GeoSTEM: "The Urban Mess" Interdisciplinary Learning in a Project-based Learning High School Environment

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Abstract

Parramatta Marist High School is a school in Western Sydney, New South Wales, that has over 14 years of experience in project-based learning in Stages 4 and 5 (Years 7–10). Over this period, projects have been constantly developed, redeveloped and improved by teachers based on their experience and feedback from their colleagues and their students. Growing out of this feedback cycle, GeoSTEM (an integration of geography and STEM) was formed to utilise complementary skills and concepts from both subjects in order to develop projects that better engage and reflect student learning in the 21st Century. In 2019, the first GeoSTEM project titled "The Urban Mess" was delivered to Year 9. This project focused on issues of urbanisation, sustainability and design within a local context, through the lens of the Stage 5 Changing Places unit. Through computer-aided design and fabrication, local geographical issues were exposed and resolutions proposed with the final products utilising laser-cut overlay maps to represent the various solutions.

Keywords: Project-based learning; GeoSTEM; integrative STEM

Educational Context

Parramatta Marist High School (PMH) is a Catholic, comprehensive, all boys secondary school located in Western Sydney, New South Wales, Australia. The school employs project-based learning (PBL)across all teaching disciplines in the junior and middle school curriculum in academic Years 7 to 10 (ages 12 to 16). The implementation of PBL began in 2008, after finding students in Year 9 were struggling to engage with syllabus content in a deep manner. In addition to reigniting student engagement with their classes, PMH wanted to best prepare students for life after school, "developing important '21st Century skills', such as communication, collaboration and creative thinking" (Parramatta Marist High School, 2021).

The Buck Institute for Education (2021) identifies seven essential project design elements in their Gold Standard PBL model: a challenging problem or question, sustained inquiry, authenticity, student voice and choice, reflection, critique and revision, and a public product. At PMH, the school has aimed to fulfil each of these elements in the projects that are designed and implemented across Years 7 through 10. This includes the integration of such key learning areas (KLAs) as Human Society and its Environment (HSIE), English, and Religious Education. Essentially, projects will generally involve the integration of two of these KLAs (when a natural fit between the knowledge and skills can be found) whilst some projects are stand-alone, drawn from a single subject. For example, Year 9 students complete an integrated History and English project titled "Tales of War", in which students study the Australians at War unit through the lens of two related texts, *A rose for the Anzac boys by* Jackie French and *Photographs in the mud by* Diane Wolfer for each respective KLA. An example of a stand-alone project includes the Year 8 project "Water in the World" where geography runs by itself for the duration of the project. In these scenarios, classes will have 60 students in the one classroom setting, with two teachers, one from each of the corresponding KLAs, acting as learningfacilitators.

Unfortunately, due to a number of factors (and in line with the statewide trend), geography at PMH has struggled to gain the interest of students in Stage 6 with the last senior class running in 2013

(Pluss, 2020). In a bid to reignite engagement in the discipline, and with the Gold Standard PBL model in mind, emphasis was placed on finding authentic cross-curricular projects to implement. According to the Buck Institute, authenticity in PBL can be defined as follows: "The project involves real-world context, tasks and tools, quality standards, or impact, or the project speaks to personal concerns, interests, and issues in the students' lives" (Buck Institute, 2021).

The building of purposeful connections through the identification of cross-curricular similarities between KLAs helps to draw out the *authentic* elements within each (Caldis & Kleeman, 2019). With these factors in mind, careful consideration was given to the integration of geography with other KLAs, and the decision was made to leverage the significant student interest in STEM. At PMH, an integrative or interdisciplinary approach to learning in STEM was adopted, based on the work of Sanders and Wells at Virginia Tech (Sanders, 2015) as it was best suited to the school's pedagogical context. PMH students undertake a compulsory integrative STEM course in Stage 4 (Years 7 and 8), with elective courses offered in Stage 5 (Years 9 and 10). Working on projects developed by a dedicated STEM department, students work in teams to solve real-world problems covering a wide array of topics; an important aspect when driving engagement (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2016). Consequently, it seemed most appropriate to develop an integrated geography and STEM project that sought to appeal to students on various levels through an authentic, real-world problem. Thus, the GeoSTEM concept was born at PMH.

