELEMENTARY STEM
Due to circumstances beyond its control, ITEEA has announced a change of venue for its 82nd Annual Conference to be held March 11-14, 2020.

ITEEA learned that the previous 2020 venue, the Memphis Convention Center, is undergoing an extensive renovation during the conference’s prescheduled dates, necessitating the move.

The new 2020 venue will be Baltimore’s Inner Harbor, which has been a popular conference location for past ITEEA conferences. Baltimore provides an easily accessible location, offering a wide range of accommodations. The nearby Inner Harbor provides an unforgettable panorama of sights, sounds, and world-renowned Chesapeake Bay cuisine. Baltimore is also family friendly, with nearby access to the National Aquarium, Maryland Science Center, Discovery Children’s Museum, and the Maryland Zoo.

The Baltimore 2020 Local Planning Team is already hard at work, planning an outstanding conference experience for all attendees.

We look forward to seeing all Technology and Engineering Education professionals in Baltimore on March 11-14, 2020!

See you there!

www.iteea.org
CONTENTS

features

P.10  ARTICLE
the power of building empathy in STEAM
Daniel Edelen, Sarah B. Bush, Kristin Cook, and Richard Cox, Jr.

P.14  ACTIVITY
worlds of the solar system
Douglas Lecorchick and Charlene Detelich

P.19  ARTICLE
equity in STEM education
Carol M. Giuriceo and Charles H. McLaughlin, Jr.

P.24  ACTIVITY – STEM CHILDREN'S RHYMES
STEM It's Raining, It's Pouring
Emily Yoshikawa Ruesch and Scott R. Bartholomew

P.30  ARTICLE
equitably engaging all students in STEM
Thomas Roberts, Cathrine Maiorca, and Pamela Chapman

P.36  ACTIVITY – ELEMENTARY ANIMATORS
animation adventureland: animation principles of timing and anticipation
Douglas Lecorchick, Victoria Ann Hoeveler, and Gianna Mastrandrea

departments

P.4  FROM THE EDITOR
equity and fairness
Thomas Roberts

P.5  MESSAGE FROM THE CHILDREN'S COUNCIL PRESIDENT
bringing STEM to life!
Kimberly Bradshaw

P.6  ESC 2020 GLOBAL DESIGN CHALLENGE

P.7  BOOKS TO BRIEFS
this classroom is fair, not equal!
Eliana Marino and Alexis Sites

P.28  CAREER CONNECTIONS
optometrists
Teena Coats and Bryanne Peterson

P.34  TEACHER HIGHLIGHT
meet Julie Sicks-Panus

Cover Image: Engineering by Design™ classes at Benton Hall Academy use heterogeneous and cooperative groups for learning and applying the Engineering Design Process as well as group presentations at the conclusion of the EbD™ Building Block.
Credit: Tracy Young, STEAM Specialist, Benton Hall Academy, NY

www.iteea.org
Produced by the International Technology and Engineering Educators Association in conjunction with its Elementary STEM Council.
**EDITORIAL**

**BRINGING STEM TO LIFE: ESSENTIALS FOR ELEMENTARY STEM EDUCATION**

**EQUITY IN ELEMENTARY STEM**

**EQUITY AND FAIRNESS**

The theme for this issue is equity in elementary STEM education. As teachers, we are all committed to our students’ learning. It is important, though, to pause and reflect on how we can better meet the needs of all our students. When we think about equity, I hope we focus on fairness, not equality. Equity goes much deeper than just fairness and includes ideas around the access students have to resources and instruction. Equity includes questions about students’ achievement. Equity in STEM includes issues of identity, how students relate to the subjects, and how they relate to the community that does STEM. In short, equity goes beyond looking at test scores and any gaps. It also focuses on how students can access quality STEM instruction, how the STEM community includes students from diverse backgrounds, and how students can use their STEM knowledge to make a difference. In this issue, you will find a range of resources to help implement more equitable instruction. The Books to Briefs piece is a great starting point for a classroom activity about fairness. The featured articles help identify equitable practices that you can use in your own instruction. Our hope is that wherever you are in your teaching journey, the activities and articles in this issue will offer you even more strategies to meet the needs of our rapidly diversifying population of students.

Continuing with this month’s theme of equity, I also want to share some exciting updates we will have for next year’s journal. A new recurring feature will offer strategies for differentiating instruction in elementary STEM. This wonderful idea came from current undergraduate students who mentioned the lack of quality differentiation resources. We hope this new feature helps to fill that gap. We will also offer a new section on coding. More groups and organizations are emphasizing the importance of coding, but elementary aged children can be overlooked. The Elementary STEM Journal is positioning itself to fill this void.

Finally, we will have a new section next year titled “Theory into Practice.” Its purpose is to expand readers’ access to timely research on important topics in elementary STEM education. These articles will all be peer-reviewed and will be longer than our current articles. We hope this new feature will become a source of discovery, validation, and dissemination of highly effective practices and tools in elementary STEM education.

As we transition into summer, I also encourage you to begin thinking about ways to share your expertise in elementary STEM. Next year’s ITEEA Conference will be in Baltimore, and applications to present are now open! No matter if you’re a seasoned presenter or thinking of submitting your first proposal to present, the conference is always a great time to catch up with other STEM educators and learn about new programs, projects, and practices. The Elementary STEM Council’s 2nd Annual Global Design Challenge was also recently announced! After a very competitive first year, we hope to have even more entries in the second challenge. Full information is available on page 6.

We hope you have a great summer and look forward to sharing more great elementary STEM ideas with you next year!

**Thomas Roberts** is co-field editor of The Elementary STEM Journal and a teacher educator and researcher at Bowling Green State University in Bowling Green, Ohio. He can be reached at otrober@bgsu.edu.
On March 27-30 STEM was brought to life in Kansas City. Attendees were able to connect with one another, share lessons and ideas, and build lifelong relationships with colleagues from around the nation and the world. As the Elementary STEM Council, we were excited to offer many sessions across all disciplines and grade levels. Sessions included topics from classroom teachers successfully using FlipGrid, blogging, and Adobe Spark within the classroom to school librarians who collaboratively used STEM as a way to build upon all grade-level standards.

In addition to learning new ways that we could bring STEM to life within our classrooms and schools, we took time as an organization to celebrate the successes of leaders within our field of work. Congratulations again to Dr. Michael Daugherty, Director of Innovative Education at the University of Arkansas, for his lasting contributions to elementary STEM. Dr. Daugherty was this year’s recipient of the Mary Margaret Scobey Award. Dr. Charlotte Holter was recognized as the recipient of the Elementary STEM Council Leadership Award for her contributions to the Elementary STEM Council. Finally, at Saturday morning’s Awards and Recognition Brunch, we celebrated as Dr. Thomas Roberts was awarded the ITEEA Award of Distinction. This award is presented to an individual within technology and engineering education who has advanced the profession through a sustained and recognized record of exemplary professional activity.

As the Elementary STEM Council, we continue to strive to bring STEM to life for each of our members. We hope that you will make plans now to join us March 11-14, 2020 in Baltimore at the 82nd annual ITEEA conference. Better yet, bring your expertise to life for others by applying to present at the conference! The application process is open until June 30 on the ITEEA website at www.iteea.org/Activities/Conference/ITEEA_Conference_2020/Application_To_Present_2020.aspx.

This edition of The Elementary STEM Journal contains ways in which Elementary STEM can be brought to life within your classrooms and schools. As many of us begin to close out our school year, we hope that you will find some inspiration to continue the vital role of STEM with your students.
In 2008, the U.S. National Academy of Engineering (NAE) identified 14 Grand Challenges for Engineering in the 21st Century. These Grand Challenges were designed to cause students and educators to think about solutions to the big challenges affecting all of our lives. Following ESC’s first very successful Global Challenge for elementary-aged students in 2018-2019, we have a new problem for you to address in 2019-2020. The Elementary STEM Journal is sponsoring the 2nd Global Design Challenge for Elementary STEM (GDC) to provide students with a chance to solve a real problem and show the world that everyone can help find solutions to these global challenges.

