SUPPLEMENT

Quality Learning and Teaching in Primary Science and Technology

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UNIVERSITY OF TECHNOLOGY SYDNEY

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In 2015, AISNSW released an in-depth literature review that aimed to address the broad research question: *What characterises quality teaching and learning in primary science and technology?*

The literature review, *Quality Learning and Teaching in Primary Science and Technology*, covered a range of focus areas including:

- broad context of science and technology education in Australia
- relationship between science and technology in the NSW Syllabus for the Australian curriculum Science K-10 (incorporating Technology K-6)
- factors that influence effective teaching and learning of primary science and technology.

CURRICULUM

The Australian Curriculum, Assessment and Reporting Authority (ACARA) provides a separate Foundation to Year 10 learning framework for Science, and for Technologies (including Design and Technology, and Digital Technologies).

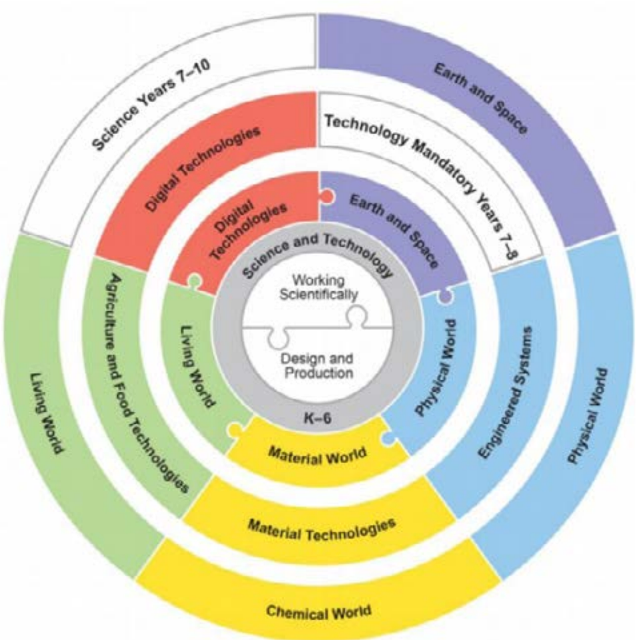

Figure 1: Organisation of Content - Science and Technology K-6 Syllabus[1]

Kindergarten to Year 6 Science and Technology forms part of this broader continuum of learning. The latest revision to the Australian Curriculum Science and Australian Curriculum Technologies syllabus by ACARA took place in 2017.

In New South Wales (NSW), the NSW Education Standards Authority (NESA) is responsible for the development of syllabuses for schools, which include content descriptions and achievement standards from the Australian Curriculum. In NSW, the syllabus documents are designed using an 'adopt and adapt' approach – the Australian Curriculum is adopted, with adaptions to suit the NSW contexts. Subsequent to the review of the Australian Curriculum, the NSW Syllabus was reviewed and updated to reflect the newly developed Australian Curriculum Band Descriptions for Digital Technology. Design and Production replaced Working Technologically as one of the two key skills areas, while Working Scientifically was retained.

The organisation of content in the NSW syllabus highlights an integration of knowledge and understanding, skills, and the learning continuum across the curriculum. Teachers are expected to program units of work that reflect the real world, and engagement with both nature and the built environment. The NSW syllabus provides guidance about the scope of learning to aid in the interpretation of the syllabus outcomes.

The study of Science and Technology in K–6 enables students to explore scientific and technological concepts and develop knowledge and understanding of the world; enabling them to inquire, plan, investigate and develop solutions to problems. Through the application of Working Scientifically, and Design and Production skills, students develop an interest in and an enthusiasm for understanding nature, phenomena and the built environment.

NSW Science and Technology K-6 Syllabus[1]

TEACHING MODELS AND APPROACHES

Research supports student inquiry as an effective pedagogical tool for the teaching of science and technology. There are numerous models available to educators, and it is recommended that any being considered are carefully assessed for relevance to each unique classroom and school context. Student needs, ways of learning, and syllabus outcomes should remain the key factors influencing an educator's choice of model for use in the classroom.

NSW teachers are increasingly engaging with a broad range of frameworks in support of teaching in an inquiry based way. Four approaches in particular have gained traction over recent years that may be of interest to teachers of science and technology.

