Australia's National
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CSIRO submission to Better and Fairer Education system

Education & Outreach

CSIRO Submission 23/[832]

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Introduction

CSIRO welcomes the opportunity to provide feedback on the Review to Inform a Better and Fairer Education System Consultation.

CSIRO is a trusted leader in STEM education, and our programs aim to inspire the pursuit of further STEM education among students and the community, to equip the emerging workforce with tomorrow's skill sets, and to strengthen collaboration between industry and classrooms across Australia. CSIRO offer a variety of student focused programs and experiences, and professional development programs and resources to assist educators as they deliver quality STEM education.

This response to the Consultation Paper prioritises specific questions that most closely align with CSIRO's expertise and interests, specifically questions 2, 3, 21, 27, 28, and 31.

CSIRO Response

Background

CSIRO has 40 years of experience and evidence of success in STEM education. Australia's STEM talent 'pipeline' (the educational and career pathways of students and employees in the fields of STEM) is becoming increasingly important, as keeping pace with technological change can advance the economy and meet the needs of Australia's future workforce.[1] STEM and digital skills will play a vital role in realising Australia's innovation and productivity potential. STEM education complements the development of critical thinking, creativity, collaboration, and problem solving, which are demanded for future careers. Employment in STEM occupations is projected to grow by 12.9 per cent in the next 5 years, well above the average growth of all occupations (7.8 per cent) and more than twice as fast as non-STEM occupations (6.2 per cent).[2]

There is an ongoing decline in high school student enrolments in STEM subjects,[3] particularly higher mathematics.[4] Student performance in STEM subjects is also declining, for example in mathematics[5] and science.[6] In the context of these declines, students generally prefer authentic inquiry-based learning experiences and partnering with STEM industry professionals and mentors who can connect real-world STEM to the classroom,[7] which align closely with CSIRO's STEM education offerings.

Under-representation in STEM is also a major issue. For example, the country's talent pool is limited by gender imbalance in STEM education and careers.[8] In addition, Indigenous-led approaches to strengthening and sharing knowledge in the area of STEM, for example land and sea management, is an opportunity for every classroom to be more inclusive of Indigenous-driven science.[9] Preparing educators to help address under-representation by creating inclusive STEM classroom environments is also an important skill that CSIRO supports.

[1] Office of the Chief Scientist. (2020). *Australia's STEM workforce: Science, technology, engineering and mathematics.* Retrieved from https://www.chiefscientist.gov.au/sites/default/files/2020-07/australias_stem_workforce_-_final.pdf

[2] Australian Government, National Skills Commission (2021) *State of Australia's Skills 2021: now and into the future*. Retrieved from www.nationalskillscommission.gov.au/reports/state-of-australia-skills-2021

[3] ACARA (2022). *Year 12 subject enrolments*. Retrieved from www.acara.edu.au/reporting/national-report-on-schooling-in-australia/national-report-on-schooling-in-australia-data-portal/year-12-subject-enrolments

[4] Wienk, M. (2022). *Year 12 Mathematics Participation Report Card: Mathematics enrolments reach all-time low*. Retrieved from https://amsi.org.au/wp-content/uploads/2022/04/year-12-participation-2022.pdf

[5] OECD (2018). *PISA 2018 results: What students know and can do. Volume 1.* Retrieved from www.oecd.org/education/pisa-2018-results-volume-i-5f07c754-en.htm

[6] OECD (2018). *PISA 2018 results: What students know and can do. Volume 1.* Retrieved from www.oecd.org/education/pisa-2018-results-volume-i-5f07c754-en.htm

[7] Morris, J., Slater, E., Boston, J. Fitzgerald, M. & Lummis, G. (2021). Teachers in conversation with industry scientists: Implications for STEM education. *International Journal of Innovation in Science and Mathematics Education, 29*(1), 46-57.

