Making It Happen: An Experience of Using Earth Observation-Based Research Outputs for Engaging High School Students in Novel Technologies for Sustainable Agriculture

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Abstract

Educational policy and management emphasise the role of science (e.g., earth science, geography) as a fundamental aspect of societal advance, but student enrolments at universities in these disciplines remain low. This commentary explores ways to foster more collaboration between university academics and high school teachers to implement STEM-related curriculum through hands-on exploration of novel earth observation (EO) technologies. To this end, we develop project-based learning activities through the Copernicus applications and services for low impact agriculture in Australia (COALA) project, an international venture of eleven partners seeking to promote the adoption of products and services for sustainable agriculture in Australia, underpinned by satellite technology from the European Copernicus programme. We reflect on our experiences developing project-based learning activities, and particularly on the benefits and obstacles we faced.

The Australian Government's National Science Statement (2017) envisages a society "engaged in and enriched by science", recognising that science is fundamental to the nation's economy (p. 4). The importance of science and technology for Australia's future development is further reinforced in the *2030: Prosperity through innovation report commissioned by the Australian Government* (Innovation and Science Australia, 2017). These messages add to voices from academia warning on the future impacts of poor university enrolments in these areas of learning (e.g., Geoscience on the chopping block, 2021). Back in 2014, The Conversation published a series of articles on "How will science address the challenges of the future?". One of those articles argued that government plans to continue building a stronger and resilient Australia require engineers and that, at present, there were "too few students studying STEM subjects at higher levels at high school, too few going onto engineering at university, and a shortage of engineering skills across the economy as a consequence" (Sahajwalla et al., 2014). This reflection can be extended to include earth and geographical sciences, also affected by a decreased enrolment at university (Cohen, 2018; Geoscience on the chopping block, 2021).

The debate on how best to engage high school students in science and technology (the STEM–STEMM initiatives, see Box 1) has been ongoing for over a decade (e.g., English, 2016, 2017) and is well summarised (Corrigan & Lancaster, 2020; Johnson et al., 2020; Kennedy et al., 2018; Lyons & Quinn, 2015). Many reports highlight what STEM is about (Corrigan & Lancaster, 2020; Lyons & Quinn, 2015; see Box 1), why STEM subjects are important (Corrigan & Lancaster, 2020; Panizzon & Corrigan, 2017), and include suggestions on how STEM education can be part of school curricula (Corrigan & Lancaster, 2020).

Box 1: a brief history of STEM's evolution

STEM education is the learning of science, technology, engineering and mathematics – and medicine, in the case of STEMM – in an interdisciplinary or integrated approach, where students gain and apply knowledge, deepen their understanding, and develop creative and critical thinking skills within an authentic context. STEM education should include inquiry and project-based learning (PBL) (Lyons, 2020; New South Wales Department of Education, 2017). The acronym STEM was introduced in 2001 by scientific administrators at the United States' National Science Foundation (NSF). The organisation previously used the acronym SMET when referring to the career fields in those disciplines or a curriculum that integrated knowledge and skills from those fields. In 2001, the NSF rearranged the words to form the STEM acronym. Since then, STEM-focused curricula have been extended to many countries beyond the United States, with programs developed in Australia, China, France, South Korea, Taiwan, and the United Kingdom (Halinger, 2019). It has been suggested that STEM merely represents individual discipline areas, though it is better described as a way of teaching that integrates each of the four areas by removing subject barriers and making links to real- world learning experiences (Lowrie et. al., 2017).

However, less has been written about how to engage and *what* practices (e.g., activities, collaborations) are best to entice students to enrol in STEM subjects such as geography and geoscience; and, more to the point of this commentary, how university research can be used to support teachers with hands-on materials in high schools to promote those subjects (McLaren & Kenny, 2015).

Though arguments that universities should engage with schools are not new, these days in Australia many collaborations between secondary and tertiary educators, in the interest to promote students' enrolment in science courses, primarily happen ad hoc, fuelled by individuals' enthusiasm and motivation, particularly in areas such as geography and geoscience and technologies (e.g., earth observation (EO) associated with them. The Australian Academy of Science's Decadal Plan for Geography, for instance, presents recommendations on how that might happen based on American experiences (see Box 2).

