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Stronger Smarter Institute Research & Impact Footprinting

Reading Review : Indigenous STEM Education Project – First Evaluation Report

Stronger Smarter Meta-Strategy links:

1. Acknowledging, embracing and developing a positive sense of identity in schools → 2. Acknowledging and embracing Indigenous leadership →3. High Expectations Relationships → 4. Innovative and Dynamic School Models →5. Innovative and dynamic school staffing models

This Reading Review is based on a national evaluation report of the targeted Indigenous STEM approach taken by CSIRO as part of their successful procurement of a $28 million grant from BHP Billiton Foundation. The Report by Tynan and Noon (2017) expands more specifically into the Indigenous STEM space by providing a comprehensive Literature Review and Evaluation of the Indigenous STEM initiatives as mandated through CSIRO's approach.

Page numbers shown throughout this Review refer to page numbers of Tynan and Noon's Report.

Contents of this Review

Why the Research?

As established by the Institute's earlier Reading Review, "A Pedagogical Model for Engaging Aboriginal Children with Science Learning" there is a need for specific, analytic and targeted STEM innovation in the teaching and learning space. (see http://strongersmarter.com.au/reading-reviews/)

SSiSTEMIK is the Institute's pathway for curriculum and pedagogical reform. Of particular interest and highlighted program kinnected most strongly to SSiSTEMIK is the I2S2 program. I2S2 focuses specifically on Culturally Responsive Pedagogies and Curriculums, core elements of the SSiSTEMIK professional developments (www.strongersmarter.com.au)

I2S2 was written and managed largely by Institutes Adjunct Science Fellow, Joe Sambono and overseen by current Team Leader, Liz Kupsch' while previously working for CSIRO. All I2S2 teams partook in Stronger Smarter Leadership training (2017) held at Cherbourg, Ration Shed Museum. As a team, the purpose for participation and ongoing PD with the Institute was to learn more Culturally Competent ways of working.

What is the research?

Tynan and Noon's (2017) Indigenous STEM Education Project – First Evaluation Report is a 76 page report. As a national evaluation it captures all the core elements of program design, research methodology and individual approaches for achieving targets set by individual CSIRO Indigenous STEM programs (see www.csiro.au).

There are two components which are key elements for this SSiSTEMIK Reading Review. The first is the comprehensive Indigenous STEM Literature Review flagged as Chapter 2. The second element is the specific evaluation of I2S2, Ch 3.3. These two components provide the highest connectivity to the Stronger Smarter Metastrategies.

Chapter 2: Indigenous STEM Context

Tynan and Noon's (2017) Literature Review starts with a recontextualisation of the STEM teaching and learning challenge by linking to international data which flags the challenge is more of a 'crisis' (p.13). The 'crisis' comes from a current workforce lack of STEM literacy combined with the prediction of a 75% increase in STEM occupation shifts. As Tynan and Noon flag, this is an international concern. Coupled in this reality is Australia's lag as a STEM performing nation.

Nationally Australia invests 8.6 million dollars into STEM research however we rank 81st internationally for research conversion to beneficial outputs (Office of the Chief Scientist (OCS), 2013 & 2014). A national peak employment body AIG flagged that 44% of employers found it hard to get qualified staffers (p.13).

So in STEM there is a real international and national workforce crisis in play and potentially in the future if there are not more specific targeted responses. Augmenting this concern is Australia's decline in performance in international testing related to STEM. Tynan and Noon highlight OECD research (p.13). OECD reports highlight a maths literacy decline steadily from 2003 – 2013. In PISA this has corresponded to a seven place drop in international performance. Ranked in 6th position in 2013, Australia over a 10-year period has fallen to 13th place on PISA rankings by 2015.

Tynan and Noon flag the 40% non-specialist teaching teams from Years 7-10 in both Math and Science as directly impacting on the downward trends. In Science, Australia's PISA ranking has shifted from 4th to 6thover the same 10-year period. Subsequent tertiary enrolments and eligibility has shifted as well from 12th to 15th. Deductive reasoning from a deficit model to 'close the gap', would signal catastrophic outcomes for Indigenous students based on these national benchmarks. That is, if mainstream, national benchmarking signals a downward trend (as flagged above) ergo the logic would mean Indigenous outcomes could look demonstrably worse.