The Process
Working with their teachers, elementary STEM students from around the world will work in small design teams to solve the GDC outlined below. As students attempt to solve the GDC, the elementary classroom teacher will document the process with a simple journal or portfolio that describes the problem-solving process, the products developed, results of product market testing, as well as the final product pitch presentations. Photos and videos of proposed solutions will be posted on the Elementary STEM Council’s Facebook® site and ultimately, the team with the most elegant solution to the GDC will be provided an opportunity to present their solution during the International Technology and Engineering Educators Association Annual Conference in Baltimore, Maryland, on March 11-14, 2020. A story about the winning team will also be featured in The Elementary STEM Journal.

The 2nd Global Design Challenge
One of the original Grand Challenges (NAE, 2008), called for engineers to provide clean water that could make a difference for millions of people around the world. Currently, one of the largest threats related to water is called the Great Pacific Garbage Patch. It is a collection of plastic and discarded trash floating in the Pacific Ocean. Just type the words “grand challenges” into your Internet browser for more information about these challenges or type “Pacific garbage patch” to learn more about the pollution problem. This Global Design Challenge calls on you and your team to develop a product that might help keep the water cleaner and reduce the amount of trash floating in the Pacific Ocean and other bodies of water.

Most conservationists agree that humans create too much waste and that actively reusing and reducing the number of single-use disposable products is the best way to reduce pollution problems. One way that people are responding is by reusing drinking containers rather than discarding plastic drinking containers after one single use. A large percentage of the waste materials currently floating in the Pacific Ocean and other bodies of water is single-use plastic waste. By finding viable and economically feasible secondary uses for plastic containers originally designed for a single use, we could substantially reduce the number of these items that end up in the water—thereby helping clean up our water sources.

LEARN MORE AT www.iteea.org/ESCGDC19.aspx
Application deadline: December 15, 2019
this classroom is fair, not equal!

by Eliana Marino and Alexis Sites

Book Used:
Yes I Can: A Girl and Her Wheelchair
Book image courtesy of Amazon.com

book synopsis
Carolyn is a new student in her first grade class, and she is really excited to get to know her teacher and peers. The other students in her class are interested in learning more about Carolyn because they think that she is very different from them. That’s because she is in a wheelchair. Carolyn wants them to know that she is just like they are and that she enjoys doing the same things, too!

lesson synopsis and goals
Students will be designing a tool that a student in a wheelchair could use to make life easier in the classroom. The goal of this lesson is to allow students to use the design process to create a solution that will help a student with a disability who could potentially be in their class. This will help students understand how some peers require different tools to succeed and that not everyone in the classroom requires the same things. Equity is fair, not equal.

lesson objectives
Students will:
- Reflect on the theme of the book in a whole-class discussion.
- Explain the difference between equity and equality.
- Use the design process to gather information, plan, sketch, and construct a solution to the problem that works within the constraints of the design brief focused on development of a new or improved tool.
- Describe tools and identify how they help people to complete tasks.
- Use appropriate measuring tools to record sizes and lengths of products.

standards
Next Generation Science Standards (NGSS Lead States, 2013)
- K-2-ETS1-1: Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- K-2-ETS1-2: Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- K-2-ETS1-3: Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
- **Standard 1.B.**: All people use tools and techniques to help them do things (p. 24).
- **Standard 2.C.**: Tools are simple objects that help humans complete tasks (p. 34).

National Common Core Standards (Common Core State Standards Initiative, 2019)
- **CCSS.ELA-LITERACY.RL.2.3**: Describe how characters in a story respond to major events and challenges.
- **CCSS.ELA-LITERACY.RL.2.7**: Use information gained from the illustrations and words in a print or digital text to demonstrate understanding of its characters, setting, or plot.
- **CCSS.MATH.CONTENT.2.MD.A.1**: Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

**design brief**

**This Classroom Is Fair, Not Equal!**

Some students need to do their work in a quiet location separate from classmates because that is what helps them to focus successfully.
procedure and teacher hints

1. Read the story, Yes I Can!: A Girl and Her Wheelchair, to the class as an introduction to the idea of equity in the classroom. Conduct a class discussion, making sure to address the literacy standards noted.

2. Take time to discuss what equity means. Explain the difference between equity and equality, as well as why some students require different tools and resources than others.

3. Conduct a discussion about tools. Help students define what they are and share examples of all kinds of tools used daily at home and school. Have students cut pictures of tools from magazines and make a class collage on a poster board.

4. Introduce the design process and walk your students through it if it is your first time using it in the classroom. Be sure to effectively address the NGSS standards by encouraging students to ask questions and make observations to help them solve the problem. Expect students to document their design process with sketches and narrative.

5. Split students into groups of 3-4 students each. Provide each group with different supplies, some less/more than others and explain why each group has different supplies. This is when you would want to tie in the idea of equity and how it applies to a classroom setting.

6. Have the students design, draw, and construct their solutions. Consider testing designs by having students sit in a wheelchair (borrowed from school nurse or local medical supply) or stationary chair to see how their device works.

7. Have students practice their math skills by taking and recording measurements of each solution to compare the reach of each device. If possible, have them use a variety of measuring tools (i.e., ruler, yardstick, tape measure).

8. Allow each group to present its solution and design process to the class. Address the NGSS K-2-ETS1-3 standard by comparing the different solutions and identifying the strengths and weaknesses of different designs. Point out how everyone still solved the problem even though they worked with different resources.

references


Eliana Marino is an undergraduate student at Millersville University of Pennsylvania. She is an Early Childhood Education Major with a Minor in Integrative STEM Education Methods. She can be reached at elmarino@millersville.edu.

Alexis Sites is an undergraduate student at Millersville University of Pennsylvania. She is an Early Childhood Education Major with a Minor in Integrative STEM Education Methods. She can be reached at amsites@millersville.edu.
the power of building empathy in STEAM

by Daniel Edelen, Sarah B. Bush, Kristin Cook, and Richard Cox, Jr.
The inclusion of the ‘A’ to transform STEM into STEAM is about much more than just the aesthetics.

Rather, it is importantly about the inclusion of culture, self-expression, creativity, and community, as students gain insights into the lives of others and ultimately themselves. STEAM brings in the much-needed human side of the problem-solving process as students design, create, and empathize their way to making sense of our world. Art can be the vehicle in which subjects can be integrated in ways that transcend typical boundaries and connect to students’ personal expression. Within such integrations, students become so enthralled in making sense of the task that they draw upon and apply previously learned content as well as gain new knowledge from the STEAM disciplines as they generate novel solutions to problems with the goal of helping others (Bush, et al., 2018). Planning and implementing transdisciplinary learning experiences can be daunting, as this type of instruction has not been the focus of most teacher preparation programs (Kelly & Knowles, 2016). Transdisciplinary teaching and learning occurs when the content area disciplines become authentically intertwined as students focus on finding a solution to the problem under investigation and seamlessly apply the disciplines (in this case, in STEAM) to solve the authentic problems (Quigley & Herro, 2016). These types of learning experiences help students see how the disciplines are truly interconnected in our world.

Through our collective experience implementing transdisciplinary inquiries, we have seen firsthand how transformative this type of instruction is for students as they move from their traditional role as a receiver of information to being positioned as an expert—one whose lived experiences are valued and important to solving the problem. Living in a world that is changing daily through innovation and technology and where the workforce is relying more and more on interdisciplinary collaborations, it is becoming increasingly important for students to have experiences that require them to transfer content knowledge and practices from multiple disciplines so that they can be positioned as problem-solvers to improve and solve complex problems of the world.

Planning for transdisciplinary instruction through design thinking

We have found that planning STEAM transdisciplinary learning experiences through the lens of the Design Thinking Framework (Cook & Bush, 2018; Doorley, Holcomb, Klebahn, Segovia, & Utley, 2018) helps teachers thoughtfully create valuable learning experiences for their students. Through Design Thinking, students tackle authentic problems in their school, community, or the world, and they enter the problem by first establishing feelings of empathy for the person or situation under investigation. Design Thinking is a systematic yet flexible process of solving an authentic problem that maintains a critical focus on human needs (Swift, Strimel, Bartholomew, & Yoshikawa, 2018). See Figure 1 for an overview of the Design Thinking Framework, which has been adapted to focus on empathy of person(s), organism(s), and environment(s).

