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10 Projects for the PBL Classroom: Science

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INTRODUCTION

Why Project-Based Learning?

Twenty-first century skills, or survival skills, as termed by Tony Wagner in his book *The Global Achievement Gap* (2014), involve students being able to do more than memorise facts and instead apply skills and, more importantly, problem solve (Stoof, Martens, Van Merriënboer & Bastiaens, 2002). In short, teachers are tasked with the difficult job of trying to create thinkers. This results from businesses complaining that the best and brightest students that the educational system is sending their way are very intelligent but woefully inept at figuring out problems, arguing students know a lot of "facts" but are not "competent" (Bastiaens & Martens, 2000). Any teacher able to help students become these thinkers would be providing them with an advantage when they enter the real world.

The educational system has to do a better job of preparing students to solve real-world problems. How do we do that in the current system of standards and testing? With so much at stake on these achievement tests, the bigger question is: how often in life are we asked to take a pencil-and-paper test? Not very often unless you count online personality quizzes. In real life we are usually dealing with projects, either at work, home or other settings. If we truly want to get students ready for the real world, we should be teaching them how to handle the real-world dilemma of a project.

As mentioned in *Project-Based Learning for Gifted Students: A Handbook for the 21st-Century Classroom* (Stanley, 2012), according to the Buck

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Institute for Education, research studies have demonstrated project-based learning can:

- increase academic achievement on standardised assessment tests
- teach maths, economics, humanities, science and health-related subjects more effectively than traditional teaching methods
- increase long-term retention of knowledge, skill development and student and teacher satisfaction
- prepare students to integrate and explain concepts better than traditional instructional methods
- prove especially helpful for low-achieving students
- present a workable model for larger school reform
- help students to master 21st-century skills such as independent and critical thinking, communication and research. (p. 4)

This is why project-based learning is such a good fit for creating such thinkers. It has been discovered that students:

- prefer to structure their own tasks they are working on and establish deadlines as opposed to having the teacher assign them (Dunn, Dunn & Price, 1984; Renzulli, Smith & Reis, 1982; Stewart, 1981)
- learn more and retain content more accurately when allowed to work on projects in which they set the pace (Whitener, 1989)
- show an increased benefit in learning when they teach each other through projects (Kingsley, 1986; Johnsen-Harrris, 1983)
- show improvement in cooperative learning skills when working in groups because they must work together to solve problems (Peterson, 1997)
- show increased engagement after participating in PBL than students who did not (Grant & Branch, 2005; Horton, Hedetniemi, Wiegert & Wagner, 2006; Johnston, 2004; Jones & Kalinowski, 2007; Ljung & Blackwell, 1996; McMiller, Lee, Saroop, Green & Johnson, 2006; Toolin, 2004).

Based on this research, a better question to ask is not why use project-based learning, but rather why not use project-based learning?

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What Are the Advantages of Using PBL in a Science Classroom?

Project-based learning is an excellent vehicle to teach 21st-century skills. In *21st-Century Skills: Learning for Life in Our Times* (2009), Bernie Trilling and Charles Fadel mentioned, among valuable 21st-century skills, eight specific skills that PBL can effectively teach:

1. public speaking
2. problem solving
3. collaboration
4. critical thinking
5. information literacy
6. creativity
7. adaptability
8. self-direction. (p. viii)

Science lends itself to the skills of creativity and adaptability. Creativity involves outside-the-box thinking. When you think about the greatest outside-the-box thinkers, you might consider Leonardo da Vinci, Albert Einstein or Stephen Hawking – all of them scientists. How much of an outside-the-box thinker must one be to propose that the sun is the centre of the universe when other scientific experts placed the Earth at its centre? Or how creative was the individual who suggested that man evolved from apes even though the popular doctrine was more divine? As radical and preposterous their thinking was in their times, Copernicus's and Charles Darwin's theories are now accepted as scientific fact. It took these men questioning what they had been told and being creative enough to think of better solutions. How creative are today's scientists who are able to create computers that fit in the palm of your hand or cars that run on electricity? Creative writers can imagine all the crazy, outside-the-box ideas they want – but these are just words. Scientists actually create these advancements. How many ideas from Jules Verne's imagination became reality due to a scientist creating it, including the submarine, videoconferencing and the taser gun? Without the creativity of scientific minds, we would probably still be living in caves, but some creative individual figured out how to use fire – and the world has never been the same.

