TABLE OF CONTENTS

PRU9204 • 9781760569204 • © 2018 Hawker Brownlow Education

Table of Contents

Why STEM?

STEM (science, technology, engineering and maths) education is much more than the mashing together of these subject areas. In this book, students will utilise STEM principles to engage in project-based learning through performance-based projects. These projects will involve:

- Designing, developing, and utilising technological systems
- Open-ended, problem-based design activities
- Cognitive, manipulative and effective learning strategies
- Applying technological knowledge and processes to real world experiences using up-to-date resources
- Working individually as well as in a team to solve problems (International Technology and Engineering Educators Association, 2016, para. 3)

Typically, students utilising STEM principles to engage in PBL will:

- Access and synthesise prior knowledge in science, maths and technology to solve a real-world problem
- Research and collect evidence to solve a problem
- Gain firsthand experience on how science, maths and technology solve problems in the real world
- Conceptualise, build and test concrete models of solutions
- Work collaboratively to critique and build on their peers' ideas
- Communicate and defend solutions based on evidence (Advancement Courses, 2015, para. 3)

STEM-based PBL provides students with authentic learning experiences. Through such experiences, students understand the context of how what they are learning fits into the real world. This means that students are better equipped to apply a concept or skill in a later project or unit, as well as when they go on to college or enter the workforce. By developing authentic products and solving real-world problems, students are able to experience and see firsthand how classroom concepts work in real-world settings. By utilising STEM principles, they are also able to see how concepts connect across subject areas.

Traditionally, students might work on maths for 45 minutes. Then, the bell rings, and the maths books and work go away, only to be replaced by science books and assignments. When the bell rings again, everything

students have been learning about is put on hold, and they transition into learning about something else. This is a very unnatural way to learn about science and maths – and any other subject, for that matter. Maths and science are subject areas that are very close cousins, with a lot of overlap between the two of them. Why do we try so hard to separate them?

Anyone who lives in the real world knows this is not how it works. Oftentimes, you employ several different areas of learning while working on a single project. For example, the simple act of making dinner uses several disciplines:

- **English:** Reading the recipe or the directions for preparing the meal.
- **Maths:** Measuring out what is needed to create the meal and using a timer to determine how long it should cook.
- **Science:** Understanding when water is boiling, an oven is warmed or what to mix and what not to mix together to get the desired results.

By completing almost any task, you integrate different subject areas to be able to achieve a goal. That is the way our lives work, and it is how classrooms should work as well. If the STEM education initiative has done anything, it has taught teachers and students how all of these areas work together and how they can be used collectively to achieve a greater accomplishment than if using a single subject area.

You can also use STEM-based PBL to engage students in the engineering design process (Engineering is Elementary, 2018). See Figure 2 for a breakdown of the process. This five-step cycle (ask, imagine, plan, create, improve) is the same process real-world engineers utilise. This is a sound process that can even be applied to subjects unrelated to science, technology, engineering or maths.

For example, if you have asked students to write an essay on what their favourite colour is, they could easily go through these steps in order to complete their task:

- **Ask:** Students ask and consider, "What is my favourite colour?"
- **Imagine:** Students ask and consider, "Why is it my favourite colour?"
- **Plan:** Students ask and consider, "How could I explain to others why it is my favourite colour, and what examples could I use?"
- **Create:** Students write their essays.
- **Improve:** Students read through their essays, looking for clarity, as well as spelling and grammar errors.