Design Thinking has five nonlinear phases. Phase one begins with developing empathy towards the person(s), organism(s), or environment(s) in need. Students transition into phase two as they define the problem based upon their empathetic feelings by asking questions to seek further information needed to aid in generating solutions. Phase three entails students brainstorming new, novel, and creative solutions to their defined problem. In phase four, students focus upon one solution and generate a prototype of their idea. In the fifth phase students test their prototype to determine if their solution helps their person(s), organism(s), or environment(s) in need. Importantly, students might move back and forth between these phases multiple times throughout the duration of the Design Thinking process (Cook & Bush, 2018).

Empathy is a key component of transdisciplinary inquiries, as we have found through our own teaching experiences that when students are solving a problem for someone else they are positioned as the one in charge of their own learning who has valuable insights and contributions to help another. Students develop an immense compassion for the person(s), organism(s), or environment(s) for which they are solving the problem and begin to seek out the knowledge they need to solve the problem on their own, rather

Figure 1. The Design Thinking Framework, Adapted from d. school at Stanford University (2018).
than waiting for the teacher to guide them step-by-step. We have found that positioning empathy as a focal point of STEAM inquiries pays off in high dividends, as any time invested in building empathy pays off many times over in student engagement and passion for creating a solution to the problem (as described in Bush & Cook, 2019). Expressing empathy can provide meaningful engagement into the context of the problem. Empathy can also position students to discuss and traverse difficult concepts that often exist outside of their own concrete world views.

**how do I build empathy?**

As you develop a STEAM inquiry, intentionally pose the problem (we use a problem statement) in such a way that will allow for students to feel empathy. Make sure the problem is about a person(s), organism(s), environment(s), or situation to which your students can relate. When introducing the problem statement to your students, give them a copy (or have it permanently posted) so that students can refer back continually as they work through the inquiry. Teacher guidance is needed to ensure students are returning to the problem statement and staying true to the goals and parameters of their inquiry. Now, let’s dive into an example!

Figure 2 displays a STEAM problem statement created by the first author. We have highlighted key aspects for you to consider to guide in the development of your own problem statements.

We have also found the use of a bio card to be especially helpful. Bio cards help to add a level of authenticity and realness to the inquiry—especially if your students do not personally know those in the problem statement. See Figure 3 for an example bio card.

After equipping students with the problem statement and bio card, allow students the time to develop empathetic feelings towards those in the problem statement. As students continually return to the empathy aspect of the inquiry, allow them to ask questions and discuss with their peers at the beginning of the STEAM inquiry and revisit often so that students are reminded of “why” they are looking for a solution. Asking students to close their eyes and imagine what they might do in a similar situation is a great strategy to establish student empathy. Allowing students to share times they felt similar to the person in the problem statement can also be a great way to help your students feel empathy.

The following is a list of helpful hints for building empathy in your students:

1. Keep problems as authentic as possible. When developing problem statements, look for real-world opportunities that have multiple solution paths and solutions so that students can creatively approach the problem in ways they believe would be best for those in need.

2. Develop problem statements relevant to students. Students will have an easier time developing empathy when the problem they are attempting to solve is something they have experienced or to which they can easily relate.

3. Empathetic problem statements should make each and every student feel included. Multiculturalism plays an important role in developing empathetic moments based upon the person(s) (and organisms or environments) for your students. Think about access and equity for your students and select authentic moments that your students would be able to relate to or may even have experienced themselves.

4. Revisit empathy as often as possible. Remind students to revisit the needs of those for whom they are solving the problem as a means to refocus them. Allow for time throughout the inquiry for students to continue to develop empathy, as it does take time and will not always happen immediately.

5. Solve for a singular problem. Allowing students to focus on the needs of a singular problem of a small group of people, animals, or the environment helps them critically focus on one issue. When students are faced with multiple problems, it becomes increasingly difficult to develop empathy as well as generate novel solutions.

**our students**

Our students have a difficult journey ahead of them. They will need to be able to navigate a world and make sense of situations that we, as teachers, cannot even predict. However, we can prepare them for an unknown future. Focusing on empathy, through problem solving,
equips our students with much needed real-world skills. Doing so brings their humanity to the forefront of their learning experiences. As our students transition into future problem solvers, they will need the ability to empathize to make our world better for all.

references


Sarah B. Bush is an associate professor of K-12 STEM Education at the University of Central Florida in Orlando. Dr. Bush's scholarship focuses on deepening student and teacher understanding of mathematics through transdisciplinary STE(A)M problem-based inquiry. She can be reached at Sarah.Bush@ucf.edu.

Daniel Edelen is a doctoral student in elementary mathematics education at the University of Central Florida in Orlando. Mr. Edelen’s research focuses on integrating social justice into mathematics and transdisciplinary STEAM with a critical emphasis on equity for high needs populations. He can be reached at Dan.edelen@Knights.ucf.edu.

Kristin Cook is an associate professor of science education at Bellarmine University in Louisville, KY. Dr. Cook’s research focuses on engaging students and teachers with the community of science through the exploration of socio-scientific inquiry and transdisciplinary STEAM instruction. She can be reached at kcook@bellarmine.edu.

Richard Cox, Jr. is a K-5 Instructional Coach and STEAM facilitator in Bullitt County Public Schools, Mt. Washington, KY and a doctoral candidate in the Education and Social Change program at Bellarmine University (Louisville, KY). Mr. Cox’s research focuses on conceptualizing and articulating alternatives to longstanding and dominant curriculum in science and mathematics through the use of transdisciplinary STEAM. He can be reached at rccox01@bellarmine.edu.

This is a refereed article.
worlds of the solar system

Douglas Lecorhick and Charlene Detelich
overview

This lesson aims to help students gain a better understanding of how diverse the worlds in our solar system are and give them a sense of scale as to how many solar system objects there are. Students will research a planetary world and record a few facts, just as an actual planetary scientist would. They will also cut, color, and fold paper printouts of the different worlds into a sphere. Once the entire class is finished with their cutouts, they will turn them in to the teacher who will hang them around the classroom, along with the research sheets, so the students can visually understand how vast our solar system is.

background

Common knowledge is that our solar system has eight official planets, but what is and is not a planet? The rules to become a planet are decided by the International Astronomical Union (IAU) (IAU resolution B5) and include:

1. The world is in orbit around the sun (any planets orbiting other stars are technically not planets, and by this rule, there are only eight planets in the entire universe).
2. The world must have enough gravity to pull itself into a sphere (a video on astronauts using water in space to make spheres may be helpful).
3. The world must have “cleared the neighborhood around its orbit,” meaning there is nothing in its path of substantial size.

This is why the large spherical bodies in the asteroid belt are termed “dwarf planets” rather than “planets”—because they have not cleared their neighborhood. Pluto was demoted from planethood in 2006 mainly because it has a moon, Charon, that is almost half of Pluto’s size (Stern et al., 2015). It is so large that it technically shares an orbital center with Pluto rather than the moon simply orbiting around the dwarf planet. Some scientists consider this a binary system (Richardson and Walsh, 2005), and because Pluto orbits around this invisible point, it does not technically orbit around the Sun. Pluto also orbits in the outer asteroid belt, also termed the Kuiper Belt, and because of this it has not “cleared its neighborhood.”

It is important for students to realize that these rules were arbitrarily created by a team of astronomers rather than geologists, and that geologists consider almost every spherical body in the solar system a planet. The field of “Planetary Geology” studies all bodies in the solar system down to the smallest asteroids and comets. By this definition, there are far more than only eight planets in the solar system, including moons and dwarf planets, some of which are larger than the planet Mercury (Showman and Malhotra, 1999).