Indigenous STEM CH 2.2.2

2013 PISA finding that Indigenous students have a higher level of contextual insight in science. The OID (as reflected on in earlier Reading Review series), flags that the portion of 20-24 year olds completing Year 12 increased 14% from 2008 to 2013. Post-schooling education and training grew 12% over this period as well.

The challenge and 'catastrophic' nature of the Indigenous STEM challenge is embedded within the earlier years of schooling. Again the OID reporting is used to highlight that the National Minimum Standard (NMS) benchmark for all schools has not shifted for Indigenous Jarjums and communities. Tynan and Noon draw on the work of the ACER Indigenous education team, Dreise and Thomson (2014) to highlight the fact that 'Indigenous students are two and a half years behind non-Indigenous…" (p.14).

This trend although not as catastrophic is still a lag in relation to ATAR benchmarking and university enrolment and completion. This is signalled by Tynan and Noon via the Berhrendt report (2012). Indigenous enrolment is not representative of the 2.2% populous so Indigenous students are underrepresented. In university though, STEM course enrolments for Indigenous students have increased at a greater rate than the overall university enrolments (Australian Government see p.14).

Completion at university remains a significant challenge for tertiary systems. Tracked from a nine year cohort, mainstream completion in STEM sits at ~70%. Attending university and completing courses leading to employment is a well being track and tried and true measure of future success for non-Indigenous Australians (p.14). For the Indigenous cohort the number is ~46%. Key concerns that are signalled for the needed tertiary pathway are, lack of student prioritisation of STEM studies, the completion rate

impact on future workforce, overall decline in international student performance and lack of conversion from research innovation to business opportunities.

In school education, the pipeline to university, there has been no change in a decade. A two and half year gap remains the reality for Indigenous students. A widening ATAR gap is offset by increased Indigenous enrolments and completions however without targeted and systemic program development and delivery on STEM pathways this 'balancing act' cannot sustain.

ACARA as the lead framework for all school, Foundation years to Year 10 represents another school challenge. The focus in Science from ACARA is on Inquiry-based approaches. There is less focus on transmission model of pedagogy to an emphasis on models of student's engagement and inquiry. Within schools though there remains a lag in teacher professional development (which Tynan and Noon evaluate in Chapter 3).

Jurisdictionally there are a number of initiatives which heighten the visibility of STEM across the country. Tynan and Noon completed a desktop scan capturing the mosaic of responses (p.16). Juxtaposed against this mosaic is the tertiary response to STEM. Specifically the university Indigenous unit 'support models' are highlighted as leading examples of 'safe spaces' to learn and grow future Indigenous leadership. Tynan and Noon then shift the broader snapshot of STEM to best practice models in Indigenous Education in Australia.

Best Practices CH 2.4

This part of Chapter 2 focuses on Indigenous STEM education. Again a comprehensive literature review is flagged through the research which highlights the CTG Clearing House 2010 – 2011. Tynan and Noon signal that the CTG Clearing House research (from Helme & Lamb, 2011; Mulford, 2011; Dockett, Perry & Kearney, 2010) groups five significant factors connected to educational lift:

- High expectations of success for both staff and students;
- A learning environment that is responsive to individual needs;
- A drive for continuous improvement;
- Involvement of the Indigenous community in panning and providing education; and
- Quality career education

The core take-outs from the research highlighted is that the mainstream implementation cycle of reforms takes three to five years to cede. Indigenous education specific outcomes take four to six years (Luke etal, 2013). The 'best' and largest sample of Indigenous education 'best practice' models Tynan and Noon amplify is the Stronger Smarter Institute.

Specifically, Tynan and Noon focus on 'High-Expectations Relationships'. (Stronger Smarter Institute, 2014). They quote, "developing relationships that connect teachers

and students through their shared humanity…" (p. 17). The largest longitudinal study taken on Indigenous education (Luke et al., 2013), confirmed for Tynan and Noon, "the critique of the Stronger Smarter Approach that deficit thinking is a major obstacle to improving outcomes for Indigenous students…" (p. 17).

The Stronger Smarter Learning Communities study confirmed that 'default modes of pedagogy for Indigenous students are basic skills instruction…' (p. 17). This type of transactional relationship can lead to a workforce and tertiary pathway that is Vocational Education focused, and lacks coherence of teaching approaches and curriculum materials. Exemplified by "lack of school leadership knowledge and engagement", which leads to "major barriers to Indigenous student outcomes" (Luke et.al, 2013).

