Sabbatical Report 2018

How can science engage learners at risk of not achieving in literacy and mathematics?

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Executive Summary

I believe that all students should be able to experience a rich, holistic curriculum that includes science. I am very pleased that the Kāhui Ako that my school belongs to, has science as one of its areas for development. This focus has helped strengthen science in our school, and I am able to share across the Kāhui Ako.

Science is a wonderful, easy way to excite children about their learning and through meaningful integration support their development in literacy and mathematics. Science is an effective way of connecting students' to their cultural knowledge and experiences, and supports what they are passionate and curious about. As outlined in *Primary science education for the 21st century*, and I totally agree, primary science can be taught through stimulating activities which include, "lots of purposeful classroom talk: ensuring literacy programmes include both narratives and factual writing about science topics; and supporting teachers to be clear about how all these activities contribute to the citizenship aim of science education" (p. 2). This article also reinforces the importance of schools linking with children's experiences at home and providing a wide range of experiences at school.

Most of the New Zealand schools that I visited had teachers that had taken part in the Science Leadership Programme facilitated by the Royal Society. Personnel in these schools spoke about the increase in science teaching and learning as a result of being part of the programme. Based on positive professional learning experiences, school leaders and teachers highly recommended that colleagues apply to participate in this programme.

Some of the schools I visited have a strong focus on cultural responsiveness and ensuring students can make cultural connections to science experiences. The majority of schools made very good use of their local environments and connections with people in the community. As a result of some of my initial visits and what was happening in schools, the purpose of my visits extended to looking at the place of STEM and in some cases STEAM (Science, Technology, Engineering, Arts and Mathematics) local curricula.

I was fortunate to begin my sabbatical by taking part in a Sir Paul Callaghan Science Academy 4-day professional learning programme. Different speakers reinforced my belief in the importance of schools focusing on the Nature of Science and the Science Capabilities. Providing students with exciting "wow" experiences was strongly reinforced - to fully engage them in science and as a means to involve them in deeper learning.

I was pleased to have some guidance from Ian Milne, a science educator and consultant, whose philosophy is to promote awe and a sense of wonder for students in science lessons.

The quality and amount of assessment in science varied among the schools that I visited. Some are just at the beginning of that journey, choosing to begin with strengthening student and teacher engagement.

It was beneficial to have time in Hawaii to explore how science and STEM subjects are taught. One of the programmes-for-purchase used in a number of American schools is *Amplify Science*. It is based on the principle of students in science lessons doing, talking, reading,

writing, and visualizing. Evaluations of the programme have shown the effectiveness of this approach.

Purpose

The purpose of the sabbatical was to gain ideas about effective science programmes and assessment and how these could be used to promote connections with students who underachieve, thereby helping them to improve their learning and achievement. I also wanted to look at ways to increase my own knowledge of science pedagogy, and investigate what was happening in Kāhui Ako and other schools that had a focus on science education.

As a result of the sabbatical I wanted to have a clear direction for science teaching in our school and have more ideas on how science can engage Māori students, and students whose performance is below expectation. The sabbatical provided me with an opportunity to have time to read and reflect on science teaching and learning.

While I initially proposed a visit to Alaska taking part in *Science at Sea*, the professional learning experience was too expensive. Instead, I visited schools in Australia and attended a STEAM teaching conference on the Big Island, Hawaii. I also met with educators in Hawaii and had the opportunity to fly over the island's active volcano and hear about people's experiences during the eruption. The conference had a range of interesting speakers and a large variety of workshops.

Findings

Preparing students for the future means that scientific thinking and problem solving is a vital part of their education. As outlined in the New Zealand Curriculum, it is very important to include a strong focus on science for citizenship so students can fully participate in society.

During my sabbatical I maintained a blog of the schools that I visited: https://dianatregoweth.blogspot.com/

I collected a number of resources and ideas to share with Kāhui Ako colleagues and teachers at my school. Not all gems school personnel shared with me were to do with science per se. Gaining more ideas for the incorporation of STEM in our school was a wonderful spin-off. Related to this theme, I also gained some ideas to support the introduction of an effective digital curriculum.

