



STEM in Geography Education – an Earth Science Perspective

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Introduction

In the Australian school curriculum, geography is housed within the humanities and social sciences. This classification affects the content within the curriculum, the backgrounds of teachers and their professional development opportunities, and also the expectations and subject choices of students. As an earth scientist working in the Australian university sector, my research is closely linked to geography and I teach many undergraduates who had their passion sparked during geography lessons at school. From this perspective, I suggest three reasons why the expansion of STEM (science, technology, engineering and mathematics) skills in the school geography curriculum would be of benefit.

1. It would help students pursue and achieve their own goals.
2. It would help interested students find fulfilling careers in areas of national skills shortages.
3. It would help develop a population and future leaders who will make successful and well-informed decisions.

1. The expansion of STEM skills into geography teaching will help students to pursue their goals.

If a keen high school student were to type *geography* into the search bar of the *Good Universities Guide* (www.gooduniversitiesguide.com.au), they may be surprised at the diverse range of university degrees they are directed towards. While someone wanting to study chemistry could be confident they should do a science degree and someone wanting to study history will almost certainly do an arts degree, our student looking for a geography major has a more ambiguous path. They will be directed to a Bachelor of Science at the University of Melbourne, but to a Bachelor of Arts at the University of Adelaide. At the University of Queensland, geography sits within the School of Earth and Environmental Sciences, while at Macquarie University it sits within the School of Social Sciences. This range of paths reflects the broad range of areas of

focus within geography, which include both human geography and physical geography and span the arts and the sciences. However, our current school curriculum, focused on the humanities and social sciences, may not be fully preparing students for these future options.

Students who choose to study geography at school are often interested in questions like how humans interact with their environments, how environments change, and how that change can be monitored and mitigated. From the perspective of an earth scientist, I would argue that an enhanced emphasis on STEM skills within geography teaching in schools will support students to understand and address these questions and to pursue further study. These skills would include, but not be limited to, improved numeracy and confidence with maths, statistical analyses, programming and data processing, GIS and online mapping tools, familiarity with the scientific method, and an understanding of earth science, chemical, physical and biological analytical tools (Figure 1).

In many cases, answering geographical questions requires STEM skills. This is clearly true for physical geography but many questions in human geography also require thorough statistical analyses and an ability to tap into big data. For instance, Wolf et al. (2021) argue that quantitative analysis in human geography can help developments in the field become more replicable, inclusive, specific and open. Expanding the inclusion of STEM in the school geography curriculum would highlight the importance of quantitative skills to students and better equip them to successfully solve problems. In the lifetimes of our current students, in which incredibly vast volumes of data are likely to be collected, those who have the ability to access, analyse and understand that data will be able to create much more significant and effective change than those who do not.

The application of STEM skills to topics in geography, in which students are already interested, may also help improve student

confidence and self-efficacy in STEM (e.g., Rittmayer & Beier, 2009). For instance, if a student successfully applies a mathematical tool like a linear regression to a geographical question that concerns links between income and population density, their overall confidence in maths is likely to improve. Given that geography majors at so many Australian universities are within the Bachelor of Science, it is also likely that more students will choose these majors and continue to pursue their geography education if they are exposed to more STEM at school (e.g., Moakler & Kim, 2014). Inclusion of more STEM skills within the geography curriculum may therefore be expected to improve students' effectiveness as geographers, their willingness to continue with geography study, and their perceptions of their STEM skills.

2. The expansion of STEM skills into geography teaching will strengthen Australia's capability in vital areas.

The diversity of departments in which geography is housed at Australian universities highlights the diverse fields that benefit from the unique skills of geographers. Australia is facing a skills shortage in many fields that are relevant to geography. Indeed, in June 2021, surveyors, cartographers, spatial scientists and geotechnical engineers were added to the Australian Government's Priority Migration Skilled Occupation List, a list of only 41 occupations defined as those that fill critical skills needs. These recently-added jobs, which involve tasks like analysing satellite imagery to track bushfire risk, or finding groundwater to ensure it is not polluted by construction, are likely to be appealing to many school students who are interested in geography. Importantly, these jobs also require STEM skills. For instance, algorithms need to be written to filter the satellite data and inversions need to be run to find the groundwater.

There is no doubt that many of the students in our schools who are passionate about geography have the capability to be our future surveyors and spatial scientists. However, without a focus on STEM skills within the geography curriculum, they may not recognise that these career paths match with their interests and may not feel confident to take on the university-level STEM subjects they need to become qualified. As a specific example, in earth sciences, we currently face a skills shortage of people working in sectors such as environmental monitoring, mineral exploration, and geospatial science. We also face low student numbers at

universities which have led to reductions in offerings including closures of earth science departments at Macquarie University and the University of Newcastle. These closures are likely to exacerbate future skills shortages. Earth science has many of the same attributes that attract students to geography: a goal of understanding the world around us, monitoring environmental change, and an opportunity to conduct fieldwork and to travel. If the STEM-based links between geography and earth science were made clearer to students at school, perhaps more students would be motivated to study earth science at university and Australia would be able to meet its skills needs.

3. Engaged citizens need to understand human impacts on the world with a solid STEM base.

Although only some of our geography students will go on to work in geography-related fields, all of them will hopefully go on to become engaged global citizens, helped by their geography training. The current dual crises of the COVID-19 outbreak and of climate change highlight how important it is to have leaders and a population who can understand science as well as human impacts and responses. Geography is in a unique position to train upcoming generations in understanding and balancing these concepts, so long as STEM skills are included in the geography curriculum.