Design Thinking

Design Thinking has been highlighted in the NSW Science and Technology syllabus[1] as a useful tool to support elements of the design process. This approach was originally developed for use at Stanford University[2] and is recognised for its ability to stimulate creativity, critical thinking and problem solving. Rather than a complete framework, the processes involved in Design Thinking can be applied to a range of problem solving situations. This may include generating ideas for a project, or used to solve a problem as part of the investigation process within another inquiry framework. The depth and time taken to move through the various Design Thinking stages can vary depending on the purpose for their inclusion.

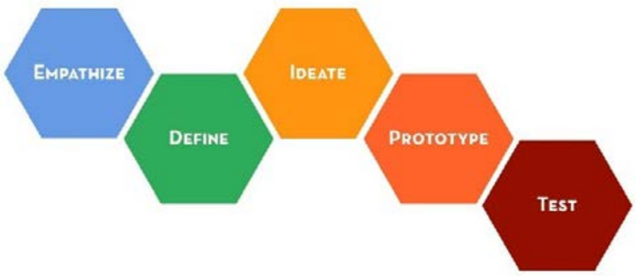

Figure 2: Stanford University Design Thinking[4]

Project Based Learning

Project Based Learning (PBL) is 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"*[3]

Project Based Learning (PBL), and its emphasis on an inquiry process, is recognised for its benefits across a variety of curriculum areas including science and technology. PBL provides opportunities for teachers to facilitate deep, sustained engagement by students with real world knowledge and skills. In a successful, or gold-standard PBL project[3], students are empowered through collaboration and encouraged to engage higher order thinking skills. It is helpful to view Project Based Learning as a series of layers that support teachers in unit planning, provides frameworks for structuring learning, and offers teaching approaches that assist in enhancing student engagement.

Seven essential project design elements can assist in enabling high quality integration of Project Based Learning in a school or classroom. This model can assist an educator measure and understand the success of PBL projects, while supporting development of student skills, knowledge and understanding.[13]

- **Challenging Problem or Question** – meaningful and appropriate to the level of challenge.
- **Sustained Inquiry** – extended process of exploration.
- **Authenticity** – real world context that are relevant to students.
- **Student Voice and Choice** – students decide on aspects of the project.
- **Reflection** – collaborative reflection to understand effectiveness of inquiry and activities.
- **Critique and Revision** – feedback shared to help improve process and product.
- **Public Product** – work shared with audiences beyond the classroom.

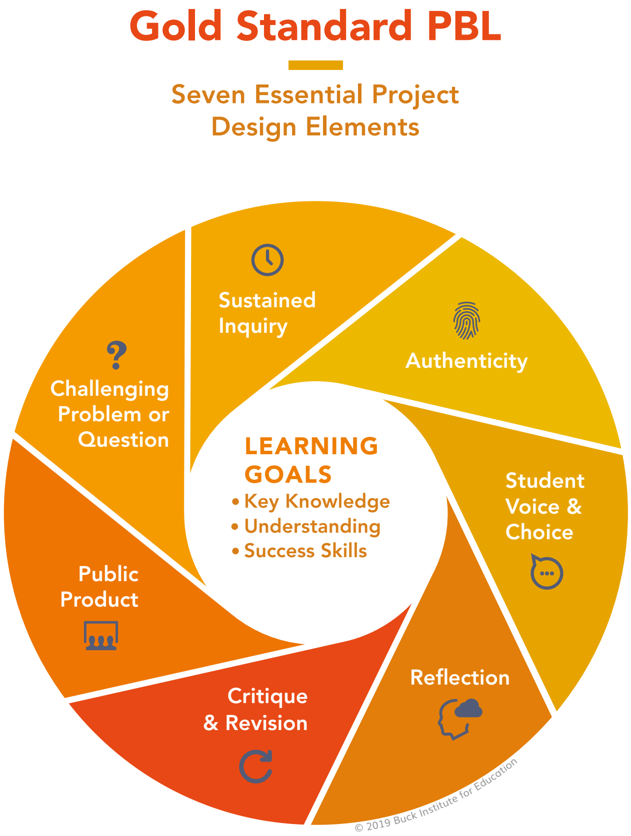

Figure 3: PBL Works[3]