The Urban Mess

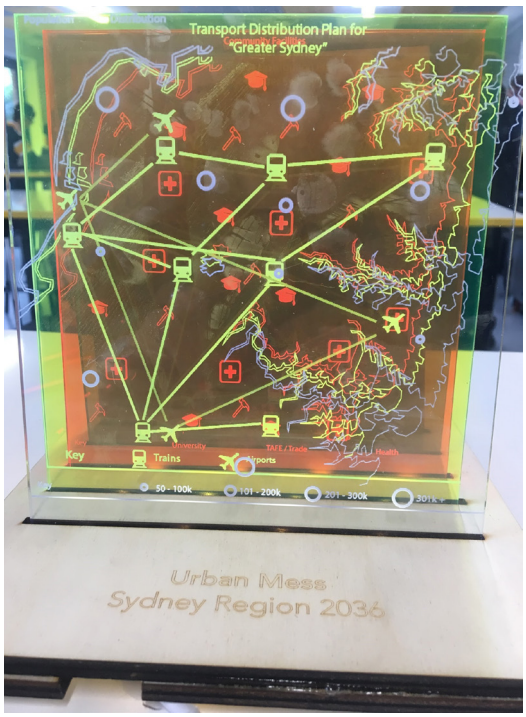
The first task after deciding on geography and STEM integration was to look at the respective syllabi and decide which aspects of both would be best suited to developing this project. It was decided that geography would be the main driver for the content, and STEM would provide support for both students and teachers in terms of the development and application of the targeted skills. Due to timetabling constraints, two geography team teachers would be present in the class at all times with the STEM department providing support in the form of flipped instructional videos and fabrication. Whilst there were many options and possibilities across the Stages 4 and 5 work units, it was decided that the first project would focus on the Changing Places unit from the Stage 5 syllabus (New South Wales Education Standards Authority [NESA], 2015).

At first glance, the key inquiry questions for this work unit (based on urbanisation and migration) do not appear to fit within what most consider a traditional STEM framework (Zeidler, 2016). Although they lean more towards the human side of geography, an integrative STEM approach aims to contextualise learning for students in ways reminiscent of the real world (e.g., interdisciplinary and "messy"). In The Urban Mess unit, students are required to 'investigate the management and planning of Australia's urban future' with consideration given to population projection and its associated strategies for sustainable management (NESA, 2015). The PHS project has been named as such to imply the wicked problems that students face when grappling with the complexities and issues of urban sprawl and its management. In more detail, students explore the data, statistics and processes associated with population projections and consider the engineering and technological advancements allowing for sustainable urban designs at a given point in the future. These pieces of knowledge, processes and inquiry skills are inherent to both domains of geography and STEM.

To the geography teacher, implementing sustainable practices for inevitable population growth could not be any more relevant and is very clearly a real-world problem but how does one get their students to see this as well? The Urban Mess sought to do this by presenting students with a project focused on their own local context within the Sydney Basin and thereby creating those authentic connections to an existing and challenging problem. The driving question underpinning the term-long 10 week project was "How can we design urban places that can sustainably cater for an increasing population?" The purpose of the driving question in a project is to act as a rudder, guiding students to make corrections over the course of the project. In line with PBL practices, the defined summative task, or end product, for students was to develop an urbanisation plan for the future of the Greater Sydney Region with a target of the year 2036, inspired by the New South Wales Government's *A metropolis of three cities – the Greater Sydney Region Plan* (2017). Within that defined end product, students were free to collaborate in groups and present their solution for this project in the form of a laser-cut overlay map designed with Adobe Illustrator (Savery, 2006). An example of an end product, with four layers of perspex each representing a different sector within the Greater Sydney Region – transport, population distribution, community facilities, and green spaces – is shown in Figure 1. Students had to take into consideration the projected population growth and how they could and would cater for this expansion with regards to the spatial

distribution of these four sectors. Supplementing their design was a presentation justifying their urban plan and explaining how this would provide a sustainable future for Sydney.

