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Digital Innovation in Secondary Education

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Table of Contents

Introduction

CSIRO Education and Outreach welcomes the opportunity to provide input to the Western Australian Education and Health Standing Committee's Inquiry into Digital Innovation in Secondary Education.

As the national science research agency, CSIRO's vision is to be Australia's innovation catalyst and our purpose is to solve Australia's greatest challenges through innovative science and technology. The *Science and Industry Research Act 1949* defines our purpose and the functions we undertake for the benefit of Australia, which encompasses taking a leadership role in transforming our economy to capitalise on the industries of the future. This includes significant investment, through our CSIRO Education and Outreach team, in programs that help to build and equip Australia's future science, technology, engineering and mathematics (STEM) workforce.

CSIRO Education and Outreach is focused on delivering high-quality, engaging STEM learning experiences for primary and secondary schools and teachers to help ensure all Australian students are equipped with the skills they need to enter the workforce. Through our science outreach programs, we promote the importance and application of CSIRO research to the community and to increase Australia's STEM literacy.

Within several of our education and outreach programs, we are implementing and trialling digital technologies to increase our engagement and reach, especially for students in remote and regional areas and for students traditionally underrepresented in STEM education. Our submission provides case studies from our programs in response to areas of the Terms of Reference in which we have relevant expertise and insights. As a national organisation, our programs are generally not jurisdiction-specific, however most are active in Western Australia or have findings applicable to Western Australia.

CSIRO response to the Terms of Reference (ToR)

1. How digital innovation can assist secondary students to learn anything, anywhere, anytime

Our 2019 Virtual Work Experience Pilot Program provides an example of where CSIRO Education and Outreach is using digital technology to successfully increase educational access for secondary students regardless of their location.

Virtual Work Experience Pilot Program

Research shows that well-designed work experience programs play an important role in transitioning students from study to employment and that they support students to make informed study and employment choices, assist in developing valuable work-based skills and enhance employment prospects (Oliver, McDonald, Stewart, & Hewitt, 2016). Each year, however, organisations such as CSIRO receive significantly more applications for work experience than there are places available. In 2019, CSIRO received 834 applications for 102 placement opportunities. In addition to this, many students are unable to participate in their specific area of interest or undertake meaningful work experience due to accessibility issues such as cost and distance of travel.

To help address these challenges, CSIRO worked with the Commonwealth Department of Education and Training[1] to trial the Virtual Work Experience Pilot Program in Semester 1, 2019. The program sought to use digital technology to increase access to work experience opportunities for students across Australia, especially for those who may face geographic or other barriers to participation.

The program provided an opportunity for students to undertake collaborative, group STEM projects, including projects linked to real-world CSIRO research and industry challenges. Students participated in work experience projects using an online platform while in their schools or homes. Experienced CSIRO and industry STEM professionals—who were remote from the students—were engaged as work experience supervisors.

A total of 57 students participated in the pilot, with 74 per cent of these students living in regional or remote areas of Australia. Students worked in physical or virtual groups averaging four students. All interactions between the students and their experienced supervisor were undertaken via video conferencing and a secure online collaboration platform.

The evaluation of the program found that the majority of students would recommend the program to a fellow student, with many noting the program had inspired them to identify new career and educational paths in STEM. Evaluation also shows statistically significant growth in student negotiation and communication skills and high levels of satisfaction among all cohorts of participants, regardless of age, program duration, academic ability and geographic location.

[1] From 29 July responsibility for this program was transferred to the Department of Employment, Skills, Small and Family Business.

2. The role of digital technology in addressing secondary student engagement and retention

Several CSIRO Education and Outreach programs specifically use digital technologies to increase secondary students' engagement and retention in STEM education, including Educator on Board, Digital Careers, Bebras Challenges, CSIRO Research Datasets Project and the CSIRO Discovery Centre.

Educator on Board

CSIRO's Educator on Board program uses the digital capabilities of the research vessel RV *Investigator* to engage teachers and students in STEM. Through the program, teachers are invited to sail on board the vessel to experience a unique professional learning opportunity and engage secondary school students using live video link-ups. Students gain insights of life aboard a research vessel, including its facilities, equipment and research activities. The live video link-ups also provide a unique opportunity for secondary students to meet voyage researchers, crew and guests.