This lesson aims to teach students about the worlds of our solar system beyond the main eight planets by focusing on worlds that are spherical. It is important to note, however, that the solar system is vast and consists of over 200 large bodies orbiting the Sun and orbiting other, larger, bodies.

worlds of the solar system lesson plan

Begin the class by explaining to students what the IAU rules for planets are (rules outlined in the background section). Once students understand what the official rules for a planet are, assign each student a solar system world from the list below to research (can be adjusted for class size). Be sure to hand each student a planet map template to color, cut, and fold into a 3D world:

<table>
<thead>
<tr>
<th>Mercury</th>
<th>Venus</th>
<th>Earth</th>
<th>Mars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jupiter</td>
<td>Saturn</td>
<td>Uranus</td>
<td>Neptune</td>
</tr>
<tr>
<td>Luna</td>
<td>Pluto</td>
<td>Charon</td>
<td>Ceres</td>
</tr>
<tr>
<td>Europa</td>
<td>Io</td>
<td>Ganymede</td>
<td>Callisto</td>
</tr>
<tr>
<td>Titan</td>
<td>Dione</td>
<td>Enceladus</td>
<td>Tethys</td>
</tr>
<tr>
<td>Titania</td>
<td>Triton</td>
<td>Miranda</td>
<td>Ariel</td>
</tr>
<tr>
<td>Umbriel</td>
<td>Oberon</td>
<td>Iapetus</td>
<td>Mimas</td>
</tr>
</tbody>
</table>

Students should spend 20-30 minutes researching (using the computer/iPad) and recording their findings (with pencil and research worksheet) about their world. Once students are done researching their world, students should use a pair of scissors.
to cut out the map of their world and use a glue stick to fold and assemble the tabs of the map to create a 3D model. Finally, the student will turn their planet in to the teacher who will attach the planet to a string and hang it somewhere visible around the classroom.

After the students have all turned in their worlds, discuss with the class how many different types of worlds there are across the solar system, from rocky planets, to gas planets, to ice worlds; emphasizing that the solar system is incredibly diverse. Be sure to also discuss with students the vast amount of worlds in the solar system and how there are almost eight times as many worlds as they created. A good comparison to use may be that the entire grade level (depending on the size of the school) would need to create a world to represent all of the worlds in the solar system. There are so many that there are still hundreds of worlds that humans have yet to visit with spacecraft, and we do not even know what they look like yet.

**materials**

- Research worksheets for each student (Figures 1 and 2). Available at [https://www.iteea.org/153834.aspx](https://www.iteea.org/153834.aspx)
- Computer/iPad - internet access
- Planet cutouts (15 faces model)
- Scissors
- Glue sticks
- Hole punch
- String (enough for all planets)

**learning objectives**

- Learn the official definition for what is and is not a planet.
- Understand the diversity of the worlds in the solar system.
- Understand that there are more than just eight worlds in our solar system

**assessment**

- Students will recite rules of what makes a planet.
- Student will be able to describe what makes their world unique from others.
- Student will be able to tell the teacher how many worlds exist across the solar system.

**references**


**Douglas Lecorchick** is an Assistant Teaching Professor at North Carolina State University. Any questions or comments regarding this manuscript should be directed to dlecorc@ncsu.edu.

**Charlene Detelich** is an undergraduate student studying geology at North Carolina State University and has previous experience researching Mars as well as one of Saturn’s moons.
Worlds in the Solar System

Name of world: ____________________________________________

Size of world: ____________________________________________

Distance from Sun: _________________________________________

Is the world a Planet, Dwarf Planet, or Moon? (circle one)

If the world is a moon, what planet does it orbit? _______

Does the world have an atmosphere? _____________

Three fun facts about the world:

1. _________________________________________________________

2. _________________________________________________________

3. _________________________________________________________
ACTIVITY

The 15 Faces Model

Worlds of the Solar System
Jobs requiring STEM (science, technology, engineering, mathematics) and STEAM (arts/design added to STEM disciplines) knowledge and expertise at all educational levels continue to grow. Yet participation by groups historically underrepresented in STEM/STEAM is not following the same trajectory (NSF 2018). According to the National Center for Science and Engineering, the highest percentage of science and engineering degrees earned by women in 2016 are in psychology, biological sciences, and social sciences. Computer science, engineering, and physical sciences have low shares among women degree recipients. Women completed bachelor’s degrees in mathematics and statistics with a share over 40% (NSF, 2019).

Similarly, students from historically underrepresented groups receive a low percentage of science and engineering degrees. Latinx students earned 13.5% of science and 10% of engineering bachelor’s degrees with black/African-American students earning 9% and 4% respectively. The highest concentration of science and technology degrees earned by Latinx in 2016 were psychology, social sciences, and biological sciences, with low representation in physical sciences and mathematics/statistics. Black/African American students also have high shares in psychology and social sciences. Bachelor’s degrees in computer science have increased over the last 20 years, but the other science and engineering degrees have declined, with the most noticeable difference in mathematics and statistics (NSF 2019).

An understanding of STEM, however, goes beyond workforce issues. All people need the content, skills, and practices of STEM to participate and contribute to today’s rapidly changing society, so STEM literacy represents not an elective but an essential requirement for all students in Grades K-12. According to the National Academy of Sciences, STEM literacy can be defined as: (1) awareness of the interconnected roles of science, technology, engineering, and mathematics in today’s society; (2) familiarity with some of the
fundamental concepts and knowledge in each area; and (3) ability to apply STEM to one’s own life and critically evaluate content as it relates to contemporary issues (Honey, M., Pearson, G. & Schwegingerub, H., 2014).

**the role of teachers**

In order for students to succeed in STEM studies, teachers must recognize academic inequities and their causes. Among the most glaring national issues are the lack of access to state-of-the-art scientific and technological resources and the absence of innovative and best teaching practices in communities with low social economic status, high poverty rates, and underrepresented populations. Achieving equity in STEM fields must begin with acknowledgement of the community and its cultural makeup. Awareness of students’ backgrounds and their perceived place in the school can inform a teacher of the management of instructional options necessary to assist students with success and retention in a STEM program and its associated coursework. Hunter, et al. (2010) stated, “Learning environments—the curriculum, specific activities, interactions with peers and instructors, and the overall learning community—can be created to support diverse learners and equity” (p. 53). Creating support systems may require teachers to scrutinize their own views on diversity and equity. Additionally, STEM teachers must prove that all students, not just those that look like them, have an equal opportunity to learn and succeed. As school populations become more diverse, teachers must adapt to the cultural tapestry that makes up the typical classroom. The role of developing cultural competency must become an important factor in the practice of every teacher who stands before a STEM classroom.

The narrative of instructional materials must match and augment the images used to make cultural diversity visible in STEM. That is, it is important to move away from superficial representations of diversity to more culturally and socially relevant activities that promote students’ engagement, agency, and social responsibility (STEM Teaching Tools, 2019).

Finally, Ladson-Billings (1995), an early researcher and initiator of Culturally Relevant Pedagogy (CRP), reported on classroom observations she made of the characteristics of culturally relevant teaching. During her research she deduced that teachers who practiced CRP:

- Believed that all the students were capable of academic success.
- Saw their pedagogy as art—unpredictable, always in the process of becoming.
- Saw themselves as members of the community.
- Saw teaching as a way to give back to the community.
- Saw teaching as “mining” or pulling out knowledge (pp. 478–479).

These practices, while not exhaustive, provide some guidance for developing an equitable classroom based on fairness and cultural awareness of the students who collaborate and learn together in our classrooms and laboratories.

**elements of equity**

Equity in STEM education represents an ongoing process that requires an intentional focus and commitment to embedding elements of equity in all facets of STEM education. Equity demands more than equal opportunity for groups historically underrepresented. Multiple interconnected factors influence students’
attitudes, perceptions, understanding, interest, and empowerment in STEM, and educators in K-12 must acknowledge that a one-size message or opportunity does not fit all. Five elements of equity will be addressed to examine how multiple programs in Rhode Island are addressing the continuing issue of equity.