[8] Consult Australia (2019). *Australia's STEM education challenges.* Retrieved from www.consultaustralia.com.au/docs/default-source/people/people-page/australia's-stem-education-challenges-discussion-paper.pdf?sfvrsn=652a4ab9_2

[9] CSIRO. (2023). *Indigenous science*. Retrieved from https://www.csiro.au/en/research/indigenous-science

Chapter 2: Improving student outcomes

2. What are the evidence-based practices that teachers, schools, systems and sectors can put in place to improve student outcomes, particularly for those most at risk of falling behind? Are different approaches required for different at-risk cohorts?

CSIRO has experience delivering STEM programs to a range of under-represented and disengaged student cohorts, including First Nations students. CSIRO's evidence indicates a range of effective approaches for engaging students in education (STEM specifically).

Indigenous STEM Education Project

CSIRO's Indigenous STEM Education Project (ISEP)[10], funded by the BHP Foundation, ran from 2014 to 2021. The project comprised six programs that demonstrated the link between the traditional ecological knowledge of Australia's First Nations Peoples and the science curriculum and how it can be taught using inquiry-based methods. Each of the six programs were monitored and evaluated. A series of project evaluation reports and individual case studies were produced outlining the learnings from each program and the degree to which they met their intended outcomes.[11]

A 'what works'[12] document synthesised the evidence across all the evaluations and case studies. Some of the key successful practices and approaches in a First Nations context include:

- Building and fostering strong relationships and trust with educators, schools, and communities.
- Prioritising community involvement and local connections.
- Flexibility and patience to allow new programs to evolve and flourish over several years of implementation and iteration.
- Realistic expectations of program outcomes and acknowledgement of environmental, historical, and other factors.

The large evidence base and experience from ISEP has been used to develop a new program called Living STEM, funded by Chevron and delivered by CSIRO, which seeks to connect Indigenous knowledges to the classroom.

Digital Careers

CSIRO's Digital Careers program,[13] funded in part by the Department of Industry, Science and Resources, commissioned the Australian Educational Research Council to undertake research into the factors (barriers and facilitating factors) of young women pursuing digital technology education and careers. The research[14] found several key factors, with two key ones being:

- Representation, for example, female students being exposed to positive, female role models in relevant fields and areas, and the impact of parents on students' attitudes towards digital technology.
- Inclusivity and culture of learning, for example, actively recognising and dismantling negative stereotypes and stigma; and creating inclusive digital technologies curriculum.

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[10] https://www.csiro.au/en/education/programs/indigenous-stem-education-project

[11] Evaluation and case study reports at https://www.csiro.au/en/education/Programs/Indigenous-STEM-Education-Project/Monitoring-and-evaluation

[12] Banks, C. (2022). '*What works' in Indigenous STEM education*. CSIRO: Canberra. https://www.csiro.au/-/media/Education-media/Files/Indigenous-STEM/Evaluation/21-00120_SER-EDU_FACTSHEET_WhatWorksIndigenousSTEMEducation_WEB_210414.pdf

[13] https://www.csiro.au/en/education/programs/digital-careers

[14] Osbourne, K., Felgate, R., & Buckley, S. (forthcoming). *Engaging young female students in digital technology programs. Part Two: Primary research project report for CSIRO*. Canberra: CSIRO.

STEM Together

STEM Together,[15] funded by the BHP Foundation and delivered by CSIRO, is in the process of developing a student-centred, inclusive approach to STEM education focused on under-represented cohorts of students, including First Nations students, young women, students from regional areas, and from schools in lower opportunity areas. STEM Together aims to strengthen the confidence, capability, and connection with STEM through tailored recognition opportunities, group learning experiences, and professional learning and tools for educators. STEM Together is based on the principle of try, test, learn and the evidence from this program will be shared to inform other programs aimed at under-represented and under-served students.