ACOLA international standard of high performing STEM systems is the next body of research Tynan and Noon unpack in relation to 'Best practice' models (p.18). Shanghai, Singapore, Hong Kong, Taiwan and Finland are all examples of countries with high performing STEM systems. Part of the data story for these countries is they share the smallest proportion of underachieving on PISA. Strong research systems rapidly growing scientific output and experienced two decades of exceptional economic performance. In these countries all three levers of Science; Universal knowledge; and Economic dynamism are key to the interdependent and successful development of a STEM responsive system.

Furthermore, Marginson (2013) highlights key components of and on these leading STEM countries. First, school teachers and systems are dealt with and afforded a higher esteem. Secondly, there is a higher commitment to disciplinary content – so experts are teaching specific disciplines like Science and Maths. Thirdly, major curriculum and pedagogical reform is a focus which aims at making Science and Maths more engaging. Fourthly innovative policies to lift STEM. Lastly there is a development of standardised national policy frameworks and directions relating to STEM.

In Australia, the Aboriginal and Torres Strait Islander Higher Education Advisory Council (2012-2015) recommended Science and Maths needed to be made more exciting. The Higher education teams found "…Aboriginal and Torres Strait Islanders students have a higher contextualised interest in Science…" (p.17). It also recommended a strong usage of Traditional Ecological Knowledges as central to improving Science literacy. In doing so, "They achieve the significant implications for the potential learning for teachers to do this effectively…", McConney et al (2011) (p. 17).

The learning potential rests in student's meta-awareness as Tynan and Noon explore through discussion of Professor Nakata's Cultural Interface theory. Holistic learning – balancing the dominant western education system is key to developing more appropriate approaches to learning. To highlight this point Tynan and Noon focus on five specific Maths / Science PDs which focus on Aboriginal and Torres Strait Islander learners. The PDs include: Primary Connections: Desert Knowledge Cooperative: SciTech: Learning on Country and Yumi Deadly Maths (see pp. 19-21).

To backend these specific Aboriginal and Torres Strait Islander PDs Tynan and Noon use Canada and US models specifically to relate to. The Saskatchewan Science and Curriculum and the Maths in Cultural Context program Alaska are the two focal points. The Saskatchewan model over a decade has seen the increase of native Canadians taking Science courses into Years 11 and 12. Adapting the curriculum for the Manitoba people of Canada saw a subject choice increase of 80% (p. 21). Similarly, the Maths and Culture Classes created statistically significant shifts in Alaskan student outcomes (p. 21). The Native Science Connections Research in the U.S. had a Year 5 focus. The Native sciences models were tested at areas of high Indigenous populations; Navajo: Hopi: Apache. Key differences which sparked interest for Jarjums was the pedagogical process of "whole to part studies" (p. 21). Mainstream education tends to focus on the molecular whereas Indigenous pedagogical modelling began at teaching the ecosystem level then working away to the molecular.

Summarising the Chapter 2 Literature Review, Tynan and Noon highlight that the Evaluations team's adoption of their STEM theory of change is well supported by the Literature reviewed. Strength-based approaches, Closing the Gap focused on key quantitative indicators namely PISA and ATAR and completion of tertiary STEM pathways are important steps to create stronger change.

Issues which impacted on delivery of Indigenous Knowledges (IK) in STEM were: many teachers not being science specialists, teachers not understanding Indigenous Australians, and the gap in Indigenous science content knowledge. ICT skills, expertise in alternate assessment models were other challenges flagged.

From this CSIRO evaluative study, Tynan and Noon flag prioritising a focus on building understanding of the pathways and processes of place and strength-based interventions that lead to engagement and aspiration building (p. 30). The key factor and point of difference on targeting on these approaches as Tynan and Noonan state is to highlight how these interventions can be scaled up.

I2S2 CH 3.3

In the initial PD cycles CSIRO has begun deepening understanding on what works for PD'ing teachers. I2S2 for example originally had an eight-hour PD model design. Over the course of the pilot it became increasingly clear that eight hours was not sufficient for teacher delivery. Even with the scaffolded curriculum and lessons, outputs from teachers post PD was not achieved (p. 29).

Positives to come from the I2S2 cycle of PDs was a confirmation of the value of inquiry base as a pedagogical and curriculum focus to build teacher capacity. Key insight from the PD sequencing that Indigenous Knowledge relationships, deepening Community engagement should shift as a program 'output' to more specifically as an outcome (p. 30).