Leveraging the digital capabilities of RV *Investigator* in this way has been instrumental in highlighting the application of STEM skills to students as well as the diversity of STEM-based careers available, while contributing to the debunking of gender stereotypes. It also enables students to gain "virtual" access to STEM-based environments not otherwise accessible to such a wide range of secondary students from across Australia.

Digital Careers

The Digital Careers program helps address the critical shortage of ICT professionals in Australia. The program offers a range of primarily online activities that help to raise awareness, interest and participation in digital careers to grow the number of students preparing for a career in the ICT industry, including information, classroom resources and challenges for secondary school students.

The Digital Careers website hosts resources for students and teachers and meets CSIRO's accessibility standards ensuring the content, tools and technology are accessible to a wide range of students. The website includes interactive elements to allow secondary students and teachers to discuss new technologies and digital concepts.

The Digital Careers team also supports SAP Australia's Young ICT Explorers competition. The competition's alignment with the Australian Curriculum enables students to apply what they learn in their ICT/Digital Technologies classroom to develop a technology-related project of their choice. At the judging event, students present their projects to a judging panel comprising representatives from academia, industry and research.

Bebras Challenge

As part of the Digital Careers program, CSIRO Education and Outreach administers the Australian component of the Bebras Challenge, an international computational thinking challenge run in 60 countries. The challenge is delivered via an online platform and completed by students individually or in teams. The platform includes auditory aids and visual cues for each question to improve student engagement and interaction. In addition to the Bebras Challenge, CSIRO offers Bebras 365, which is an online tool providing teachers and students access to previous challenge questions for practise or classroom diagnostic purposes.

Evidence of the strong interest in computational thinking as a skillset necessary for future employment, and the role of digital technology in engaging students, is seen in the increasing demand for this program. In 2018-19, students across Australia engaged with the program more than 123,000 times including more than 10,000 engagements from WA students, up from 4000 in 2017-18.

Earthlight: Lunar Hub moon landing virtual reality experience

Research has shown that virtual reality (VR) is an effective method of developing knowledge in the classroom (Yahaya, 2006), and that it can make abstract knowledge easier to learn and enhance achievability in scientific studies (Lei, Zhang, Wang, & Rau, 2018). In particular VR technology has the potential to promote learning in STEM areas by providing learning environments that include: (a) first order (person) experience that supports social constructivist learning principles; (b) reification or the ability to transform or represent abstract ideas in perceptible representations and interactions; (c) size interaction where users can change their size or the size of objects to experience micro and macro worlds; and, (d) safe and secure exploration where users can have simulations of experience that in real life would be too dangerous or beyond their resources (Mikropoulous & Natsis, 2011).

Recognising the potential of VR for enhancing educational outcomes, CSIRO's Discovery Centre recently launched *Earthlight: Lunar Hub*, a moon landing VR experience allowing students and the public to experience life as an astronaut. The 20-minute experience enables students to explore a lunar space station, walk on the Moon and take in different views of Earth. The experience incorporates a range of science disciplines and brings together knowledge and expertise to inspire the next generation of scientists, engineers and explorers.

CSIRO Research Datasets Project

The CSIRO Research Datasets Project features an intuitive access platform, access to CSIRO research datasets and creative resources to guide teachers in introducing data analysis and computer science principles to their students, with a focus on real-world scientific research. Using the data to build capability, teachers and students are able to make scientific discoveries and gain real-life experience using data to learn a range of STEM skills including coding, statistical analysis, scientific, and computational thinking, logical thinking and reasoning. The project also provides opportunity to build trust in datasets and scientific organisations as well as to inspire invention and innovation using data to create products and services.

3. How digital innovation can increase equity of opportunity in secondary education

CSIRO Education and Outreach has designed and delivered several programs which employ digital technologies to increase equity of opportunity in secondary education, including the Indigenous STEM Education Project and the 'Your Diet and Your DNA' simulation pilot, as well as the Virtual Work Experience Pilot Program outlined under the response to the first of the terms of reference.

Indigenous STEM Education Project

The Indigenous STEM Education Project, funded by the BHP Foundation and delivered by CSIRO Education and Outreach, aims to increase participation of Aboriginal and Torres Strait Islander students in STEM from primary school into employment. Several components of the program employ digital tools to enhance the learning outcomes for students, recognising that digital technologies are integral to the lives of Aboriginal and Torres Strait Islander young people (Rice, Haynes, Royce, & Thompson, 2016). The familiarity that Aboriginal and Torres Strait Islander young people have with these technologies, particularly mobile phones, mean that there are opportunities to enhance active learning (Townsend, 2015), including student-generated digital content and developing alternative forms of learning.