1. **Accessible Opportunities** – Promoting equity requires more than just offering STEM opportunities. In addition to providing accommodations and modifications for students with special needs, practical factors such as transportation to venues, work schedules of students and caregivers, locations of events, and associated costs are some of the issues that need to be considered.

2. **Empowering Physical and Social Environment** – The environment plays an important role in learning both in physical and social/emotional ways. The arrangement of tables and desks in a room promotes or discourages a collaborative space where the educator is positioned either as the facilitator/leader of a team or an authority figure. Additionally, students who feel comfortable are empowered to ask for assistance when needed.

3. **Continuing Support** – After enrollment or recruitment into a class, workshop, or special event, lines of communication between students and educators need to remain open with all students but especially with students who may benefit from one-on-one conversations. Awareness of student perceptions, peer attitudes, and other challenges is essential. Multiple elements, including but not limited to the home, school, community, and media affect students’ view of their place within STEM and must be considered when offering support.

4. **Foundational Knowledge** – STEM represents an educational approach that focuses on multidisciplinary teaching with emphasis on real life. Concepts are embedded into open-ended projects that allow for flexibility with assessments that can be modified to fit student needs.

5. **Gender and Culturally Aware Pedagogy** – In addition to providing multiple means of engagement, representation, and action/expression for all learners, educators need to emphasize an incremental view of intelligence (growth mindset), counter stereotypes, monitor small group work for equitable distribution of roles, and include prior student experience in lessons (CAST, 2018).

These five elements do not represent a comprehensive view of equity practices. However, they provide a structured way to frame an initial discussion of addressing equity issues in STEM.

**Rhode Island and equity**

The Rhode Island STEAM Center at Rhode Island College (RIC) serves as a central educational hub and statewide resource focused on building partnerships, advocating for increased STEM/STEAM literacy, and promoting and implementing research-based practices, programs, and special events. The STEAM Center believes in a "it takes a village" approach and partners with higher education, K-12, business and industry, nonprofit organizations, community-based groups, and government agencies to build long-term interest and active engagement in STEM/STEAM among ALL Rhode Islanders through the continual sharing and exchange of knowledge, ideas, and experiences.

Using the five elements above, three programs/initiatives will be discussed. The STEAM Center was/is involved with all three initiatives.

**Rhode Island Highlights**

**STEM in the Middle**

Until the program ended two years ago, the Tech Collective, Rhode Island’s information technology association, organized the annual STEM in the Middle Workshop & Career Expo. This half-day event brought together middle school girls from school districts near the capital city of Providence to participate in hands-on workshops led by STEM/STEAM female (and male) industry professionals from across the state and Rhode Island College faculty.

During one of these sessions, the students were invited to participate in a design activity within the Langevin Center for Design, Innovation, and Advanced manufacturing. The girls were provided instruction on using design software to create a small personalized laser-etched plaque. The brief lesson identified connections between the

| **Accessible Opportunities** | Invited schools participated during in-school time at a local college. Buses transported students to and from their schools, thereby eliminating time and location constraints for students. |
| **Empowering Physical and Social Environment** | Classrooms and other college spaces were organized into informal and collaborative spaces. |
| **Continuing Support** | Workshop presenters supplied teachers with additional materials so conversations could be continued post-workshop in the classrooms. |
| **Foundational Knowledge** | Many of the workshops focused on STEM/STEAM concepts with an emphasis on real-world applications. |
| **Gender and Culturally Aware Pedagogy** | Invited presenters understood and addressed their audience—middle school girls of varying abilities and interest in STEM—appropriately. |
practice of design, the products that result from designing, and design opportunities available in Rhode Island. As we moved to the laser, a discussion about the use of lasers to create products requiring precision ensued. Technical details about our system were given to the girls. Since access to high technology was not available to many of the urban schools represented, our student visitors were full of questions and ideas for the use of laser cutting/etching. In one instance, we had a student who asked if she could send us a design to be cut for her. She dutifully sent the design, which we cut to her specifications and then mailed back to her. These are the connections that the STEM in the Middle program sought to make.

Computer Science for Rhode Island (CS4RI)

CS4RI, a state initiative launched in 2016 to bring high-quality computer science (CS) learning experiences to all students in Rhode Island, continues to thrive as a partnership between state government, state department of education, K-12 schools, higher education, private industry, and nonprofits. CS4RI builds educator capacity by providing district teachers access to a menu of CS professional development opportunities, developing CS K-12 pathways, and supporting districts with implementation strategies and resources. Equity is embedded in all plans and activities.

<table>
<thead>
<tr>
<th>Accessible Opportunities</th>
<th>School districts throughout Rhode Island receive professional development from content providers that they choose from a menu of options. In this way, districts can partner with a provider that works best for their students’ needs and capabilities.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empowering Physical and Social Environment</td>
<td>Professional development focusing on effective and inclusive practices offered.</td>
</tr>
<tr>
<td>Continuing Support</td>
<td>Teachers encouraged to support individual students after recruitment and enrollment in classes.</td>
</tr>
<tr>
<td>Foundational Knowledge</td>
<td>Equity embedded in the Rhode Island Computer Science Standards as well as the descriptions and the accompanying suggested activities.</td>
</tr>
<tr>
<td>Gender and Culturally Aware Pedagogy</td>
<td>Professional development workshops, online courses, and supplemental resources focusing on broadening participation and equity offered.</td>
</tr>
</tbody>
</table>

Million Women Mentors – Rhode Island Affiliate

Million Women Mentors (MWM) is a national movement with the shared goal of attracting and retaining more women in the STEM (science, technology, engineering, mathematics) fields through high-quality mentorships. The Rhode Island affiliate includes members from industry, education, community-based organizations, and nonprofits across Rhode Island and focuses on building awareness for mentorship, partnering with mentoring organizations, and providing outreach to students in Rhode Island.

<table>
<thead>
<tr>
<th>Accessible Opportunities</th>
<th>Mentoring partners include organizations that work with groups currently underrepresented in STEM including: Girl Scouts of Southeast New England; YWCA, Rhode Island, and MentorRI.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empowering Physical and Social Environment</td>
<td></td>
</tr>
<tr>
<td>Continuing Support</td>
<td></td>
</tr>
<tr>
<td>Foundational Knowledge</td>
<td></td>
</tr>
<tr>
<td>Gender and Culturally Aware Pedagogy</td>
<td></td>
</tr>
</tbody>
</table>

levels of equity

For simplicity, the tables used above identify ways the listed programs approach equity. However, they should also list at what level of success they are situated. Are the programs/initiatives emerging (no serious effort), approaching (some effort), developing (adequate effort) or mature (strong effort) as they relate to issues of equity?

For example, the STEM in the Middle program addressed accessible opportunities by inviting students during the school day so teachers can take advantage of the buses available to schools. No student was excluded due to lack of transportation or other conflicting commitments. This effort could be judged to be approaching since some obstacles to participation were eliminated. However, much more can be done. In another example, gender and culturally relevant pedagogy may be classified as developing in the CS4RI initiative since professional development workshops, online courses, and supplemental resources focusing on broadening participation, effective and inclusive practices, and equity are continually and frequently offered to teachers. However, there is a need for improvement since implementation of these practices is voluntary and no follow-up measurement is applied. Perhaps additional columns are needed in the table to illustrate the complex process (page 23).

equity—an ongoing process

Equity in STEM/STEAM in Rhode Island continues to be an ongoing process. Equity is not . . .

- A milestone to be reached or
- A box to be checked or
- One-size-fits all.