Figure 1. Prototype of laser-cut perspex overlay map end product.



The project included scaffolding from both the geography and STEM teachers to support students (who required it) in developing this project. Whilst the project was solely focused on the geographical content and skills, and facilitated by the geography teachers like any standard geography project, the STEM department assisted in developing videos and supplementary materials on how to use Adobe Illustrator, and joining timetabled geography lessons where possible to run workshops. Given many students were already familiar with Adobe Illustrator from their compulsory STEM courses in Years 7 and 8, there was still a need to provide scaffolding for intermediate and advanced learners. Additionally, geography teachers took the opportunity to be upskilled in similar programs and offer optional workshops with smaller groups of students within the Hive (the school's dedicated STEM fabrication space). This was enabled by geography team teachers working with two classes run concurrently.

Thoughts and Considerations about the Project

Based on student feedback collected at the end of the project, students were highly engaged and found that its structure helped them to see the real-world application of the geography course content. Whilst the laser-cut perspex design provided an engaging tangible facet to the project, it also helped students to develop skills in mapping and understand concepts of spatial distribution and sustainable practices. However, teachers observed that whilst the local context was most certainly helpful, students struggled to conceptualise the size of the Greater Sydney Region, and proposed that future iterations of the project focus on a smaller area, such as the Parramatta Local Government Area.

Remembering that the "public product" at the end of the project is a critical component of Gold Standard PBL (Buck Institute, 2021), further improvements to the authenticity of the project and greater connections to the real world need to be considered for the future. This could include fieldwork within the area of focus (such as an excursion into the Parramatta Central Business District) as well as inviting comments and critiques on the students' project solutions from such experts as a local urban planner or council member.

Another consideration is that the project was more costly (than class-based projects) and rather time consuming. For example, the scheduling of the laser cutting and etching of pieces of perspex for 180 students was a significant undertaking. However, the school is in the fortunate position of having invested in the STEM space and therefore able to run such a project for its students allowing them access to facilities such as a laser cutter, 3D printers and support staff. Ultimately, the end product for this project could be transferable to a digital overlay map designer or, if wanting a tangible product, utilising overhead transparencies making this project possible for those without access to these facilities.

It could be argued that this unit of work could remain a standard, stand-alone geography project, however, by taking an interdisciplinary approach we can highlight the relevance and connectedness of geography through such cross-curriculum priorities as sustainability, and investigate them through the lens of STEM (Salter & Maxwell, 2020). Moreover, this project demonstrates how much symmetry the discipline of geography has with integrative STEM approaches in both the skills and concepts as developed and explored by students. Whilst it is true that geography provides a literal and metaphorical place for these concepts to be investigated, STEM also provides complementary skills and concepts as well as some of the vehicles in which these concepts can be presented. And here is where the lines begin to blur (Caldis & Kleeman, 2019). For example, consider the suggestions above regarding optional presentation formats for the project. A geography class does not have to have

access to a lasercutter in order to undertake this project. If they were to create overlay maps using a digital program or overhead transparency sheets, this would still be very much a GeoSTEM project in action. Students can still meet the identified cross-curricular outcomes and target the desired concepts and, therefore, the common goal of solving real-world problems and exploring concepts embedded in science, technology, engineering and mathematics and geography still remains.

In conclusion, this interdisciplinary project, The Urban Mess, demonstrates the complementary nature of geography and STEM by affording students the opportunity to engage in authentic, challenging, problem-solving scenarios and engaging them in both disciplines through sustained inquiry. Whilst this is simply one example, the possibilities of other GeoSTEM integrations in junior geography classrooms are varied, whether it is through a PBL approach or perhaps even more traditional approaches.

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