You might wonder how students can use creativity in the science classroom. Are they not just learning facts that someone else was creative

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enough to discover? How much creativity can be used in learning the elements or knowing the three stages of the rock cycle? How outside-the-box can one get while learning about different types of clouds or the states of matter? The non-scientific answer – plenty. In the science classroom, students need the chance to be innovative and creative. After all, the very nature of science is questioning and thinking outside of the box. And being able to think creatively is essential to students' futures. Some overseas studies have listed the two fastest-growing occupations as biomedical engineers and network systems and data communications analysts. Both of these careers require workers who can be innovative and think creatively (Haines, 2011).

Even a brief glance at the content descriptions listed in the Australian Curriculum reveals a need to master many skills:

- Questioning and predicting: With guidance, pose clarifying questions and make predictions about scientific investigations
- Processing and analysing data and information: Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends
- Processing and analysing data and information: Compare results with predictions, suggesting possible reasons for findings
- Evaluating: Reflect on and suggest improvements to scientific investigations
- Communicating: Represent and communicate observations, ideas and findings using formal and informal representations
- Communicating: Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts

Science also relies on adaptability. If you need proof of its importance, look no further than Thomas Edison, one of the greatest inventors and scientists of all time. Some of his inventions include the motion picture camera, phonograph and the mimeograph. Arguably his greatest invention was the incandescent light bulb. While testing his experiment, Edison went through various materials to use as its filament. He tried platinum, but that was too expensive. Carbon burned up too easily. He used carbonised sewing thread, but the bulb would not last more than a day. Finally, while fanning himself on an especially hot day, he unwound a thread of bamboo from the oriental fan he was using. He carbonised it and experimented with it as a filament – and history was rewritten. When asked about his

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The student's goal in an oral presentation is to verbally teach classmates or the audience what they have learnt after researching a particular topic or skill. A successful oral presentation needs to be set up just like an essay would, with a topic sentence, supporting details and several drafts before the final presentation. This structure is something that should be taught to students. This can be done with modelling, looking at exemplary examples of great oral presentations or practising presentations with no consequences.

Survival of the Fittest

Plants and animals have both internal and external structures that allow them to survive. In this project, students will research and study a specific plant or animal, looking at what internal and external structures it has that allow it to survive and grow, and how those structures affect behaviour and reproduction. They will then present their findings to the class.

Materials

- Project Outline: Survival of the Fittest (student copies)
- Suggested Timeline
- Lesson: What Helps Organisms Survive?
- Lesson: Conducting Research
- Lesson: What Makes a Good Presentation?
- Handout 1.1: Internet Scavenger Hunt (student copies)
- Handout 1.2: Researching Your Topic (student copies)
- Handout 1.3: Organism Graphic Organiser (student copies)
- Handout 1.4: What Makes a Good Presentation? (student copies)
- Handout 1.5: Peer Review (student copies)
- Product Rubric (student copies)

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Biome in a Biodome

In this project, students will work in groups of five to create an ecosystem for a biodome. They will decide the features of the ecosystem, as well as the organisms that inhabit it. They must select organisms – producers, decomposers, herbivores, omnivores and carnivores. Each must be from a different ecosystem and must allow the ecosystem to maintain itself over a number of years. They will develop a model of their biodome and present it to a panel, justifying their decisions. The panel will then take counterpoints from the audience and decide which proposal they believe will be the most successful.

Materials

- Project Outline: Biome in a Biodome (student copies)
- Suggested Timeline
- Lesson: What Is an Ecosystem?
- Lesson: Roles in an Ecosystem
- Lesson: Different Types of Ecosystems
- Lesson: Creating an Argument
- Handout 2.1: Exploring Ecosystems (student copies)
- Handout 2.2: Ecosystem for Biome (student copies)
- Handout 2.3: Creating an Argument (student copies)
- Product Rubric (student copies)

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