Box 2: Collaboration between universities and school geography

The Australian Academy of Science Geography Decadal Plan (National Committee for Geographical Sciences, 2018) acknowledges the prime role that universities can play in promoting geography in schools, stating that "school geography would benefit from a renewed collaboration with university geographers, and university geography programs could also benefit if increased enrolments in the senior secondary years resulted in more students enrolling in university geography courses" (p. 87). The plan advises emulating the American Geographic Alliance model, where academics from universities work with local geography teachers associations to provide professional learning opportunities for teachers, as a way to promote collaboration between teachers and university faculty.

In this commentary, we argue that in spite of the body of knowledge reported in peer-reviewed literature, faculty and university strategies to reach out to schools and promote science, technology, and engineering still lag practical guidance. In this regard, we maintain that through engagement with high school curriculum developers, we could further use research outputs that advance disciplinary – or inter-disciplinary – knowledge to promote engagement with science and technology (which we call "double dipping"). However, the research grant writing process needs to accommodate, and budget for, funding and time to develop activities and foster collaborations with high schools. Our argument underpins recent experiences enabled by a research project (Copernicus for Sustainable Agriculture in Australia or COALA) that promotes the adoption of satellite earth observation products and services for sustainable agriculture in Australia.

Earth observation from satellites, airborne or drone platforms has evolved over the decades. Its use has been democratised (such as in Google Maps, Google Earth), and it has made its way into high school geography and earth science textbooks and curriculum. However, as a fast-evolving technology, it can be difficult for teachers to keep up-to-date with the latest application developments and, importantly, to design hands-on activities for the classroom. Guidelines for research funding from the European Community request a well-developed strategy for communication and dissemination of results (Metternicht et al., 2020). The current project introduced a concept of legacy that enabled us to co-design activities tailored to specific educational outcomes of the New South Wales syllabus as described hereafter.

Case study: The COALA project and communication of science outputs

The essential pillar that underpins COALA (www.coalaproject.eu) is the Horizon 2020 program (European Commission, 2020) that promotes the use of Copernicus, the European Union earth observation and monitoring program. During the 36 months scheduled for completing this project, 11 partners, including academic institutions, small and medium enterprises in Australia and Europe, are developing mechanisms for sharing European knowledge and expertise in the field of EO-based applications for agriculture with Australian institutions. The overarching aim is to support more sustainable use of water and nutrients in the advanced agricultural systems of Australia. Water conservation is vital in Australia, an already dry continent. As climate change continues, we will face more dramatic and frequent droughts. COALA aims to provide long-term assistance for long-term issues that lie at the core of human agriculture, farming, and climate concerns. For this reason, we determined that we would not merely communicate short-term drivers but long-term scale visions. We wanted to consider what will be left behind and how this research could impact future generations.

Conditions of the grant require preparing a communication and dissemination plan adapted to various relevant target audiences (Metternicht et al., 2020). We designed a communication and dissemination plan centred around “legacy”. One aspect of legacy, in this context, involves direct engagement with high school students, tailoring research outputs to engage them in the classroom with current remote sensing technologies used for on-farm management. Compelling legacy narratives are curated throughout the projects, where those involved consider the end-result and focus on moments of shared engagement and development (Khan & Fatma, 2019). The best legacies are held up by those who want success to continue by inspiring and fostering trust with stakeholders and future stakeholders (Trudeau & Shobeiri, 2016).

The need to tailor communication for legacy audiences has been established; for example, a survey by Herington et al. (2019) found that 50% of Australians perceived science as inaccessible to the public, and they thought that the current dialogue between scientists and the public is not meaningful, and is insufficiently resourced. In a similar vein, a more focused example on knowledge about water conservation by Roseth (2006) found that while over 93% of respondents agreed that water must be carefully conserved, 20% of respondents reported that they do not know how to save water. These results show that the public is interested in science and new knowledge, which is also underexploited. The communication focus towards creating legacy is one of the ways COALA plans to transfer knowledge.