Effective Project Based Learning relies on teachers guiding learning and considering an alternative range of teaching approaches. Seven are proposed as a way of reframing more traditional instructional practices for a PBL context[14]

- **Design and plan** – project adapted for unique context, with room left for some student input.
- **Align to standards** – mapping to ensure key knowledge and understanding from the curriculum are met.
- **Build the culture** – open-ended inquiry, collaboration and student independence is promoted.
- **Manage activities** – students are supported to develop tasks and schedules.
- **Scaffold student learning** – variety of instructional strategies used to support all students in achieving project goals.
- **Assess student learning** – knowledge, understanding, and skills are assessed using formative and summative methods.
- **Engage and coach** – collaborative learning by teachers and students, with skill building and support provided where needed.

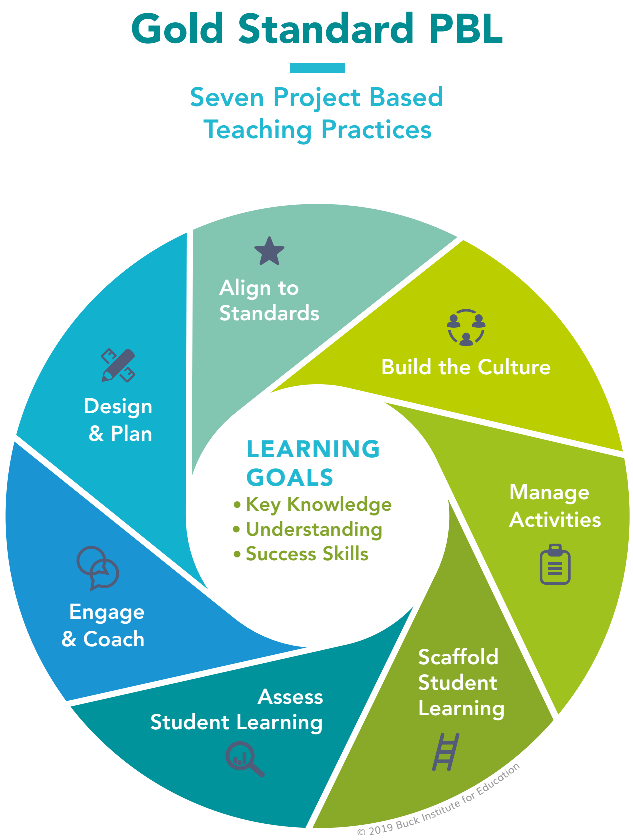

Figure 4: PBL Works[3]

The degree of guidance required for effective Project Based Learning in Primary education has been the source of some debate by educators and academics[5,6]. It is recommended that close consideration is given to context, student ability and need when looking to apply Project Based Learning as an approach in any school environment.

Guided Inquiry Design

It is *"a way of thinking, learning and teaching that changes the culture of the school into a collaborative inquiry community"*[15]

Guided Inquiry Design (GID) is a model for inquiry that can be applied across a whole school (K-12). It was originally developed by a team of three educators from different fields of education to support teachers in addressing student learning needs in an inquiry process. The model emerged from a library and information services perspective, but has been recognised for its benefits in helping teachers leverage instructional design when supporting students in science and technology inquiry. GID is a learning centred model that adopts a constructivist approach and can assist with research based investigations[7,8]. The structure of the process is not strictly linear, with overlap possible as a student progresses through the various stages of the model. GID supports a reframing of the teacher's role, where they become more of an instructional designer and facilitator who encourages student questioning and curiosity[16].