PRU9204 • 9781760569204 • © 2018 Hawker Brownlow Education

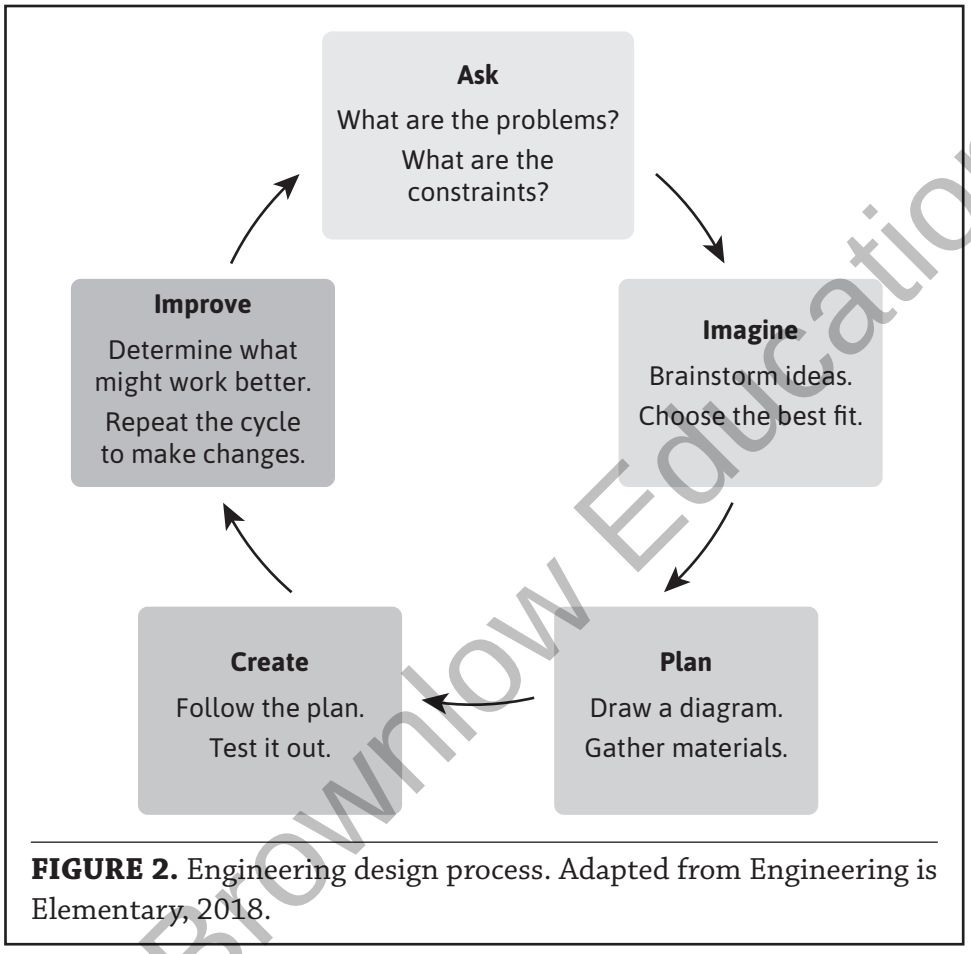

FIGURE 2. Engineering design process. Adapted from Engineering is Elementary, 2018.

The engineering design process gives students a good, solid model to follow, which can be applied throughout STEM areas, as well as to social studies, art and even PE. Once students are familiar with the engineering design process, they will intrinsically revert to it whenever they are working on something. This is the true value of STEM learning.

Why STEM and PBL?

STEM-based PBL naturally lends itself to the formation of 21st-century skills, which are crucial to students' development in school and beyond. STEM learning engages students and equips them with critical thinking,

problem solving, creative and collaborative skills. Because of the authentic nature of STEM-based PBL experiences and the final products that students create, students also develop communication skills as well as self-direction. STEM and PBL create a perfect marriage in ensuring students are ready to be the leaders of tomorrow.

How This Book Is Organised

This book features 10 projects. Each project is linked to national STEM education goals. In selecting projects and the skills that they emphasise, I utilised the STEM Learning Goals and the System Dynamics and Systems Thinking Tools and Learning Strategies that make up effective STEM education, according to Creative Learning Exchange (2016; see Figure 3), as a framework.

Each project focuses on a selected skill crucial to STEM learning; however, note that additional goals, big ideas, and essential questions are outlined in the introduction to each project:

- **Project 1:** Communicate effectively.
- **Project 2:** Focus on inquiry and collaboration.
- **Project 3:** Understand multiple content areas.
- **Project 4:** Explore contemporary issues.
- **Project 5:** Use technology, maths and reasoning.
- **Project 6:** Use and analyse models.
- **Project 7:** Record and analyse data.
- **Project 8:** Investigate change over time and patterns.
- **Project 9:** Use computer models or simulations.
- **Project 10:** Construct and explain systems.