It is a continuous journey with different levels of success. Equity in STEM/STEAM is a complex issue that requires a multipronged approach in response to, but not limited to, differing student needs and capabilities, fluid environmental and social factors, and inequitable resources and support. In Rhode Island, the challenge of equity in STEM/STEAM has been identified and acknowledged. Work continues as we address this challenge.

references

### Elements of Equity Components

<table>
<thead>
<tr>
<th>ACCESSIBLE OPPORTUNITIES</th>
<th>EMPOWERING PHYSICAL AND SOCIAL ENVIRONMENT</th>
<th>CONTINUING SUPPORT</th>
<th>FOUNDATIONAL KNOWLEDGE</th>
<th>GENDER AND CULTURALLY AWARE PEDAGOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELEMENTS OF EQUITY</td>
<td>CURRENT PROGRAM/INITIATIVE COMPONENTS</td>
<td>LEVEL</td>
<td>FUTURE ACTIONS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emerging</td>
<td>Approaching</td>
<td>Developing</td>
<td>Mature</td>
</tr>
</tbody>
</table>

- **Future Actions**
  - Accessible Opportunities
  - Empowering Physical and Social Environment
  - Continuing Support
  - Foundational Knowledge
  - Gender and Culturally Aware Pedagogy

---


---

**Carol M. Giuriceo** serves as the director of the Rhode Island STEAM Center at Rhode Island College.

**Charlie McLaughlin** is a Professor of Technology Education and the Coordinator for the Langevin Center for Design, Innovation, and Advanced Manufacturing at Rhode Island College. He can be reached at cmclaughlin@ric.edu.
STEM

its raining,
its pouring

by Emily Yoshikawa Ruesch and Scott R. Bartholomew
overview

This activity allows students to use a familiar children's rhyme to learn and incorporate principles of integrated STEM. Students practice recognizing words, identifying a problem (we want to be able to help the Old Man avoid bumping his head).

This activity is designed to take approximately 90 minutes. The progression includes: reviewing the rhyme, completing a cut-out and fill-in activity, and producing a STEM portfolio. Once the students have worked through the portfolio, they will work to build a prototype of their solution. While prototyping, the students will use “tails” in the classroom to test and improve their designs.

materials

- "Bed" (could be just an improvised headboard or a taped out area in the classroom)
- Handouts (Cut-out/Fill-in activity, STEM design portfolio packet)
- Building materials (e.g., construction/tissue/printer paper, cardboard, pipe cleaners, straws, toothpicks, Styrofoam, tinfoil, etc.)

suggestions for adapting to older grades

- Use a scaled room set and have the students design solutions to scale.
- Have students provide a write-up with reasons and rationale for product.

history

"It’s Raining, It’s Pouring" does not have specified origins.

It is suggested that the song originated in England because of its infamous rainy weather. This rhyme is often sung by children on rainy days when they cannot go out to play.

The first copyright of the rhyme was by Freda Selicoff from Indiana in 1944. There are segments of the rhyme found in newspapers from 1909, but there are no references to the rhyme between 1909 and 1939.

The tune had appeared previous to this by composer Charles Ives but is thought to have existed beforehand.

Source:

Rhyme

It’s raining, it’s pouring,
The old man is snoring.
He went to bed and bumped his head,
And he couldn’t get up in the morning.


It's Raining, It's Pouring lesson plan

Level: Kindergarten
Duration: 1.5 hours

lesson objectives

K.CCSSI_ELA.RR.1. With prompting and support, ask and answer questions about key details in a text.
K.CCSSI_ELA.RR.2. With prompting and support, identify the main topic and retell key details of a text.
K.CCSSI_ELA.RR.3. With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text.
K.CCSSI_ELA.CC.2. Confirm understanding of a text read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood.

phase one

Gather the class together and go over “It’s Raining, It’s Pouring” together. Use the cutout sheets to allow the students to fill in the blanks.

Once you have said the children’s rhyme together, hand out the planning sheets and go over the key details of the rhyme.

- What happened to the man when he went to bed?
- Do you think this could have been prevented? What does "prevented" mean?
- What might the old man have bumped his head on?

identify the problem

Explain to the students that we don’t want the old man to bump his head, so we need to create some device or a way to stop this from happening to him.
**It's Raining, It's Pouring Worksheet**

List three ideas to stop the old man from bumping his head.

1. __________________________________________
2. __________________________________________
3. __________________________________________

Go look at the materials and then list three ideas that you can make using the materials we have.

1. __________________________________________
2. __________________________________________
3. __________________________________________

**activity**

The students will participate in a design challenge where they have to design a way to stop the old man from bumping his head when he goes to bed. There will be teacher sign-offs so that students work through the design process.

On the worksheet, have the students list three things that they could make to stop the old man from bumping his head. When they are done with this, have them get a teacher sign-off.

Once the teacher has reviewed the three ideas, have the students look at materials. Once they know what materials are on the table, have them list three things that they could build with the supplies that are available to stop the old man from bumping his head.

Have the students pick their favorite idea and do a more detailed drawing of it. Once the drawing is complete, have the students find the teacher to explain their product. The teacher can then write down the description of their product.

**build, improve, and share**

From their drawn designs, have the students build. Allow the students to come up and test the design on the “bed” brought into class. As they see what works and what needs improvement, encourage the students to go back and improve and make further iterations of their design.

Find the teacher and explain the drawing to them so they can take notes below.

The students can then come together and, as a class, explain their products, share what they chose, and discuss improvements or questions peers may have.

**Emily Yoshikawa Ruesch** is a Project Lead the Way teacher at the Weber Innovation Center. She currently teaches digital electronics, engineering design, and physics with technology. She can be reached at emruesch@wsd.net.

**Scott R. Bartholomew** is an assistant professor of Engineering/Technology Teacher Education at Purdue University, West Lafayette, IN.

Correspondence concerning this manuscript should be addressed to Emily Yoshikawa Ruesch at emruesch@wsd.net.
It’s Raining, It’s Pouring

It's _________, it's pouring. 🌧️

The old man is snoring.

He went to bed and bumped his _________,

And he couldn't get up in the _________.

---

**Note:** The It's Raining, It's Pouring Portfolio can be accessed at [www.iteea.org/152130.aspx](http://www.iteea.org/152130.aspx), and the It's Raining, It's Pouring Fill-In can be accessed at [www.iteea.org/152128.aspx](http://www.iteea.org/152128.aspx).
optometrists

by Teena Coats and Bryanne Peterson
Optometrists, also known as eye doctors, help people who are having trouble seeing get glasses or contacts to correct their vision.

Optometrists work to promote healthy lifestyle decisions that can affect a patient’s eyesight, such as not smoking and wearing safety glasses when doing dangerous work (BLS, 2018). Optometrists often work in private practices working full-time, either on their own or with a group of other doctors within the same practice.

Optometrists do a lot more than just help people find which set of glasses is best for them. They can diagnose and treat major problems or diseases, injuries, and eye disorders. Optometrists utilize a lot of different technology in diagnosing their patients (BLS, 2018). For instance, they use a special machine called a tonometer, or the puff test, to determine the internal pressure of the eyeball. Tests like this one can inform the optometrists of diseases that affect this pressure and can leave a patient blind if not diagnosed early. However, these doctors are not licensed to do any type of surgery or procedures on the eye itself (AAPOS, 2011). To do this, individuals would have to seek a different doctoral degree along with eight years of residency training.

Individuals who specialize in optometry work hard every day to make sure that everyone can see. Many of these doctors will participate in charity programs that allow them to serve people outside of the United States and make a global impact with the work they do. The work they do is crucial, and the need for them is growing.

references


Teena Coats is currently pursuing her doctoral degree in STEM education at NC State and is a graduate of the Integrative STEM Education MA program at Virginia Tech. She can be reached at tlicoats@ncsu.edu.

Bryanne Peterson, Ph.D., has a decade of classroom experience and now works with educators to improve STEM education and career development in their classrooms. She can be reached at bryanne@vt.edu.
equitably engaging all students in STEM

by Thomas Roberts, Cathrine Maiorca, and Pamela Chapman
The United States faces a shortage of STEM majors and graduates (National Science Board, 2016). Women and minorities are consistently underrepresented in STEM majors and careers (NSF, 2017). With STEM career opportunities continuing to grow (U.S. Bureau of Labor Statistics, 2018), waiting until high school and college to engage students in STEM will be too late because many students decide STEM is too difficult, boring, or uninteresting before they reach eighth grade (PCAST, 2010). Thus, it is imperative for all students, particularly girls and students of color, to receive high-quality equitable STEM learning experiences beginning in elementary school.