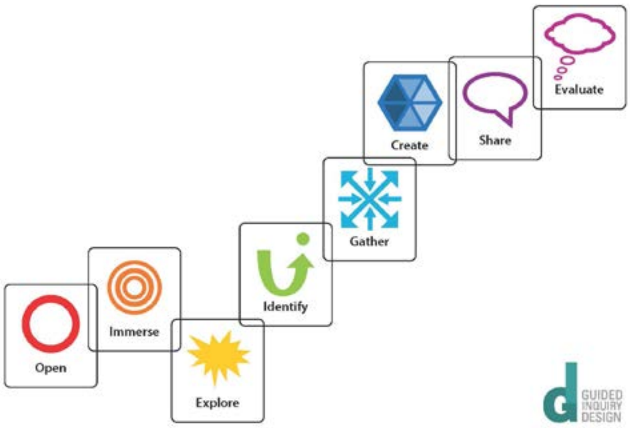

Figure 5: Guided Inquiry Design process[9]

- **Open** – Activities are done to engage the learners and invite them to the inquiry.
- **Immerse** – Students engage with background knowledge and skills to support the inquiry.
- **Explore** – Sources of information are used to form a series of questions.
- **Identify** – A focus is formulated by the students.
- **Gather** – Evidence is collected about their inquiry question in a variety of ways and meaning is explored.
- **Create** – This phase is where students translate then shape ways to share their understanding in creative ways such as written information, making a model or coding.
- **Share** – Students learn from each other by sharing their projects.
- **Evaluate** – A guided student reflection of the process to complete the cycle.

Murdoch's Phases of Inquiry

The research based inquiry cycle developed by Kath Murdoch is an alternative and non-linear model developed in the Australian context with a K-6 learner focus.[11] It has been influenced by extensive work with students and educators, and is perceived as offering greater flexibility than comparable frameworks such as the 5Es.[7,12] In addition, Murdoch also promotes the use of discovery learning for younger learners and recommends a play-based approach to engaging in science and technology teaching and learning.

Six phases are included in the proposed cycle:

- **Framing the inquiry** – targets indicators of learning and the context, establishes outcomes, goals, skills and dispositions.
- **Tuning in** – includes gathering data, providing a purpose, motivating and engaging students, and helping them make connections.
- **Finding out** – includes gathering and recording information and sharing ideas with others.
- **Sorting out** – encourages students to make meaning from the gathered data.
- **Going further** – encourages the creation of opportunities for students to pursue interests and work independently on their projects.
- **Reflecting and acting** (activated through the cycle) – emphasises the centrality of student questioning and considers its importance in the inquiry process.