The Sir Paul Callaghan Science Academy course was very useful in developing my confidence and knowledge about science teaching and the New Zealand Curriculum. Involvement in this professional learning gave me the opportunity to network with science educators in other schools and to gain further ideas in regards to resources.

The aim of the course is to equip teachers with skills, techniques and resources to support the delivery of the science curriculum. The goals as set out at the beginning of the course are to create recognised champions and leading educators of science who are:

- engaging and enthusiastic

- highly skilled, capable and confident
- aware of the relevance and interconnected nature of science
- inspirers of the science achievers and citizens of tomorrow and, who fuel students' interest in science through awareness of:
    - how science is the key to almost everything this country must do
    - the impact of science on all New Zealanders
    - the wide variety of science careers available and the many paths to becoming a scientist
    - the importance of a science literate society
    - the vibrancy of working with science today (heroes)." pp 9 and 10, Sir Paul Callaghan Academy presentation folder.

Through attendance at the academy I was reminded of the importance of students learning about the Nature of Science and its place as the overarching strand in science. As stated in the New Zealand Curriculum (NZC):

> "The **nature of science** strand is the overarching, unifying strand. Through it, students learn what science is and how scientists work. They develop the skills, attitudes, and values to build a foundation for understanding the world. They come to appreciate that while scientific knowledge is durable, it is also constantly re-evaluated in the light of new evidence. They learn how scientists carry out investigations, and they come to see science as a socially valuable knowledge system. They learn how science ideas are communicated and to make links between scientific knowledge and everyday decisions and actions. These outcomes are pursued through the following major contexts in which scientific knowledge has developed and continues to develop."
> P.28

The core strand, Nature of Science, is required learning for all students up to Year 10, unlike the other four context-for-learning strands. The NZC stipulates that these strands should be included over the course of Years 1-10, not necessarily all covered in one year.

As stated by the Sir Paul Callaghan Science Academy and various research, it is important that student performance in STEM subjects improves. This lift in performance will enable students to be able to problem solve and develop skills that are important for their future. This area for development is reinforced in the very useful book, *Constructing your primary school's curriculum*. This resource for schools and teachers promotes the notion that science education is not just relevant for science careers, but for lifelong learning and problem-solving.

The Sir Paul Callaghan Science Academy emphasises the importance of students being active in their learning. Practical examples are shared to help educators to provide rich experiences for students to take part in, and promote their thinking and curiosity. This entails teachers and programmes fostering children's interest in the world around them. Many of the schools I visited have set up *Wonder Tables/Science Tables/Discovery Centres* to support children's curiosity. These tables and centres varied in their organisation. Some had questions attached such as: What do you notice? What do you wonder? The best examples of these

tables/centres prompted literacy starters with a science focus. Some teachers also included science/maths related activities.

In promoting the Nature of Science strand, many schools I visited brought experts in to classrooms, or took the students out to see scientists at work. Schools in Rotorua, for example, made excellent use of the region's geothermal activity and expertise along with the local marae.

Waikato and Bay of Plenty schools I visited are very fortunate to have access to *Science Kits*. These are made available to schools in some regions by The House of Science. It was evident from my school visits that those schools that were doing really well in providing science education had the the support of principals with a strong interest in science, and at least one or two passionate teachers or Science Champions. As outlined in ERO's 2012 evaluation of science Years 1 to 8, "High quality science teaching and learning requires teachers to be enthusiastic about teaching science, have sound pedagogical and subject knowledge and set high expectations for student achievement. Effective teachers of science use a wide range of teaching strategies." p. 16.

One of the school visits that I made was to Long Bay Primary. The principal, Linda Barton-Redgrave undertook an ASB/APPA Travelling Fellowship during 2016. Her report, *Bringing Science to Life: Promoting Scientific Thinking in Primary School* is well worth reading. The topic of her study, and many of the things she experienced during her sabbatical aligned with my own study and findings. One of the findings in common is the importance of play-based learning to develop students' independence, creativity, thinking skills and socialisation as they transition from preschool to primary school. Some of the schools that I visited set up play-based discovery learning activities with a science focus. Because of the interactivity and variety of choice that these activities provided, students loved doing them.