Challenges that specific Curriculum and Pedagogical approaches like I2S2 include the limited human resource factor. By prediction, if STEM is flagging as a crisis (as ascertained through this study) then the specific knowledges and expertise on Indigenous Knowledges in STEM is even more remote. In I2S2 specifically this led in the pilot stage to a prolonged selection and recruitment process, taking over three months (p. 28).

ACARA is a challenge for I2S2 type programming as well. As a Cross-Curriculum Priority (CCP), a perception by non-Indigenous teachers is Aboriginal and Torres Strait Islander people are not capable of science inquiry. The specific Teacher Professional Development days were a targeted approach at breaking the deficit thinking of a largely non-Indigenous teaching force. Such has been the continued success of I2S2 is that the model has grown from original parameters and is now expanding to further school spaces.

The success of a program like I2S2 lies in the specific human resourcing modelling – with all senior leads being Indigenous curriculum experts. Coupled with an intense focus to PD teaching staff, I2S2 has by Tynan and Noon accounts "achieved great success through completing nearly all output targets (p. 29).

Summary of Key points

Challenge for all Australian Educational Institutes

- 2013 PISA finding that Indigenous students have a higher level of contextual insight in science.
- Indigenous students are two and a half years behind non-Indigenous…" (p.50). Dreise and Thomas to highlight the fact that
- Completion at university remains a significant challenge for tertiary systems. Tracked
- A widening ATAR gap is offset by increased Indigenous enrolments and completions.

Transforming the Australian Indigenous Education Experience

- Indigenous education specific outcomes take 4 – 6 years (Luke et al, 2013). The 'best' and largest sample of Indigenous education 'best practice' models Tynan and Noon amplify is the Stronger Smarter Institute.
- ACARA – school challenge is ACARA Science Foundations Year -> Year 10. Focus on inquiry-based approaches. Less focus on transmission model of pedagogy to an emphasis on models of student engagement and inquiry.
- Traditional Ecological Knowledges as central to improving Science literacy.

- Five focused Indigenous STEM PDs operating now include: Primary Connections: Desert Knowledge Cooperative: Scitech: Caring for Country and Yumi Deadly Maths.
- Canada and US models specifically relate to our 'Indigenous experience'. The Saskatchewan Science and Curriculum and the Maths in Cultural Context program Alaska are two prime exemplars. The Saskatchewan model over a decade has seen the increase of Native Canadians taking Science courses into Years 11 and 12. Adapting the curriculum for the Manitoba people of Canada saw subject increases of 80%. Similarly, the Maths and Culture classes created statistically significant shifts in Alaskan student outcomes.

Understanding 'what works' & adapting

- In the initial PD cycles CSIRO has begun deepening understanding on what works for PDing teachers. I2S2 for example originally had an 8-hour PD model.
- Issues which impacted on delivery of IK in STEM were: many teachers not being science specialists, teachers not understanding Indigenous Australians, gap in Indigenous science content knowledge. Other challenges were ICT skills and expertise in alternate assessment models.
- Positives to come from the I2S2 cycle of PDs was a confirmation of the value of inquiry focus as a pedagogical and curriculum focus to build teacher capacity.

Stronger Smarter Provocations and Discussions

The challenge to embed practically more IK in STEM is to honour the higher expectation of Indigenous Jarjums, who show high interest in STEM (Tynan & Noon, 2017). As a supporter of teachers and the teaching profession the Institute holds an equally high expectation of educators to rise to the challenge and meet our Jarjums' learning potential.

The 'learning potential' is highlighted through the PISA (2013) data. The Stronger Smarter Approach Framework confirms the Institute's position on developing, designing then evaluating research (Stronger Smarter Institute, 2017). To that end the Institute has gone deeper in developing 'Lead and Lag' indicators on transformative change. Tynan and Noon highlight the inquiry-based model of learning as a lead indicator for increased student and community engagement. The 'Lag' to this indicator would be a drop in STEM ATAR pathway to university.