“Equitable learning experiences” and, more broadly, “equity” are often used as buzzwords without clear definitions. In this article, equity is comprised of access, achievement, identity, and power (Gutierrez, 2007). In other words, equity focuses on what resources students have, how students perform, how students relate to and bring their cultural capital into subjects, and how they can use their knowledge to make change. Equitable instruction does not look the same for all students. Instead of giving everyone the exact same instruction, equity requires us to meet students where they are. Some students need to be pushed beyond minimum requirements, while other students may need assistive technology to access the project and to communicate their solutions.

When equitable instruction is seen in action, teachers often say “it’s just good teaching” (Ladson-Billings, 1995). Unfortunately, equitable instruction is not happening regularly for all students. This is not because teachers lack good intentions for their students, but because integrating high-quality STEM experiences in elementary school is not an easy task. This could be because elementary teachers have higher levels of mathematics anxiety (Vinson, 2001), science is not consistently taught at the elementary level (King, Shumow, & Lietz, 2001), or that resources, including time and supplies, are limited (Meyers et al., 2015). There are strategies that can be implemented to promote equitable STEM learning opportunities for all students. In the rest of the article a vignette of a STEM activity used in elementary classrooms is presented, the strategies used for equitable learning are unpacked, and suggestions for how these strategies can be implemented elsewhere are provided.

**programming challenge vignette**

Jude, a black male fourth grade student, attends a high poverty, high minority school that recently created a STEM lab. The school has been labeled by the state as a “failing” school based on years of low test scores on culturally biased standardized tests. Jude is an inquisitive young man who often uses innovative strategies to solve mathematics problems, but reads slightly below grade level. He enjoys going to the STEM lab where he is able to explore different topics and test different ideas to solve the challenges the teacher gives the class. Nonetheless, the district-mandated benchmark tests classify Jude as in need of remediation.

Ms. Johnson, the STEM teacher, has years of teaching experiences and initially resisted implementing STEM projects due to the open-ended nature of the problems and their correlation to state-mandated tests. After seeing how students made connections to content through their project work, Ms. Johnson now integrates more STEM projects into her instructions. She leverages relationships with parents and the community to gather supplies and to design authentic projects. Ms. Johnson gives Jude’s class the following challenge: use Scratch to create a game that has more than one background, at least one controllable character, and at least one automated component.

Scratch is a free programming language and online community where people of all ages can create a variety of digital products, ranging from animations to games. After a brief introduction on how to use Scratch, Ms. Johnson allows the students to work on their projects. Over the course of the next week, students design, test, and improve their games. Jude excels at creative problem solving. He brainstorms many different designs for the challenge. He quickly figures out how to create automated components in Scratch. As word spread through the classroom of his discovery, other students ask for his help, which he proudly provides. After students have a first iteration of the game, Ms. Johnson encourages students to get feedback from others, both in the class and outside of school. The next morning, Jude begins making some slight changes to what he previously thought was a finished product. He had asked his cousin, a high school student and avid gamer, for feedback on his game and was implementing some of his suggestions.

By the end of the week, Ms. Johnson has 14 video games from the class of 28 students. Some students, including Jude, created their own game, and collaborated with peers for help. Other students collaborated on a game, allowing some students to specialize on specific aspects of the game, such as creating the setting for the game while their partners explored programming. As students shared their games, they focused not just on explaining how to play the game, but on how they created different backgrounds and explained how they improved their programming to control characters or to increase the difficulty of the game. Ultimately, every student in the class not only met Ms. Johnson’s expectations, but exceeded them and created a tangible product, which was proof of their hard work and brilliance.

**unpacking the vignette**

There are three major strategies the teacher used in the vignette to create an equitable learning environment: project-based learning, valuing and leveraging of student and community knowledge, and focusing on the application of STEM
content. The Buck Institute for Education defines project-based learning as “a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge.” It is important to note here the emphasis on authentic problem solving, which requires a real-world context, open for interpretation and complex, so that it requires collaboration and leads to multiple solutions (Roberts & Chapman, 2017). Thus, knowing your students is critical because students’ lived experiences vary and influence activities that are meaningful for them. For example, a problem centered on apple picking when there are no apple orchards, or a problem based on pollution at the beach where most students have not visited the beach would be less authentic to those students.

In the vignette, the teacher gave students a challenging problem, creating a video game. Creating a video game was authentic for her students because of their interest in video games, both at home and as rewards in school. She also gave them time for sustained engagement with their project. She layered the complexity of the problem so that students had to design the setting of the game, learn how to program characters, and learn how to automate aspects of the game. This activity had a low floor, but high ceiling, and limited barriers to participation. Students could specialize in areas where they were most interested, such as programming or creating a background. Students who were really engaged in the activity could exceed the minimum constraints and add more complex programming to their games. Throughout this project, the students were engaged in “doing” instead of passively completing assignments. Moreover, they were engaged in the content practices, such as Standards for Mathematical Practice (National Governors Association Center for Best Practices and Council of Chief State School Officers, 2010) and the science and engineering practices (NGSS Lead States, 2013). Throughout the activity, students had to ask questions and define problems, persevere in solving problems, develop models, plan and carry out investigation, and then analyze data from their investigations to improve their video games. Ultimately, because students were able to draw on their interests, develop knowledge and confidence, and produce a tangible product in this project, all students demonstrated success and exceeded minimum expectations. Project-based learning, when implemented with appropriate supports and using problems that are authentic to students’ lives, can be a powerful tool to increase learning for all students.

The teacher also valued and leveraged student and community knowledge when completing this project. The open nature of the task allowed for students’ interests and creativity to be reflected in the final project. As students worked on their projects, they eagerly shared new knowledge with others and helped increase students’ confidence in their own skills. The teacher did not prioritize only the knowledge contained within the classroom. Instead, she had students seek help from others whom the students identified as people who could help them, such as Jude’s cousin. This provided a variety of sources of knowledge and valued input from diverse experiences. Moreover, it allowed for community knowledge to be included in the project and valued in the classroom (Calabrese & Tan, 2018). The teacher’s strategic planning empowered students to create a product reflective of their interests, creativity, and knowledge. Moreover, the final product was improved based on their collaboration with their peers and with family/community members with whom students chose to engage.

Finally, the teacher created opportunities for students to apply STEM content knowledge. For example, in the video game, students were applying knowledge of rays, angles, and lines as they programmed the movement of the characters. Activities that require students to apply content have been shown to be effective for increasing students’ interest in STEM and their subject matter knowledge (Coxon, Nadler, & Dohrman, 2018; Roberts et al., 2018). When students engage in activities that show them how subject matter can be applied, they make more connections to why the content is important to their lives.
conclusion

All students should have access to high-quality STEM experiences where they are provided with excellent instruction and supports for them to achieve in the different subjects. Just as important, however, is the need for students to have the opportunity to build positive identities in STEM subjects. STEM is often seen as a white male space (Coxon, Nadler, & Dohrman, 2018) where girls and racial and ethnic minorities, particularly black and Latinx students, are not empowered. In this case, the teacher empowered students who are typically excluded from STEM as she used project-based learning, valued student and community knowledge, and focused on the application of STEM content. The sources of knowledge that teachers value, the tasks teachers provide, and the trust teachers build with students influence students’ perseverance and success.

references


Gutierrez, R. (2009). Framing equity: Helping students “play the game” and “change the game.” Teaching for excellence and equity in mathematics: A publication of TODOS mathematics for all, 1(1), 4-8.


President’s Council of Advisors on Science and Technology (PCAST). (2010). Prepare and inspire: K-12 education in science, technology, engineering, and math (STEM) for America’s future. Executive Office of the President of the United States. Retrieved from https://www2.govovation.com/attachements/117803/public/2a--Prepare_and_Insire--PCAST.pdf


Thomas Roberts is an Assistant Professor at Bowling Green State University where he teaches elementary education courses. He can be reached at trober@bgsu.edu.