A conclusion I reached from visiting schools is that assessment of students' science capabilities and knowledge does not feature strongly in schools currently. Instead, teachers are focusing on the provision of very good quality science experiences and learning opportunities for their students. Some schools have used NZCER's online Science engagement survey tool as a way of gauging students' engagement with science and their perceptions of the learning opportunities that have been provided for them. Some other schools are using NZCER's Junior Science: Thinking with Evidence for Years 4 - 6.

Kāhui Ako Science Responses

During my time on sabbatical I asked the following questions of schools who had science as one of their achievement challenges. Below are some of their responses to those questions.

Are you able to tell me if you think that being part of a kāhui ako has assisted in increasing science engagement in your school and if so how/why?

School A
Being in a Kāhui Ako has without doubt promoted the teaching of science at our school. Each teacher self assessed their science teaching ability. From the collated information, targets were formed to guide the work of the across schools teacher and within school teacher. It was

a real help that the across schools teacher had already written an aligned curriculum and an aligned skills progression. The within school teacher and across schools teacher then worked with the teachers by modelling, coaching and providing resources. Every teacher at school this year school was asked to carry out an inquiry in science. Anecdotally, the targeted teachers have made significant progress.

School B
Teachers carry out a collaborative inquiry in science with a view to building scientific literacy. As part of this inquiry process, science readings were shared regularly with staff.

School C
Yes, through supporting the curriculum team and planning for science through a relevant concept each term. Experienced science teachers have supported the growing profile of science - from developing long term plans, lesson plans and demonstrating how the skills transfer in to practice. It helped by targeting Year 6 teachers and two 'go-getter' teachers to inspire others. Across-schools teachers have supported the within-school teacher to be successful in their role.

School D
It was hard to tell for us as our delivery of science is covered consistently for all students. We have a mini high school timetable at the intermediate, where the children are timetabled over the two years to get a decent amount of science. Kāhui Ako has provided a more stimulating engagement of science having worked with across CoL staff. This has lead to to our five teachers delivering science education with confidence.

School E
Team teaching opportunities with the across schools CoL science leader were held in the Wonder Hub (library) earlier this year and this meant sharing resources, getting to know more about what the college could help us with in the future. These possible opportunities include student visits, sharing equipment, using secondary science teachers' knowledge to help with lessons. Demonstration science lessons were an engaging and motivating start for teachers and students in our school. It was an opportunity to model teaching and learning to other teachers.

School F
When at CoL meetings with other in-school leaders, there were opportunities to share what schools were doing and how they were doing it in their respective schools. Leadership professional development was useful in assessing complex problems as well as developing a clearer understanding about student centred leadership. The kāhui ako has a shared Google document with resources that include back-mapping, rubrics and example plans which can be used by schools involved.

School G
We are a college that has high student engagement in science. The science department is the largest department in our school as many of our students choose science in the senior school. We have a philosophy of making science hands-on and tangible. This facet of our programme increases student engagement. Through the use of student voice, we know that learners rate science highly. We have inconsistent experiences of science in our feeder schools. Having

visited them though, my hope is that the CoL will provide a consistent experience of science among the schools.

School H

Whole school goals are reflective of COL goals and achievement challenges.
There is an ongoing focus on what is required in Years 9, 10 science in order to prepare students for NCEA Level 1.

Over the last 3 years the science department has increasingly looked to involve students more in contextual/community learning. For example, to name some, we are involved in a Science Fair, Year 9/10 South Auckland science competition, 'Trees for Survival', a local 'Bee Hives' project and a 'South STEM Project'.

What forms of assessment are you using/if any in science in your school?

School 1

Formative assessment from teachers in the school has been collated which shows that all classes have taught science to a good depth this year. For some class programmes, assessment focuses more on science learning outcomes while others have integrated literacy goals with science goals. We rely solely on formative assessment. School-wide assessment is based on the curriculum levels (Year 2 links to level 1.2, Year 4 links to level 2.2 and Year 6 links to level 3.2 and above). We have collected this data for at least ten years. End of year summative assessments have not been collected yet so we cannot determine the effect on school wide achievement.