The use of digital tools in the Indigenous STEM Education Project is informed by international research, which demonstrates that digital tools can enable Aboriginal and Torres Strait Islander students to have agency of their learning, and to produce and easily share their own content—including multimedia, video, social media, animation and music—without the input of adults or the non-Indigenous community (Loewen, Kinshuk & Suhonen, 2018).

Examples of the use of digital technology to increase equity of opportunity and enhance student learning outcomes within this Project's programs are outlined below.

- **Inquiry for Indigenous Science Students (I^2S^2):** The I^2S^2 program works with teachers and students to build skills and capability through hands-on inquiry-based projects in an Indigenous context. The program has engaged with more than 7600 students over the past four years and has involved more than 1150 teachers.

  CSIRO recently piloted the I^2S^2 online learning program, which offers professional learning modules to increase teacher capability and enable them to effectively engage Aboriginal and Torres Strait Islander students in science. Learning modules are delivered through SAP SuccessFactors, and a perpetual community of practice is offered through SAP Jam collaboration spaces. To date more than 100 teachers have enrolled to participate and future roll out will assist to increase program reach and impact.

  The I^2S^2 program also provides eBooks which allow students to illustrate learning by recording oral, written and multimedia responses throughout the inquiry process. These recordings may then be submitted electronically to the teacher for assessment. In 2016, 66 per cent of Aboriginal and Torres Strait Islander students achieved an A, B or C grade after participating in the program (up from 49 per cent).

- **Aboriginal Summer School for Excellence in Technology and Science (ASSETS)**: The ASSETS program provides a nine-day residential summer school and ongoing leadership and support for high-achieving Indigenous Year 10 students. CSIRO Education and Outreach has conducted 13 summer schools over the past four years involving 430 students from across Australia. ASSETS participants use digital technologies to enhance their learning at the summer schools. For example, toward the end of the summer school, students develop and deliver PowerPoint presentations, embedding videos and sounds they have recorded over four days of inquiry learning. Evaluation demonstrates the success of the program in inspiring students in STEM, with more than 80 per cent of 2016-17 participants reporting their intention to pursue a STEM career following ASSETS (up 33 per cent from before participation in the summer school) and 84 per cent of 2016-17 ASSETS students reporting a desire to study STEM at university.

- **Science Pathways for Indigenous Communities:** The Science Pathways for Indigenous Communities program works with remote schools in Western Australia and the Northern Territory to develop on-country projects as the context for learning science linked to Indigenous ecological knowledge. Participating schools use digital technologies to enhance learning. For example, students and teachers use remote sensors to collect data, Google Earth to find locations on maps, and contemporary mobile applications to gain and share knowledge in local Indigenous languages and in English.

'Your Diet and Your DNA' simulation pilot

Laboratory exercises provide an important practical element to theoretical components of STEM education. However, access to highly specialised science and innovation equipment is beyond the reach of many schools, especially those in regional and remote settings or with low ICSEA values. Research has demonstrated that practicing practical skills in a virtual laboratory setting using digital technologies is as successful as face-to-face tutorials in preparing students for physical laboratory work (Makransky, Thisgaard, & Gadegaard, 2016).

In line with this research, CSIRO Education and Outreach is currently piloting a laboratory simulation entitled Your Diet and Your DNA. In this program, secondary students use a simulated laboratory environment to explore links between genetic damage and nutrition. This allows students to virtually access industry-standard laboratory equipment and experimental methods not available in many secondary schools. CSIRO Education and Outreach expects the pilot will confirm that providing access to advanced, industry-standard facilities and equipment in simulated form enables greater equity of opportunity to students.

Virtual Work Experience Pilot Program

As outlined above, CSIRO's Virtual Work Experience Pilot Program has demonstrated the utility of digital technologies in increasing equity of opportunity to work experience for secondary students. . The program evaluation revealed that, had they not participated in the virtual program, 29 per cent of participating students would have done no work experience at all and a further 29 per cent of students would not have been able to do STEM-related work experience. More than 80 per cent of this latter cohort lived in regional and remote areas. The pilot program provides useful evidence to inform the delivery of non-traditional, technology-enabled work experience programs for students with a range of barriers to meaningful work experience, including medical, social and geographic barriers.