Collaboration for implementation of earth observation technologies in support of teaching about sustainable development: co-creation of project-based learning materials.The COALA demo

The New South Wales Agricultural curriculum (New South Wales Education Standards Authority, 2019) aims to help students understand what – and how – technology could support them in their future as farmers. However, teachers often lack time, being stretched thin to keep up to date with the latest technology of a rapidly evolving field. The COALA project communication team contacted a curriculum developer in the New South Wales Department of Education to ascertain the curriculum requirements for high school students in the area of Agricultural Technology and to co-create authentic activities for the students, aligned with expected outcomes of Stages 5 (years 9 and 10, see Box 3).

We jointly developed an interactive activity that required students to use a demo of our platform to investigate the application of satellite data to agriculture, using the newest satellites of the European Space Agency. These data are open access for Australian businesses, including the farming sector. Students used the tools and research data from our earth observation digital activity (Copernicus for Sustainable Agriculture in Australia, 2021) in a series of engagements directed to help them answer questions related to Stage 5 learning objectives. The expected learning outcomes focused on collecting and analysing agricultural data and communicating results using various technologies.

In developing these class lessons (Copernicus for Sustainable Agriculture in Australia, 2021), a few issues became apparent which structure the discussion and reflections that follow hereafter.

Box 3: Expected outcomes of Stage 5 Agricultural Technology of the New South Wales curriculum.

- AG5-2 explains the interactions within and between agricultural enterprises and systems
- AG5-4 investigates and implements responsible production systems for plant and animal enterprises
- AG5-6 explains and evaluates the impact of management decisions on plant production enterprises
- AG5-12 collects and analyses agricultural data and communicates results using a range of technologies.

(New South Wales Education Standards Authority, 2019)

Lessons learned and reflections

Researchers of STEM disciplines often lack the time to develop resources tailored to school students

Dissemination of research outputs that focuses exclusively on academia as beneficiaries, often forgets to direct resources in terms of time and finance to promote technologies and emerging research to the public. In grant applications, publicly funded researchers (e.g., Australian Research Council and other Category 1 grants) often need to articulate the national benefits (social, economic and environmental) expected to be delivered from the research project. Typically, outputs associated with national benefit relate to advancing knowledge or enhancing understanding of the discipline. National benefit tends to be measured by metrics such as the number of publications in peer-reviewed journals of high impact factor, and restricted to developing academic potential or publishing in academic journals. Nevertheless, our nation benefits when we strengthen the links between universities and high school students. These links are essential when STEM subjects, such as earth science or geography, have been slashed in response to university restructuring (Geoscience on the chopping block, 2021; Selway, 2021).

In our experience with this project, we found that it is not standard for projects to consider legacy as a key aspect of communication and dissemination. PBL allows students to engage in authentic activities with driving questions using technologies to demonstrate their understanding (Hasni et al., 2016; Thomas, 2000). By providing our platform for use and working with curriculum developers, we helped to design a PBL lesson for the classroom. When PBL is implemented well it can benefit students in helping them develop increased understanding and knowledge application. A key factor in how well these PBL activities are implemented is “academic rigor”, which should allow students to improve their higher order thinking skills while being aligned to content and curriculum, and give students the opportunity to reflect on and revise thinking (Boston & Wolf, 2006; Edmunds et al., 2017). The rigour of these activities was improved by working together, since we could provide the platform and the specialist expertise while the curriculum developer provided both pedagogical and curricular expertise.

Models of engagement are insufficient

While university management and professional associations raise concerns about low enrolments in STEM subjects, not much thinking and action have been devoted to exploring and articulating pathways for how university research, supported by public funding, can provide as part of its outputs, materials to support teachers in the implementation of curriculum related to STEM subjects in high schools. When academics do reach out to schools, it is often limited to delivering lectures or talks (Cridge & Cridge, 2015). This lack of engagement can partly relate to a vague reward system for academia to engage in service to the community – high school teachers in this case. Furthermore, teachers, eager to have hands-on activities for their students arising from the latest research at universities, often lack proper channels to contact university researchers. In the case of the COALA project, serendipity (e.g., informal networks, chance talks with staff of the New South Wales Department of Education) led to the collaboration with high schools.