School 2

Assessment has not been a focus at this point - the first goal was supporting teachers with content and upskilling them in science. Next year (2019) the focus will move to assessment.

School 3

We are starting to use rubrics when planning as a way to focus what we are looking for in an activity (and then as an assessment to direct future lessons). We have used the NZCER Science Engagement Survey in the past. It is possible to use it again to gauge progress, as well as the *Science: Thinking with evidence (STwE)* assessment. Some teachers may have used the Assessment Resource Bank (ARB) resources to gauge students achievement for both context and nature of science assessment. Also, concept cartoons may have been used as an assessment. These are not used school-wide.

School 4

We are using the *Science: Thinking with evidence (STwE)* assessment tool across all schools in our CoL. The test shows great variance across the schools mostly linked to decile. I am sure it would show a strong correlation with the students reading as well. I am wanting to start

using the Science Engagement survey which is free and would provide a useful measure of a student's experience of the science curriculum.

School 5

Results are not significantly improving yet but this will obviously take time.
Assessment is a combination of both summative and formative assessment for units of work that take between eight and ten weeks. National Curriculum levels relate to achievement descriptors.
Students in Years 9 and 10 are scheduled to be involved in an assessment week which is a combination of formative/summative assessment which is increasingly focusing on key competency, soft skill development.

Are there any successful ways you have found of increasing achievement in science for Māori students?

School I

We have not 'pulled out' Māori attainment but the whānau classes have tried to put Māori contexts to their learning such as making kawakawa balm.

School II

We haven't delved into the impact across our differing ethnic and gender cohorts. All we can report at this stage is teacher and student excitement around science and positive engagement. There is also an increase in teacher capability.

School III

Not yet as our approach has been school-wide. It would be a great idea for us to track Māori achievement in Science.

School IV

At our school, Māori children who were selected for Science Champs (with Ian Milne, an external science education facilitator) have been motivated and engaged in science. They then have become 'leaders' of science in their own classrooms. Stories such as the 'In the Beginning', 'Winds of Tawhirimatea', and 'Taniwha' by Robyn Kahukiwa, and 'Maui and the Sun' have been used to engage children to explore science ideas.

School V

Thematic teaching of science content around contexts such as a hangi unit of work for Year 11 credits on heat transfer. We have purchased the readings and practicals from David E. Newton PhD on science in a Māori context.

School VI

Our department has been participating in culturally responsive pedagogy so that positive, inclusive relationships allow learning to happen. Many schools have been teaching science around their local context and around themes.

School VII

Schools involved in Kāhui Ako are definitely finding an increase in student engagement and teacher confidence. The next step will be to build on this success in order to see increases in student achievement.

School VIII

Regarding a Māori student strategy we timetable our within school science teacher to mentor Whānau Year 11 students with science being the specific focus.

Science in Hawaii

A strong influence in school curriculum design in Hawaii are the Next Generation Science Standards.
http://www.nextgenscience.org/understanding-standards/understanding-standards

It is up to the various states in America to decide whether to adopt the Next Generation Science Standards. Hawaii has adopted them and will implement them in 2019. The Science Standards include engineering and technology. The process of planning for the adoption of the standards has helped curriculum leaders and schools understand and value the importance of STEM teaching and learning principles. Planned programmes are more integrated and holistic than the previous curriculum design. There is much less requirement for students to regurgitate facts. School administrators and schools are using the idea of 'performance expectations' that are focused on promoting students' active thinking and actions.

In this framework, assessment is viewed as being 3-dimensional, each dimension linked to, and contributing to the other:

- some disciplinary core ideas (content)
- scientific practises
- processes such as investigating, developing an argument, communicating results (scientific ways of thinking and acting)

This locally devised curriculum model reflects the science and engineering practices advocated by the Next Generation Science Standards:

- Asking questions and defining problems.
- Developing and using models.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Using mathematics and computational thinking.
- Constructing explanations and designing solutions.
- Engaging in argument from evidence.