PRU9204 • 9781760569204 • © 2018 Hawker Brownlow Education

1 Communicate Effectively

The ability to communicate effectively – both verbally and in writing – is crucial to our students during their time in our classrooms and beyond. Consider a lawyer. He has to be able to write legal briefs that enable him to build his case. He also needs to communicate these briefs to the judge or court in order to effectively represent his clients. Doctors also use a combination of these skills. They have to be able to communicate effectively with their patients in order to explain what is going on, and they have to record what they learnt into patients' files so that there is an established record of patients' health. These are simplified examples, but that does not diminish the importance of communication skills.

Teachers, especially, utilise communication in their profession, from teaching concepts to a class, to communicating with parents, administrators and other stakeholders. If a teacher is effectively going to provide feedback to students, they must be able to convey this feedback both in written and verbal form. This double reinforcement better equips students to learn from mistakes and strive for improvement in the future.

What does communication look like in a STEM project? It can take a variety of forms, depending on the product that students are asked to produce. For example, if students have been charged with defending a proposal for a design for a product they wish to market to an authentic panel,

they will have to employ their speaking skills in order to effectively communicate their plan. Such a presentation requires a combination of style and substance – style in the manner in which the proposal is presented and substance in the quality of the information presented. Characteristics of high-quality presentations of this nature might include:

- The presentation can be clearly heard the entire time, and the participant speaks slowly and clearly throughout.
- The presenter's demeanour is professional throughout. It sounds as though the presentation has been rehearsed several times.
- The presentation is organised in a manner that makes it easy to follow and to understand what is going on at any given time.

If, however, students were charged with creating a brochure that conveyed the information for the project, they would have to communicate in written form. Characteristics of high-quality products of this nature might include:

- The brochure has little to no spelling/grammatical errors.
- The brochure is typed in a format that makes it easy to view.
- The brochure uses sentence structures that make the paragraphs flow and easy to read.

No matter which style students are asked to communicate in, the substance needs to have the same quality. These descriptors could be used for either written or spoken products:

- The project is organised clearly, allowing someone to know what is being discussed at any given time.
- The student provides plenty of examples to back up statements made.
- The student provides much detail, explaining concepts and ideas so that someone can gain a full understanding of what is being talked about.

It is important that any project you present to students requires them to utilise both written and spoken skills so that students display competence in any venue. This will make them that much more effective when going out in the real world to find themselves a job. After all, the top job skills that companies are looking for in new hires all have to do with communication (Graduate Management Admission Council, 2018; see Figure 4). If you were to help your students master both written and verbal com-

PRU9204 • 9781760569204 • © 2018 Hawker Brownlow Education

munication, they would have an advantage over other potential hires who are less accomplished with these skills.

1. Oral communication
2. Listening skills
3. Adaptability
4. Written communication
5. Presentation skills
6. Value opinions of others
7. Integrity
8. Follow a leader
9. Drive
10. Cross-cultural sensitivity

FIGURE 4. Top 10 skills sought by employers. Adapted from Graduate Management Admission Council, 2018.

Magnetic English

In this project, students will create a system that allows others to write their own poetry, much like the popular magnetic poetry kits that allow users to rearrange word magnets to write poems. Students' systems should have instructions and prompts in place to help users who may not know a lot about poetry. Users should also have a wide variety of words and phrases to choose from and be able to easily rearrange them to edit and revise their poems.

Students' poetry systems could be as simple as words written largely on a sheet of paper or words displayed on large building blocks. Students should be as creative as they like, but in the end, people need to be able to use their systems to easily create their own poetry.

Materials

- Magnetic poetry kits (for student use)
- Project Outline: Magnetic English (student copies)
- Suggested Timeline
- Lesson: What Is Poetry?
- Lesson: Lines and Stanzas
- Lesson: Rhythm/Rhyme
- Lesson: Tone and Mood
- Handout 1.1: Poetry Auction (student copies)
- Product Rubric: Magnetic English (student copies)