3. How can all students at risk of falling behind be identified early on to enable swift learning interventions?

CSIRO is applying Bayesian Network Analysis and causal inferencing to education datasets. These advanced analytics techniques were able to identify the key features associated with success in STEM education in senior high school based on data from primary and middle school years. By examining these features, particular student cohorts can be identified early in terms of a high likelihood of subsequently disengaging from STEM, with appropriate supports and interventions put in place to assist students as necessary. The next stage in this process is to combine data analysis with testing of new interventions.

From a STEM pipeline building perspective, an accurate understanding of the causal pathways of student's STEM aspiration and achievement could assist in the design and delivery of real-time, data-informed interventions into the education ecosystem. A principled causal modelling approach, together with methods to quantify uncertainty and ambiguity in both the data and hypotheses, will help to ensure those policy interventions are quantitatively evaluated for their ability to shape national STEM outcomes, be interpretable and aligned with future workforce needs. From a data science research perspective, this approach could also enable the development of novel solutions to address a complex challenge in statistics and computer science: combining causal inference, experimental design, and social and human behaviour to inform interventions that maximise a quantity of interest (e.g. STEM uptake) while reducing uncertainty in the causal effects of future interventions.

Chapter 4: Our current and future teachers

21. What reforms could enable the existing teacher workforce to be deployed more effectively?

Ensuring enough specialised STEM teachers and primary level teachers able to teach STEM skills (or '21st Century skills') across the curriculum and subjects, will be vital to maintain and build the STEM talent pipeline. Teaching STEM in a cross-disciplinary and integrated way requires specialised training at the initial teacher education stage.[16] Teaching 'out-of-field' in STEM subjects is a significant issue in Australia[17] and it will be important to attract and retain more teachers into STEM specialisations to help boost student engagement and performance and address teaching out-of-field issues.

CSIRO has a long history of delivering effective programs to educators, particularly in the practical teaching of STEM in the classroom through an inquiry-based learning approach. These programs can build the capability and confidence of teachers to deliver high-quality STEM education, even in cases where educators are by necessity teaching out-of-field.

[15] https://www.csiro.au/en/education/programs/stem-together

[16] Kurup, P.M., Yang, Y., Li, X., & Dong, Y. (2021). Interdisciplinary and integrated STEM. *Encyclopedia of Social Science, 1*(4)., 1192-1199. https://doi.org/10.3390/encyclopedia1040090

[17] Shah, C., Richardson, P. & Watt, H. (2020). *Teaching 'out of field' in STEM subjects in Australia: Evidence from PISA 2015*. GLO Discussion Paper Series 511, Global Labor Organization. Retrieved from https://ideas.repec.org/p/zbw/glodps/511.html

Hands-on science using real world problems and contexts are an effective way to engage students in STEM.[18] CSIRO is uniquely positioned as Australia's national science agency to connect educators to cutting-edge science that CSIRO produces.[19] Although most of CSIRO's education programs are aimed at practicing STEM educators, many of the resources and approaches could support deploying teachers to STEM areas. CSIRO's educator-involved programs can increase confidence and capability in STEM education and provide the frameworks and resources to deliver engaging and effective STEM education to students. These curriculum-aligned programs can supplement initial teacher education programs and allow mid- and late career educators to shift focus to high demand areas. They comprise:

Technology and computational thinking programs

- Bebras[20] is an international initiative aiming to promote informatics and computational thinking among students in years 3 to 12. Bebras can be used by educators to integrate computing concepts into their teaching practice.[21]
- CyberTaipan[22] is a cyber defence competition open to high school students and is based on a proven framework for educating and inspiring high school students towards further education and careers in cyber security and other STEM subjects. Educators can be involved as coaches.
- Digital Careers Teacher Professional Learning[23] are free sessions suitable for primary and secondary educators teaching the Technologies, ICT or other related STEM classes.