- Obtaining, evaluating, and communicating information.

The Amplify Science programme that was shared with me is able to be purchased by schools. The programme incorporates research into student learning. It emphasises the need for coherence in order to support students to build, and link ideas in order to develop understanding. The programme provides real world problems and gives students opportunities to investigate using digital tools. The approach expects students to do, talk, read, write, visualise. It also provides students with a means to engage with "particular concepts multiple times in multiple ways", and "shift student learning from 'learning about' to 'figuring out' science". P. 6.

I am very grateful to Aaron Sickel (STEM specialist for the Hawaii Department of Education) with whom I had very worthwhile discussions. I also attended one of his sessions at the STEAM HawaiiCon Conference that I attended on Hawaii's Big Island.

The following links are ones that he has kindly shared with me:
FAIR Features
https://drive.google.com/open?id=1rANnNLYD2qeFxg2me63bZp2KDBPaL_EJT1ZroptbMOQ

Example Units
https://drive.google.com/open?id=1IGqZn7SpPZ_WnPW4s6aZU9O6HjpVjtUegmiShhKijFs
https://drive.google.com/open?id=1iGUTQymKHqE7MxFG_dza_UirP7_SboCQtGv_hEH7FnQ

STEM Lesson Resources
https://drive.google.com/open?id=1Xutgyf8mXSvZZZz8KXIx4fiZ7iTTQh_AcJW-LF94ny0

Design Thinking Resources
https://drive.google.com/open?id=1IQZkyaQ2QzjvOBocnMy-OWb4psh4CUTK
https://drive.google.com/open?id=1MIBvN6ejbYoVatcEVD7L_ThgX9uCh7Wa

There are many similarities in the way Hawaii and New Zealand education systems are beginning to use indigenous peoples' knowledge as meaningful contexts for science learning. Hawaiian children are aware of traditional wayfinding methods using a star compass, and wind and ocean swells. Teachers in Aotearoa New Zealand are increasingly tapping into similar rich contexts for science learning: wayfaring, preparation and cooking of food, use of natural resources for kai, clothing and recreation.

New Zealand's newest Science Chief Advisor challenges some traditional thinking and structures around the teaching of science. In particular, she feels that much can be learnt from te ao Maori. Her presentation at a recent uLearn conference provides some areas of interest and further discussion. The following quote captures the tone of her message:

> "My challenge to educators is: how do we create an environment that encourages critical thinking and supports students to constructively challenge everything? How do we coax them out of their comfort zones? In Mātauranga Māori, we have a framework of knowledge that is more integrated and holistic, so there is value in incorporating greater integration of Māori values and knowledge in areas such as research and resource management, and policy development in areas such as health and education as well as science. But it must be integrated from the beginning, not added on at the last minute."
> https://gazette.education.govt.nz/articles/making-science-fly-for-all-pms-new-chief-science-advisor/

Noticings and Ideas / Possible Actions:

Integrate Learning.
In schools with passionate teachers and principals, science shone through.
Teachers in these schools often integrate science through everything they do, including reading, writing, maths, drama, music and cultural aspects.

One example of this type of integration, promoted by Ian Milne, is the use of collaborative narratives. This teaching and learning approach reinforces science processes and thinking through students' use of reading and writing. Children write about what they do, why it happens, and how they feel about it. They reread what they have written during the time they are doing the science. This process helps the science experience to become embedded in their thinking and learning.

Promote Student Inquiry and Action
Many schools whose students are highly engaged in their learning do so through an inquiry process. Students have opportunities to identify and solve problems. Schools that are Enviroschools do this well with students investigating environmental issues and determining actions to take as a result of their work. I was reminded, as a result of visits to these schools about the need to listen to children because of their strong desire to make a positive difference to the world.

Promote Wonder and Curiosity
According to Ian Milne, in order to teach science effectively teachers need to promote children's sense of awe and wonder. To build on children's questions and ideas, teachers require clarity and understanding about science concepts. This understanding enables them to support and enhance children's scientific thinking.