Cathrine Maiorca is an Assistant Professor at California State University-Long Beach where she teaches elementary mathematics education with an emphasis in STEM. She can be reached at Cathrine.Maiorca@csulb.edu.

Pamela Chapman is a Principal with the Harper Woods School District. She can be reached at pchapman1913@gmail.com.
Flight project. Photo credit: Julie Sicks-Panus.

Julie Sicks-Panus

The Elementary STEM Journal strives to not only share great ideas, but to also highlight the great work happening in elementary STEM classrooms across the country and around the world. Teacher Highlight will introduce readers to one extraordinary elementary STEM teacher in each issue. Each featured teacher is either an ITEEA Teacher Excellence Award winner or is part of an ITEEA Program Excellence Award-winning program at an elementary school. We congratulate them for the great work they do for their students and thank them for being willing to share their experiences in The Elementary STEM Journal.

Julie Sicks-Panus is a STEM Teacher at Plymouth Elementary School in New Hampshire.

by Julie Sicks-Panus
Teaching STEM, in her own words:

Life and learning is (or should be) one big integrated system—STEM is a great way to achieve integrated learning. As a STEM teacher at Plymouth Elementary School, I work to develop engineering design challenges that utilize, enrich, and extend the concepts students are learning in math and science classes. Students come to my classroom as a "special" for one 40-minute class once during each 6-day rotation. I meet with classroom teachers regularly to ensure that the engineering challenges are utilizing and reinforcing the concepts classroom teachers are covering. Several grade levels have worked with me to develop fully integrated units. At PES, we have seen that, despite being taught asynchronously (schedules do not allow for team-teaching), the units are powerful learning for our students, helping them carry knowledge from one "silo" to the next and apply skills from one in the other.

I work to challenge students with ideas and problems that stretch their abilities without overwhelming them so that even the kindergarteners and first graders can strive to meet criteria and stay within constraints of a design problem, "try and try again" with iterative design, then feel the joy of creating a successful design. I challenge my students to deconstruct and understand function to build an understanding of how to create function. Real-world problems and meeting human needs and wants is integral to engineering design, helping students see that they can help shape our future: their ideas, knowledge, and passion can solve real problems.

Any elementary STEM program should be rooted in the engineering design process, focusing on iterative design within the criteria and constraints of a real-world challenge. Successful programs will support, extend, and enrich the whole curriculum—ideally STEM is the core around which the subjects and topics are woven.
by Douglas Lecorchick, Victoria Anne Hoeveler, and Gianna Mastrandrea
overview

Disney animators, F. Thomas and O. Johnston, circa 1980 developed twelve principles of animation that are still the foundation of animation programs today. These principles can be taught to elementary students, provided the correct platform and pedagogy. This feature provides the platform and the storybook format as the pedagogical approach.

teacher script

Class, today we continue learning about animation. Animation is “bringing to life.” When we draw, either with a pencil and paper or we begin to model using software on a computer to bring those drawings to life, this allows us to become the “Animator.” We will read chapters 4 and 5 today and complete the activity at the end of each chapter.

Animation Adventureland

Chapter 4 - Animation Principle of Timing

Miss Petunia knew just where to take them next. She led them over the hill and into an open field. The birds chirped and Pocket squeaked back at them.

“Now for the fourth trial, you two must understand Timing.” Miss Petunia handed them lots of paper and crayons. Then with a wave of her wand, clouds began to float across the sky as if a great gust of wind had pushed them. “With Timing, the more clouds you draw the slower they will move. If you draw fewer clouds then they will get faster and faster! Let’s see you draw them. First they should move slowly and then grow quicker. Good luck, I know this one is tricky!”

Millie and Matias exchanged looks of excitement.

“Why don’t you draw the clouds moving slowly and I’ll draw them getting quicker?” Millie asked. “I think I should just draw fewer clouds than you.”

Matias furiously colored his pages without acknowledging Millie. He appeared too excited to listen.

Millie drew a series of four clouds spread across the page to show how they move quickly. Yet Matias also drew four clouds in nearly the same position. Once finished they called Miss Petunia over to check their work. Matias handed his drawing to Miss Petunia first and then Millie handed over her clouds.

Miss Petunia eyed their drawings.

“The clouds moving quickly look great! But I think your clouds moving slowly could use some work. Why don’t you try again?” Miss Petunia nodded encouragingly. “Keep your eyes on the clouds and how they move in the sky,” she smiled.

Millie thought about how to fix Matias’s clouds. Eventually she realized the solution was simple! All they had to do was draw more clouds closer to one another, as the more clouds there are, the slower the drawing will appear to move.

“I know just what to do,” Millie said.

“I know we can do it!” Matias exclaimed.

And that was just what they did. Together, they drew a series of ten clouds in a single line. Soon, Miss Petunia came to check their work. First it was Matias’s drawing, depicting the clouds moving slowly and then Millie showed her clouds speeding up.

“Amazing! I can tell you two worked really hard on Timing. I can’t wait to see how you two take on the next challenge!” Miss Petunia gave them a high five.
Chapter 5 - Animation Principle of Anticipation

Miss Petunia decided to keep Matias and Millie in the same field for their next challenge.

"Now for the fifth trial, I must see you two master Anticipation. You must work together to see the movements leading up to a jump. Matias can you jump up and down for me?" Miss Petunia asked and Matias crouched down and then jumped as high as he could!

"In order to understand Anticipation, I must see you draw a series of movements that depict Matias jumping. The Anticipation of the jump is what I will focus on. Have fun!"

And with that, Miss Petunia left them to work on their drawings.

Matias giggled as he jumped up and down for Millie to draw.

"If I draw you standing and then in the air, it should be perfect!" She said and then did just that.

She drew Matias in standing position and then way up in the sky! But for some reason it didn’t quite look right.

Miss Petunia came over to check their work.

“Hmmm. Could use some more parts. You’re missing the crucial Anticipation of the jump. Right now it looks as if Matias is just flying away, rather than jumping into the air. Here I’ll give you a quick hint. It’s similar to Squash and Stretch.” Miss Petunia's brows rose at the challenge.
“Squash and Stretch?” Millie scratched her head in confusion. “What could that possibly mean?”

“Here, I have an idea!” Matias smiled. “Can you jump for me and I’ll draw you?” Millie nodded and began to jump for him.

Matias drew Millie crouching, in a standing position, and lastly jumping in the air. After finishing, he ran over to show Miss Petunia his hard work.

“Looks good to me, but can you point out the point of Anticipation?” Miss Petunia asked.

Matias pointed to where Millie is crouched. “It’s right here!

“Great, the Anticipation is in the crouch! It shows the viewer that Millie is about to take off into the air. Wonderful job, you two, and great teamwork!”

**Student Activity**

Now it’s time for you to try! Let’s see you draw somebody giving a high five with anticipation.
NEW KELVIN® Kel-Air™ Air-Powered Dragster Launcher
NEW VERSION features Digital Pressure Display
Gauge that shows exact pressure measurement.

KELVIN® Economy Motion Timer
$99.95

KELVIN® Elite Kel-Timer™ Motion Timer
The NEW KELVIN® Elite Kel-Timer™ features REDESIGNED start/finish sensors with LED lights that can be aligned quickly and easily.

KELVIN® Night Light
A photocell turns on/off a super bright LED as the room darkens or lightens. Night Light Battery Charger, #842432.

KELVIN® STEM Lab: Alt. Energy
Experiments with Wind, Solar & Hydro, #842472
Find Additional S.T.E.M. Labs at www.kelvin.com

$75

KELVIN® Basic Car Platform
Add your own body design from foam, cardboard, etc. Each kit includes wood base, wheels, axles & straws. Shaping, hot gun gluing & assembly req.

842439 Kit ...................................... $2.95 or $2.45 ea./10+
841417 Bulk Pack for 100............................ 99¢ Per Kit

KELVIN® is #1 Innovation in Education

KELVIN® is #1 Innovation in Education