4. The potential for digital technology to cater to the needs of high performers and at-risk learners in secondary education

Several CSIRO Education and Outreach programs demonstrate the potential for digital technologies to cater to the needs of high performers and at-risk learners in secondary education. Two of these programs are the Adaptive Teaching and Learning Network and the Your Diet and Your DNA simulation pilot.

Adaptive Teaching and Learning Network

The Adaptive Teaching and Learning Network pilot was developed in 2016 by CSIRO in partnership with Smart Sparrow and the PwC 21st Century Minds Accelerator program. The pilot aimed to use adaptive technology to bridge the gap between students' perceptions of science and the reality of current scientific research. A new digital learning module was created based on Smart Sparrow's adaptive platform, which is immersive, incisive, authentic and adaptive.[2]

In 2017, a small cohort of secondary teachers tested a module on the platform themed around a virtual field trip to the Pilbara region. The majority of participant teachers indicated they would use this program in their classrooms. The ability to communicate concepts visually was appealing for many of the teachers, particularly for one teacher from a school with a low ICSEA value. The opportunity to adapt the lessons to suit their classroom context and to adopt the program in a flipped class model was also highlighted by teachers. Follow-up testing with a small cohort of secondary students revealed that the students enjoyed the visual elements and having the choice of what they learned.

'Your Diet and Your DNA' simulation pilot

As mentioned above, the 'Your Diet and Your DNA' simulation pilot supports the development of practical skills using a 'virtual' laboratory setting over digital technologies. As the simulation allows secondary students to work at their own pace, high performing students can complete the experiment in a shorter time span and then engage with supplemental extension materials provided as part of the platform. In pilot testing feedback, 76 per cent of students indicated that they had used the available supplemental materials to further investigate the areas of study covered by the simulation.

Indigenous STEM Education Project

Within the Indigenous STEM Education Project, digital technologies enable teachers to cater to students' differing needs and abilities. Research indicates that the oral and visual focus of digital technologies complement Indigenous ways of learning and sharing (Yunkaporta, 2009), and minimise barriers of language and literacy (Rice et al., 2016). More generally, pairing voice and perspective with technological skills offers flexibility to engage with students and allow students to creatively share learning (Rice et al., 2016). I2S2 applies these understandings by including the use of 'science selfies', taken periodically by students on a mobile device, to encourage self-reflection and discussion, and to ensure students are following inquiry steps.

[2] Adaptive courseware offers teachers comprehensive student data to inform instruction and develop differentiated learning paths for individual students. Adaptive Learning via the adaptive courseware, moves learning away from a 'one-size-fits-all approach' and takes into consideration the diversity of learners. There is potential for adaptive courseware to assist teachers in supporting the needs of high performers and at risk-learners.

5. Challenges to implementation, including provision of digital infrastructure, resources and technical support

Although digital technologies can be used as a vehicle for increasing accessibility to quality education for all groups, there are challenges to implementation, including internet speed and access to technology, support and expertise. The following insights from our Virtual Work Experience Pilot Program and Your Diet and Your DNA simulation pilot mentioned above, illustrate some of these challenges.

Virtual Work Experience Pilot Program

In 2019, CSIRO's Virtual Work Experience Pilot Program used video conferencing and online collaboration spaces to allow groups of secondary students to undertake work experience projects with STEM professionals across Australia.

Generally, students in cities and larger regional towns with access to high speed internet were able to participate with ease. For some students participating in remote locations, however, the internet bandwidth within the school system was insufficient to support the functional operation of the video conferencing. In some cases, these challenges were overcome using costly alternatives. For example, in one remote school, a committed STEM teacher personally paid for an alternative internet connection and provided technical support to students. This demonstrates the need for additional resources and technical support for schools to engage fully in digital innovation, especially for secondary schools in remote and regional areas. In addition to this, some teachers and schools experienced challenges with firewalls and a lack of support to navigate the process to access the required technologies.

'Your Diet and Your DNA' simulation pilot

Similarly, CSIRO Education and Outreach recorded challenges in implementing the Your Diet and Your DNA simulation pilot. Challenges included the need to support a wide variety of technology access within schools, and to provide training remotely to ensure that teachers were equipped with the understandings needed to support their students' use of the simulation.

To address some of these challenges, CSIRO and delivery partners ensured content was available using a web-based solution, enabling its use on a range of platforms and devices. Despite these efforts, approximately 10 per cent of participating teachers and students indicated that the wide variety of platforms in schools still caused technical issues in implementation at a classroom level.

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