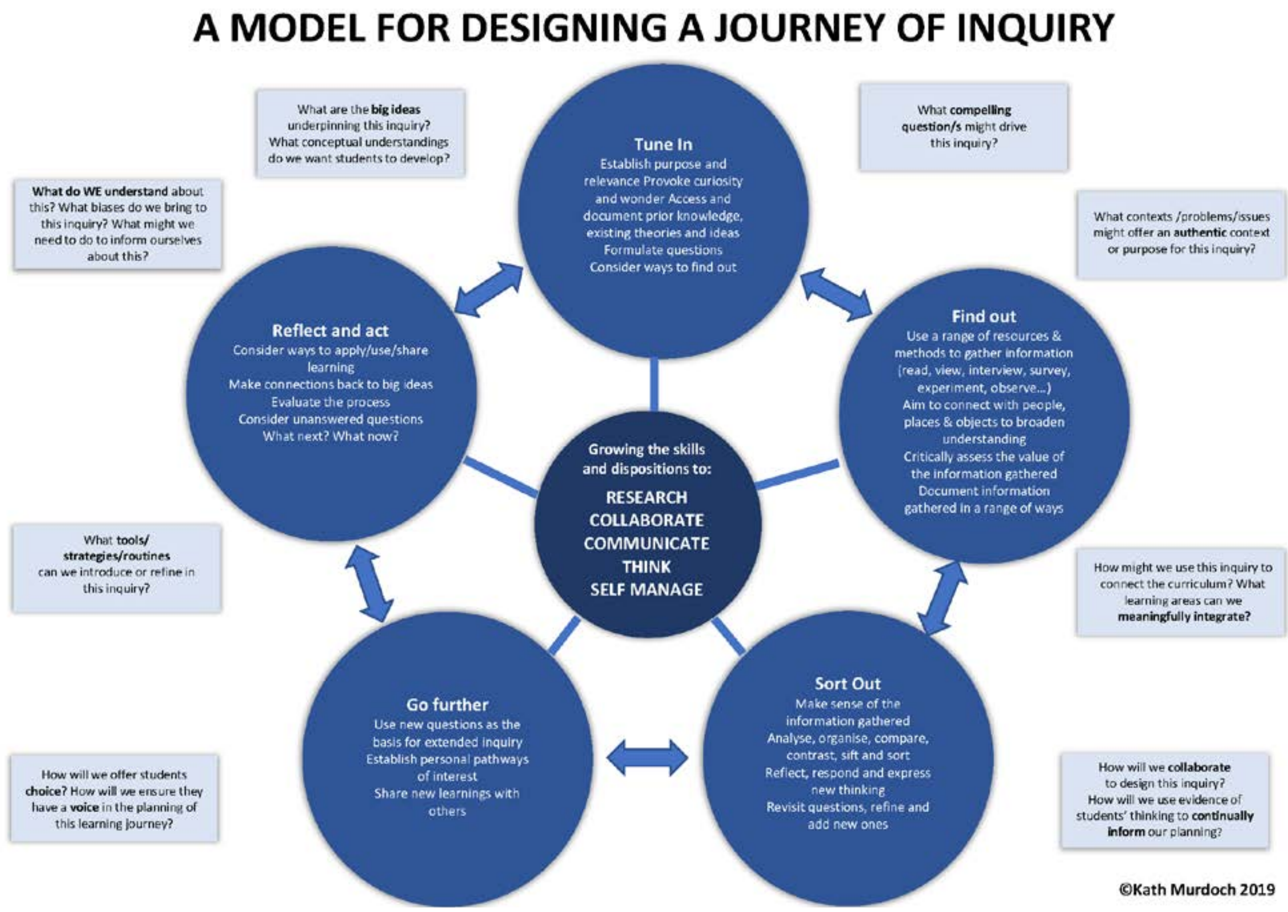

Figure 6: A Model for Designing a Journey of Inquiry[10]

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References

1. NESA (NSW Education Standards Authority). (2017). Science and Technology K-6 Syllabus. Sydney: NSW Education Standards Authority.

2. d.school (2019). HASSO PLATNER. Institute of design at Stanford University. Retrieved: https://dschool.stanford.edu/resources-collections/a-virtual-crash-course-in-design-thinking

3. Buck Institute of Education. (2019). PBL works. Retrieved from https://www.pblworks.org/

4. Hasni, A., Bousadra, F., Belletete, V., Benabdallah, A., Nicole, M. C., & Dumais, N. (2016). Trends in research on project-based science and technology teaching and learning at K-12 levels: a systematic review. *Studies in Science Education, 52*(2), 199-231.

5. Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational psychologist, 41*(2), 75-86.

6. Hattie, J. (2008). Visible learning: A synthesis of over 800 meta-analyses relating to achievement. Great Britain: Taylor and Francis Ltd.

7. Kuhlthau, C, Maniotes, L Caspari, A. (2007). Guided Inquiry: Learning in the 21st Century. Westport: CT: Libraries Unlimited.

8. Kuhlthau, C. C., Maniotes, L. K., & Caspari, A. K. (2012). Guided Inquiry Design®: A Framework for Inquiry in Your School. ABC-CLIO.

9. Maniotes, L (2018) Guided Inquiry Design in Action. Elementary School. Westport: CT: Libraries unlimited.

10. Murdoch, K. (2020). Kath Murdoch: Education Consultant. Retrieved from https://www.kathmurdoch.com.au/

11. Murdoch, K. (2015). The power of inquiry. Victoria, Australia: Seastar Education.

12. Murdoch, K. (2020). The 'Why' of Inquiry Learning. *The Queensland Principal, March.*

13. Buck Institute of Education. (2019). Gold Standard PBL: Essential Project Design Elements. Retrieved from https://www.pblworks.org/what-is-pbl/gold-standard-project-design

14. Buck Institute of Education. (2019). Gold Standard PBL: Essential Project Design Elements. Retrieved from https://www.pblworks.org/what-is-pbl/gold-standard-teaching-practices

15. Maniotes, Harrington, & Lambusta, 2015 p. xiii in Fitzgerald, 2019 Guided Inquiry Goes Global. Libraries Unlimited

16. Guided Inquiry Design. (2020). Guided Inquiry Design: Why GID? Retrieved from https://guidedinquirydesign.com/gid/#

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