Programs connecting STEM industry (including CSIRO) and the classroom

- STEM Professionals in Schools[24] is a national program that facilitates partnerships between schools and industry to bring real-world STEM into the classroom. The program individually matches teachers and STEM professionals so they can work together to increase teachers' STEM skills, knowledge, and confidence through a range of activities. The program has a substantial proportion of volunteers from CSIRO, who can connect CSIRO's cutting-edge science to the classroom. An evaluation report published in 2020 found the program's greatest impact was with teachers and in the broader community.[25]
- Generation STEM Community Partnerships Program[26] (in New South Wales) creates strong partnerships between local schools and industry, with the goal of highlighting local STEM careers and opportunities and providing avenues for students to develop their STEM skills in an engaging and rewarding way. Teachers are paired with local STEM professionals to mentor them through projects. This increases the teachers' skills and knowledge through exposure to contemporary STEM practices.

Cultural competency in teaching STEM to Aboriginal and/or Torres Strait Islander students, and demonstrating links between the knowledges of Australia's First Nations Peoples and the science curriculum (which aligns with enabling factors for learning in the discussion paper)

- As mentioned previously, CSIRO's Indigenous STEM Education Project comprised several programs aimed to increase interest and academic achievement among Aboriginal and/or Torres Strait Islander student in STEM,

[18] Cairns, D. & Areepattamannil, S. (2019). Exploring the relations of inquiry-based teaching to science achievement and dispositions in 54 countries. *Research in Science Education, 49*, 1-23. https://doi.org/10.1007/s11165-017-9639-x

[19] CSIRO. (2023). *Our achievements: Advancing Australia since 1916*. Retrieved from https://www.csiro.au/en/about/achievements

[20] https://www.csiro.au/en/education/programs/digital-careers/bebras

[21] Lonati, V. (2020). Getting inspired by Bebras tasks: How Italian teachers elaborate on computing topics. *Informatics in Education, 19*(4), 669-699. DOI: 10.15388/infedu.2020.29

[22] https://www.csiro.au/en/education/programs/digital-careers/ctaipan

[23] https://www.csiro.au/en/education/programs/digital-careers/teacher-professional-learning

[24] https://www.csiro.au/en/education/programs/stem-professionals-in-schools

[25] Tesselate (2020). *STEM Professionals in Schools 2018-19 program impact evaluation*. https://www.csiro.au/-/media/Education-media/Files/STEM-Prof-Schools/STEM-Professionals-in-Schools-Impact-evaluation-report---2020---Executive-Summary.pdf

[2626] https://www.csiro.au/en/education/programs/generation-stem/stem-community-partnerships-program

including several focusing on building the capacity and confidence of educators. Many of the evaluation reports[27] and a 'what works'[28] summary identified teacher engagement and practice, the ability to embed Indigenous knowledges in the curriculum, and employing two-way science as success factors.

Inquiry-based learning

- CSIRO's Creativity in Research, Engineering, Science and Technology (CREST)[29] supports primary and secondary students and their teachers to design and implement their own open-ended science investigation or technology project. CREST supports teachers to facilitate inquiry learning in the classroom and provides scaffolded resources to enable all students to achieve an award.

Supporting under-represented students

- As mentioned previously, STEM Together helps curious Year 5 to 10 students strengthen their confidence, capability, and connection with STEM, including professional learning and tools for educators. STEM Together prioritises opportunities for students that identify as Aboriginal and/or Torres Strait Islander, female, and from schools in regional or lower opportunity areas.

Resources and citizen science

- Your Diet and Your DNA[30] is a simulation that centres on the food choices of two students and how these choices might be impacting their performance and health. Educators can use the inquiry model to investigate in the laboratory how healthy and unhealthy diets can impact health and disease. The program includes an Australian Curriculum linked teacher guide.
- Sustainable Futures[31] supports primary and secondary teachers with free access to digital teaching resources which includes a variety of ideas and activities to support the teaching of sustainability and the environment in Australian schools.