Although service is one of the three pillars of scholarship (with teaching and research), the Global University Network for Innovation found that young academics in some universities are “discouraged from following an engaged scholarship career pathway”(Hall, 2014, p. 308). More to the point, Vuong et al. (2017) mention that many higher education institutions in the United States are criticised for emphasising the importance of collaboration between university scholars and local communities to address economic or social challenges. That situation extends to Australia, as the Productivity Commission (2017) acknowledges the need for “more closely aligning the interests of universities with those of the people they serve – students and taxpayers – could be one mechanism to drive improvements in student outcomes" (p. 27).

With funding bodies adopting more specific rules on communication and dissemination of research outputs, entry points for better articulation and translation of research results to hands-on activity in support of teaching in high schools may open. In the case of the COALA project, the European Commission Horizon 2020 scheme funding states that "project beneficiaries must promote the action and its results, by providing targeted information to multiple audiences (including the media and the public), in a strategic and effective manner and possibly engaging in a two-way exchange" (European Commission, 2017). These evolving requirements by funders to demonstrate broader research impacts has elucidated barriers and incentives (financial and non-financial) for academic faculty to engage in knowledge translation and research utilisation (Jessani et al., 2020).

Professional learning opportunities for teachers: bridging the gap

Teachers must be STEM literate and confident to teach competently and bring a real-world application of expertise to the classroom (Ledbetter, 2012). We propose that, if university researchers work with teachers to help develop demos and tutorials ready for the classroom and demands of the curriculum, as suggested by the National Committee for Geographical Sciences (2018), more applied science could end up in classrooms (Hennah, 2019), which may increase enrolments, particularly for regional and remote schools.

Several examples of formal opportunities for researchers to work with schools have arisen recently in Australia; for example,the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is working with researchers to partner mentors into schools to provide visits and help years 9 and 10 students connect with researchers (CSIRO, n.d.-a). Some students can likewise get into universities to work with researchers doing research projects for their science extension projects (University of New South Wales Science, 2021). CSIRO is also working to help teachers work with researchers and stay up-to-date with their STEM Professionals in Schools program which matches teachers and STEM professionals to help increase knowledge and confidence in STEM (CSIRO, n.d.-b). Research into programs like these show greater scientific literacy for students, a higher likelihood of engaging with interest in STEM, and for teachers to increase their confidence (Forbes & Skamp, 2012). It is not only the students and teachers who benefit, as the STEM professionals often report increased enjoyment and passion (Tytler et al., 2009). The curriculum developer we worked with sought out STEM professionals to develop the curriculum, but our connection was ad hoc, through personal networks, not a professional program.

Concluding remarks

That universities should engage more with schools has been highlighted in previous research. Through this commentary, we present a narrative experience and reflections that align with recent reports and research calling for re-evaluation of incentives and modes of engagement for enhancing faculty engagement with high school educators, (Jessani et al., 2020; Productivity Commission, 2017; Vuong et al., 2017), as one way to foster more STEM enrolments at universities.

As the face of university education is changing (Kinash et al., 2021; Matthews, 2021), a unique opportunity opens for extending those winds of change to university outreach activities to schools (McLaren & Kenny, 2015). We should re-assess incentives and barriers for university researchers to engage with STEM teachers and support quality science teaching – an essential component in sustaining the scientific interest of schoolchildren (Cridge & Cridge, 2015).

We need to get new scientific research into high school curricula to learn and benefit from current research and technologies. Practical engagement is critical with practical sciences like agricultural technology. By granting access to current university research on fundamental sciences, we present a unique learning opportunity for the next generation of agriculturalists. Collaborating with high school teachers is one way to develop students' scientific literacy and bring research directly into schools. Incentives from universities (and research granting bodies) on "expected outcomes" of projects should include – and recognise – time spent to develop research findings into the curriculum of high schools. This kind of dissemination helps democratise research findings beyond the academic ivory towers and journal paywalls.

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