As highlighted earlier, there are five specific processes the Closing the Gap Data warehouse (see above) showcase. From this research, teachers and school leaders were most effective when they understand the broader environment and organise their schools to respond to this environment, including operating as flexible organisations

that focus on developing networks, trust and resources (social capital) at three levels (Mulford, 2011):

- Within the school as a community of professional learners;
- Between schools; and
- Between the school and its community

- Specifically Tynan and Noon focus on 'High-Expectations Relationships', confirming the Stronger Smarter Approach as the most effective Indigenous education model in the field. They quote, "developing relationships that connect teachers and students through their shared humanity…" (p. 17…). The propensity for school leaders to recalibrate or default to a simple 'drill and skill' model was another vital highlight drawn from the Stronger Smarter Longitudinal study (Luke et al, 2013).
- ACOLA international standard of high performing STEM systems is all three levers of Science; Universal knowledge; and Economic dynamism are key to the interdependent and successful development of a STEM responsive system.
- With regard to student interest – Aboriginal and Torres Strait Islander Higher Education Advisory Council (2012-2015) recommended action be taken to make science and mathematics exciting and relevant in the classroom; and that groups of experts in Indigenous STEM education should be organised to provide advice on strategies to increase Aboriginal and Torres Strait Islander participation in STEM (ATSIHEAC, 2015)
  - Resonates well with McConney et al (2011: 2026) finding that, notwithstanding the two-and-a-half year gap compared with non-Indigenous students, Aboriginal and Torres Strait Islander students have a higher contextualised interest in science.
  - They subsequently recommend the greater use of Traditional Ecological Knowledge (TEK) as central to improving science literacy
  - In so doing they recognise the significant implications for professional learning for teachers to do this effectively.

Stronger Smarter Metastrategies weaves

***Metastrategy One*: Positive sense of identity** connects to the positive PISA data from 2013. Indigenous students reflect a higher level of interest in Science concepts than their non-Indigenous peers. IK as situated or place-based modelling is essential. I2S2 is a leading model on Indigenous STEM. The higher interest is reflected by

student ATAR choice, where in tertiary streams Jarjums are choosing STEM fields as a focus.

***Metastrategy Two*: Embracing Indigenous Leadership**: Both the positive sense of Indigenous student identity and the Culturally Responsive Curriculums (CRCs) as shown by I2S2 models embrace Indigenous Leadership. The strength of students' ability to relate to higher order concepts and ideas supported by (see Dr Chris Matthews research on the Cloud or Goompi Model Stronger Smarter Institute Reading Review 2017) is reflected in the PISA data and Indigenous Higher Education Council recommendations. There is a dire need to make Maths and Science particularly more engaging and exciting for students.

***Metastrategy three*: High-Expectations Relationships** was a key outtake of CSIROs first evaluation. The Australian specific model which has the highest probability of success in the field of Indigenous education according to Tynan and Noon is Stronger Smarter. Endemic to the Stronger Smarter Approach is High-Expectations Relationships, "…the work of Stronger Smarter reinforces that 'high expectations' needs to be at the forefront of Indigenous Education" (p. 16).

***Metastrategies Four & Five*: Innovative School & Staffing models** are highlighted throughout Tynan and Noon's evaluation report. The core pedagogical focus of and on 'Inquiry based learning' is a hands-on real world connection to how and why Indigenous Knowledges (IK) have led in the field of health and ecological sciences for thousands of years. As was the focus on the last Reading Review on Scitech, what the evolution of higher interest STEM learning looks like requires a paradigm shift from current status quo and operations of schooling environments at present. This needs to entail lessons learnt from other professional development models like CSIROs Indigenous STEM, specifically I2S2 whereby the pilot program hosting eight-hour training times for teachers was evidently 'not long enough…' (p. 30). IK then presents another challenge in providing a truly different and Culturally Sustaining Pedagogical approach through embedding and kinnecting to local Indigenous Community. Such was the paradoxical and demonstrated shift in pedagogical and curriculum dynamics for I2S2 that the evaluators referred to the Community Engagement model as "…shifting outputs to outcomes… as a result of doing IK properly…"(p. 30). Desert Knowledge Centre, SciTech, Caring for Country, Yumi Deadly Maths and Primary Connections are all examples Tynan and Noon highlight as leads in the Indigenous STEM field. Overtime as is Stronger Smarter's Approach, we aim to be SSiSTEMIK on how we implore and how we lead learning communities to build and grow deeper IK relationships.

The learning potential of our Jarjums is clear. The research is clear. The challenge for schools is to create more of the conditions which increase student outcomes. The challenge for schools is to be more SSiSTEMIK in their approaches.

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