Chapter 5: Collecting data to inform decision-making and boost student outcomes

27. What types of data are of most value to you and how accessible are these for you?

CSIRO runs several curriculum-aligned STEM education programs in schools, primarily in Years 5 to 10. These programs collect evaluation self-report data from students, educators, and parents to understand participant perspectives on the effectiveness and operations of programs. However, it has been challenging to obtain administrative data from schools, education departments, and curriculum/assessment authorities to assess academic achievement, elective selection, and other outcome data. Barriers to access are principally related to legislative requirements but also relate to organisations prioritising internal reporting and research projects over external evaluation projects. It is also challenging obtaining longitudinal data and linkage datasets that span primary and high school, tertiary education, and careers. New South Wales' Pathways for the Future Program is a rare example of this dataset, which presents many

[27] CSIRO (2023). *Monitoring and evaluation*. Retrieved from https://www.csiro.au/en/education/Programs/Indigenous-STEM-Education-Project/Monitoring-and-evaluation

[28] Banks, C. (2021). *'What works' in Indigenous STEM education*. Canberra, Australia, CSIRO. Retrieved from https://www.csiro.au/-/media/Education-media/Files/Indigenous-STEM/Evaluation/21-00120_SER-EDU_FACTSHEET_WhatWorksIndigenousSTEMEducation_WEB_210414.pdf

[2929] https://www.csiro.au/en/education/programs/crest

[30] https://www.csiro.au/en/education/resources/teacher-resources/your-diet-and-your-dna#:~:text=Based%20on%20CSIRO%20research%2C%20the,term%20health%20and%20well%2Dbeing.

[31] https://www.csiro.au/en/education/programs/sustainable-futures

opportunities, including helping to assess the effectiveness of education interventions. For example, these datasets have the potential to overcome the common education intervention phenomena of 'fade out', where the impacts of interventions diminish or even disappear over time, and 're-emergence', where the impacts reappear years later.[32] Relying on short-term outcome data may miss impacts that are longer-term in nature.

Another important area of data is the demographic, socio-economic, and psycho-social data of program participants and students that can help contextualise evaluation data and help understand what programs work for what participants under what circumstances. Some schools do not collect data beyond basic demographics. An important feature of the Programme for International Student Assessment (PISA)[33] is the context questionnaires that seek information on family background, attitudes, habits, school information, context of instruction, interest, and motivation. Collecting this data could allow a broader and more nuanced picture of student, school, and system performance.

Generation STEM, funded by the New South Wales Department of Education and delivered by CSIRO, is developing a project called Evidence X, which aims to address the evidence problem in the STEM ecosystem. The STEM ecosystem is the collection of schools, organisations, individuals, and communities committed to developing STEM-related opportunities and capabilities. Evidence X is attempting to address the lack of useable, accessible, timely evidence to inform the design, delivery, and evaluation of STEM programs. A consistent framework for assessing the relative success of STEM education programs could also support improving the ecosystem's understanding of what works, for who, and why.[34] Evidence X will be undertaking a design process and consultation and engagement with a range of STEM ecosystem stakeholders from August to December 2023. The outcomes of Evidence X will be shared across the ecosystem, including with schools and education systems. CSIRO would be pleased to discuss this project further and provide briefings to relevant department staff.

28. Is there any data not currently collected and reported on that is vital to understanding education in Australia? Why is this data important?

CSIRO delivers a number of STEM education programs that complement and extend what the government, Catholic, and independent education sectors provide. CSIRO is committed to robustly evaluating these programs to understand what works, for who, and in what contexts. CSIRO is also committed to sharing evidence with the STEM education ecosystem to improve Australia's STEM talent pipeline overall. All of CSIRO's STEM education program evaluation projects are approved by its Social and Interdisciplinary Science Human Research Ethics Committee, which ensures the highest levels of ethical practice. To undertake evaluation research within school contexts, for example with educators and students, additional approval is required by state and territory (8 in total), Catholic Education Dioceses (at least 30), and with individual independent schools (several hundred). The current system of seeking approvals to conduct program evaluations is challenging for national programs. Some areas where the system could better support the evaluation of national education programs include:

- More timely and consistent timeframes for approvals to ensure valuable information and insights are being collected on program implementation and delivery.
- More expertise and understanding of program evaluation, including ensuring application forms, guidance, frameworks for assessments, and decision-making explicitly acknowledge evaluation and how it differs from research.