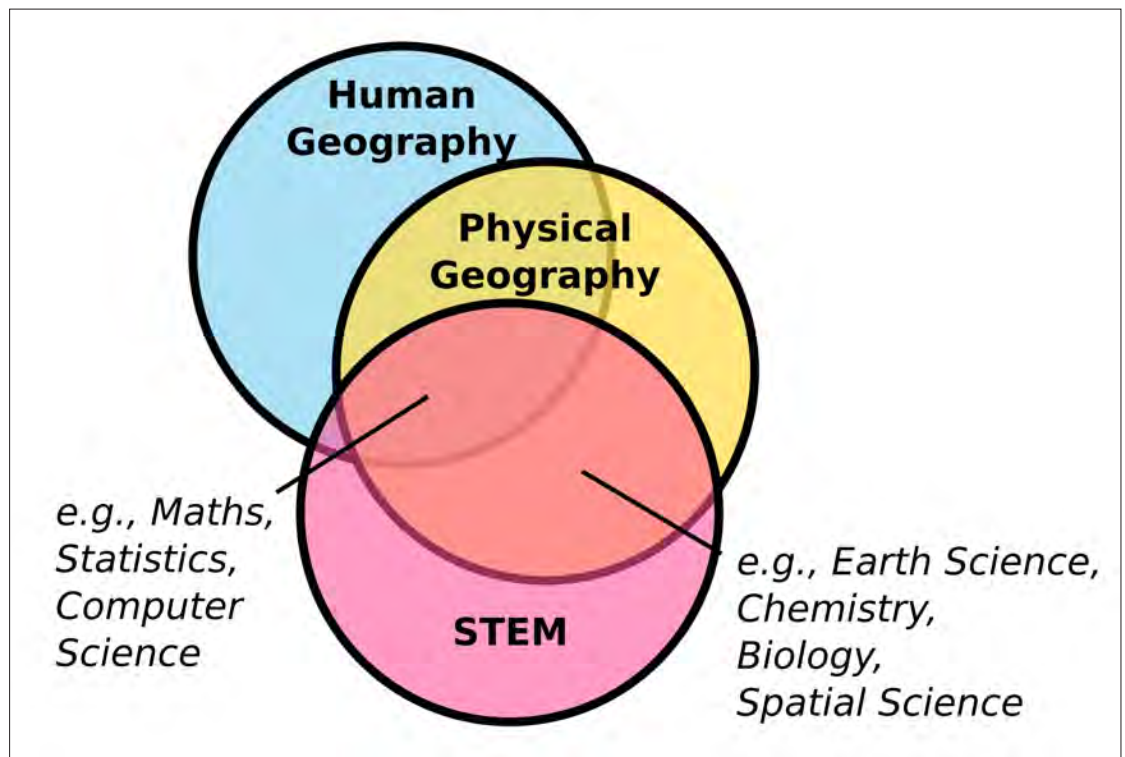
The COVID-19 pandemic has been a stark example of the need for leaders to follow medical advice and the need for the population to have a STEM literacy to understand the situation and risks that face them. Those with better STEM and health literacy report less confusion about coronavirus information (Okan et al., 2020), and are more likely to support public health measures and make safe decisions. Australia's early success in dealing with the pandemic is partly due to the strong policy focus on listening to the medical advice (Bernard et al., 2021) and the population-level support for public health measures (e.g., Pickles et al., 2021). Arguably, the approach of Australia to climate change has been a contrasting example, where policy has not followed scientific advice (e.g., Taylor, 2014). Particularly on a topic such as climate change, where political and media messaging is often contradictory and confusing, STEM literacy among the population is vital if people are to assess competing claims that will affect their actions (e.g., Leiserowitz & Smith, 2010; Tranter, 2020).

The challenges of tackling both COVID-19 and climate change also clearly illustrate that science by itself is not enough to overcome such complex problems. Instead, successful solutions also have to carefully consider how people interact with their environment and the impact of policies on citizens. For instance, COVID-19 medical advice may suggest locking down a city, but broader consideration will ensure only doing this with flexibility that will allow people to continue working, to stay healthy, and to remain supportive of the public health measures (Altiparmakis et al., 2021; Cairney & Wellstead, 2021). Addressing climate change requires disruptive shifts in energy production, agriculture, manufacturing and transport that affect jobs, industry practices, communities and individual lifestyles, so successful solutions require complex social and economic policies that must be guided by the social sciences (e.g., Shove, 2010). After decades of politicisation of climate change, entrenched attitudes can limit

the impact of additional scientific information (Kahan et al., 2012). Australia is arguably yet to embark on the path of building successful climate policy in the way it has done, relatively successfully, for COVID-19 policy (e.g., Morton, 2018).

The contrasting responses to the COVID-19 and climate change crises demonstrate how important both STEM literacy and social science literacy are for Australia's government to make effective policy decisions and for Australia's population to support those decisions. The school geography curriculum is in a unique position to train Australians to understand and balance the science and the human impacts of that science. A deeper integration of STEM skills into the geography curriculum would strengthen the ability of geography to develop Australia's citizens and future leaders, as well as helping students to find fulfilling careers in areas of skills shortages and to pursue their own interests in Geography.

Figure 1. Venn diagram illustrating some of the overlaps between STEM, physical geography and human geography.



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