Play Based Learning / Discovery Learning
In many schools I visited, teachers organise learning stations for students that relate to science. Stations are effective when they include a science purpose and there is teacher follow up. This process involves teachers talking to children about what they play with, what they notice, what they wonder about, and why things are the way they are.

Promoting Science Thinking and Learning Through the Nature of Science and the Science Capabilities

This should be done throughout the year not just as a one-off term topic. There are many ways to keep science alive throughout the year such as: being part of current issues, having an ever-changing 'Wonder Table', and integrating science throughout the curriculum. There are many online science activities that students can be involved in.

An example I observed was to involve the students online with "Mystery Doug", where students can send in questions that they wonder about. Students are involved in voting for which questions they would like to see answered. Mystery Doug contacts the writer of the question and puts up their video of them asking the question. This is then answered in an interesting, succinct way. There is a new episode produced each week and can be watched at any time. The Mystery Doug web portal proves to be a useful means for stimulating students' ongoing interest in science.

Another example is School Kit which has a number of purposeful activities and areas of interest that promote science teaching and learning.

Provide professional learning opportunities to staff
With STEM being more of a priority, there are a large number of professional development opportunities available.

One example is: Science and literacy - making it explicit and keeping it real - Approaches, ideas, and hands-on activities by Anne Barker.

Successful curriculum integration can result in literacy and numeracy occurring in a variety of contexts. Questions to consider when planning integrated studies:

- *How can teachers teach literacy in such a way that science remains explicit and something beyond developing science content knowledge?*
- *How can we build students understanding of science literacy within a whirl of planned activities?*

Promote connections with the local and wider community
Ensure students go outside as much as possible to focus on nature, gardens, local phenomena and reinforce children's relationships with the land. Schools are becoming more engaged with their local area and some are involving kaumatua or the local marae to support this engagement.

Identify and partner with community based organisations to connect STEM learning in school and out of school (as recommended by Spang, M. and Bang, M p.3)
This is very evident at Te Rangihakahaka Centre for Science and Technology which is an initiative set up by Ngāti Whakaue Ake. This community involvement was also very evident in schools that had teachers complete the Science Leadership training through the Royal Society.

Encourage students to communicate with scientists and where possible observe them at work.
Invite to school successful scientists from a number of cultures to be role models for the students and to interest them in future jobs in STEM fields. Regularly invite guest speakers to

visit such as kaumatua or people from different cultures who can engage students in narratives/storytelling that relate to science.

Provide as many learning experiences as possible for your students.
These experiences can include Skype calls with experts in the field, the use of use of the internet and YouTube. Local and school resources such as relevant library displays, the school's environment, and nearby industries can also promote children's scientific thinking.

Science resources and opportunities that I found useful

- House of Science
- Royal Society Leadership Programme
- Sir Paul Callaghan Academy
- The Science Learning Hub
  Anne Barker presents a session on the use of storyboards - linking Science to Literacy in the Science Learning Hub.
  https://www.sciencelearn.org.nz/.../2531-fostering-literacy-through-primary-science
- WAPA are some schools n West Auckland working together to promote STEAM.
  http://nzcurriculum.tki.org.nz/Curriculum-resources/NZC-Online-blog/Chantelle-s-journey-with-STEAM-and-UD
- Mystery Doug
- Science in a Van
- Motat
- Enviroschools - http://www.enviroschools.org.nz/
- Join the New Zealand Science Teachers Facebook page
- Living Eggs programme https://www.livingeggs.com.au/hatch-a-chick/
- *School Kit*
- **Explorify** - mini-lessons to get your children thinking like scientists. Gives constructive ideas on the teaching of Science.
  https://explorify.wellcome.ac.uk/
- **Young Ocean Explorers** - a fantastic website set up by Steve Hathaway and his daughter Riley to inspire a love of our ocean, through entertaining education. You can set up your own lessons or use their existing ones.
  https://www.youngoceanexplorers.com/
- **Sir Peter Blake Trust** - find out about their NZ Virtual Reality Project and education resources.
  https://sirpeterblaketrust.org/resources

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