[32] Chetty, R., Friedman, J.N., & Rockoff, J.E. (2014). Measuring the impacts of teachers II: Teach*er value-added and student outcomes in adulthood. American Economic Review, 104(9), 2633-2679.* http://dx.doi.org/10.1257/aer.104.9.2633

Bailey, D.H., Duncan, G.J., Cunha, F., Foorman, B.R. & Yeager, D.S. (2020). Persistence and fade-out of educational-intervention effects: mechanisms and potential solutions. Psychological Science in the Public Interest, 21(2), 55-97. https://doi.org/10.1177/1529100620915848

[33] OECD (2019). *PISA 2018 Assessment and Analytical Framework.* PISA, OECD Publishing, Paris. https://doi.org/10.1787/b25efab8-en

[34] Tools like the STEM Equity Evaluation Portal are useful for collating evaluation findings from diversity programs and offering general guidance on conducting evaluations.

- More streamlined processes and requirements across jurisdictions to ensure that consistent evaluation methods and data collection tools are employed. Consistency across jurisdictions would ensure all participants in programs have a voice in providing feedback on programs.
- More consultation with schools that are running education programs, to ensure that their desire to provide feedback and be involved in evaluation processes are supported by departmental teams approving evaluation projects.

A more harmonised approach among jurisdictions that values and has greater understanding of the evaluation of education programs would produce higher quality and more consistent data. This could involve reciprocal agreements, where approval in one jurisdiction could be used to fast-track approvals in other jurisdictions.

31. Is there data collected by schools, systems, sectors or jurisdictions that could be made more available to inform policy design and implementation? What systems would be necessary to make this data available safely and efficiently?

CSIRO designs and delivers several STEM education programs that would benefit from more timely and utilisable data to inform program design, implementation, and evaluation. For example, MySchool and ACARA School Profile data provide valuable high-level information on school-level attributes and outcomes. However, more nuanced and detailed data in an interactive format is generally not available. For example, a dataset with a user interface that allowed for the exploration of STEM subject selection by year level, school, and student cohort (e.g., gender, Indigeneity) would be enormously valuable to inform CSIRO's programs in terms of geographic areas and cohorts to target. This level of data would pose minimal privacy risks.

Efforts to make existing data more accessible, timely, and utilisable could be accomplished through more streamlined data requests and data sharing agreements, better and more user-centric interfaces, and data linkage. A national dataset available to education providers across Australia, similar to the Pathways for the Future dataset would be one model. There are a number of considerations that would need to be taken into account when progressing these goals, including Indigenous data sovereignty.

Conclusion

In summary, STEM comprises an interdisciplinary learning approach for students and a critical set of skills necessary for Australia's future workforce. There is a growing need to ensure Australia has educators skilled and confident in teaching STEM and a diversity of students well equipped with 21st century skills. To address this need in the context of education system enhancements, CSIRO has highlighted:

- Learning from the evaluation of approaches for engaging under-represented students, such as the Indigenous STEM Education Project.
- More use of advanced data analytics techniques to identify at risk students and interventions that work through the collection, synthesis, and sharing of evidence to inform practice, programs, policies, and funding.
- Supplementing teacher education with educator professional learning programs, particularly in areas with high levels of teaching out of field, such as STEM.
- Examining ways to increase the efficiency and consistency of jurisdictional approvals to conduct program evaluations.
- Developing timelier, user-focused datasets, including data linkages (ensuring education and industry sectors are active contributors and users), longitudinal data, and datasets that include student contextual information.

CSIRO is committed to supporting a better, fairer education system and is looking forward to participating in future reforms and opportunities.

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