



UNIVERSITY OF
CANBERRA

STEM education for all young Australians

A Bright Spots STEM Learning Hub
Foundation Paper, for SVA, in partnership with
Samsung

EXECUTIVE SUMMARY

Prepared by the STEM Education Research Centre (SERC), in the Faculty of
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Recommended citation: Lowrie, T., Downes, N., & Leonard, S. (2017). *STEM
education for all young Australians: A Bright Spots Learning Hub Foundation Paper,
for SVA, in partnership with Samsung*. University of Canberra STEM Education
Research Centre.

Overview

STEM education is currently receiving extensive policy and public attention, and is considered critical for the Australian economy. This Foundations Paper supports action to improve education for disadvantaged Australians in science, technology, engineering and mathematics (STEM). It outlines current approaches to STEM education internationally. A Framework for action for STEM education in disadvantaged communities is then presented.

Disadvantaged communities have lower levels of mathematical and scientific literacy, and fewer uptakes in STEM careers (Marginson *et al.*, 2013). They typically have lower achievement levels in STEM subjects, as evidenced by assessment exercises such as Trends in International Mathematics and Science Study (TIMSS), and the Programme for International Student Assessment (PISA). Narrow views of what constitute STEM engagement, whether being discipline-content or productivity driven, are heightened in disadvantaged communities.

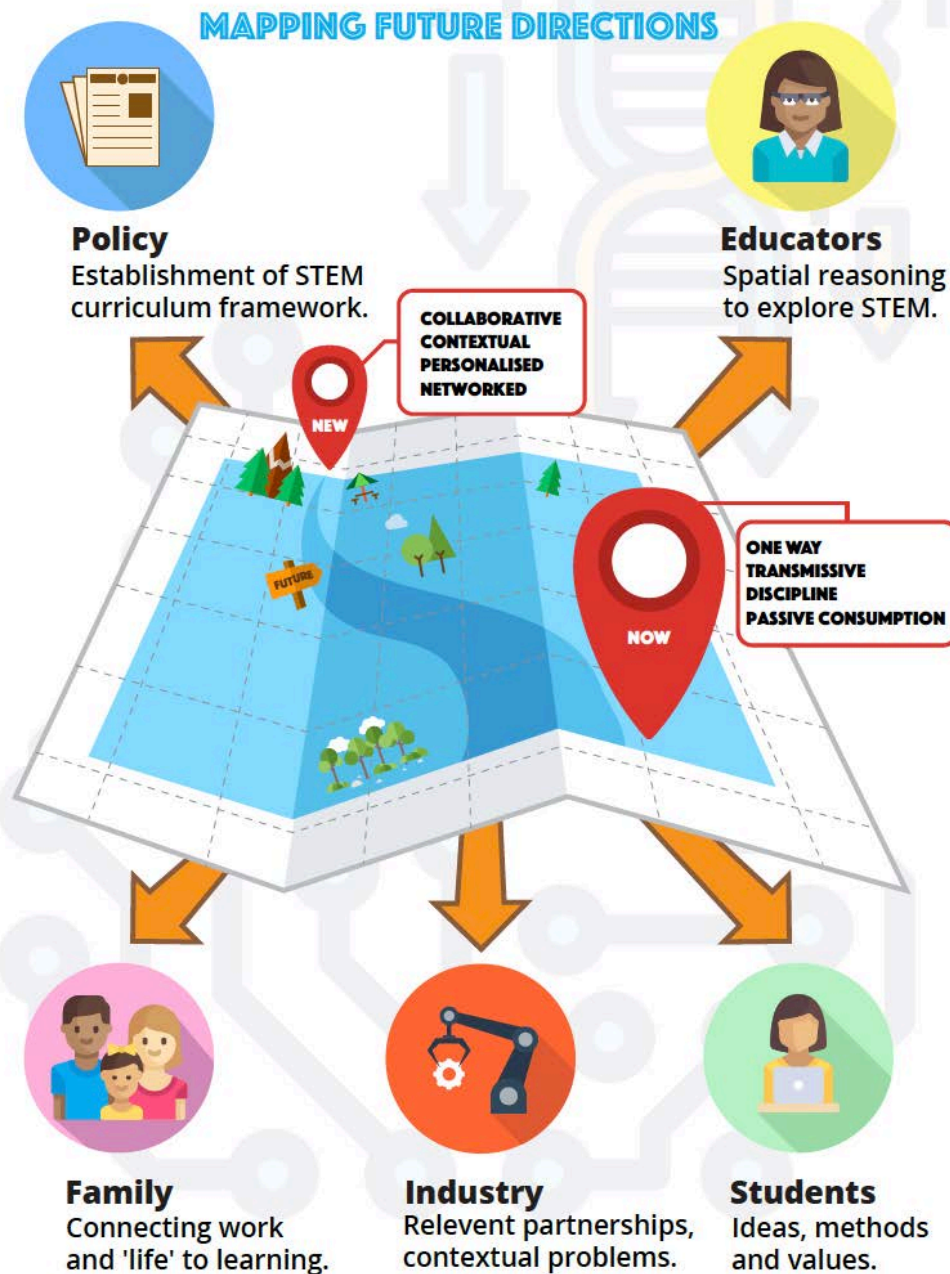
It is unsurprising that current approaches to STEM education are diverse. In some education jurisdictions across Australia, hundreds of different STEM programs are being implemented, sometimes simultaneously. In addition, numerous targeted initiatives and programs that aim to improve the situation in disadvantaged communities. Issues of time, resourcing, funding, and staffing often limit the effectiveness of these programs.

To respond to the diverse needs of disadvantaged communities, and to overcome these barriers, we propose a framework for STEM education that focuses on the practices that underpin STEM. By teaching STEM practices, content knowledge naturally follows, not just in STEM discipline areas, but all curriculum areas including English, languages, and social sciences.

In the Framework for Action, we outline what a STEM practice is (a method, value, and idea), the theoretical framing of STEM practices (practice architecture), an example of a STEM practice (spatial reasoning) incorporating the requirements of the Australian Curriculum, and recommendations for policy. In particular, we suggest that a national framework for STEM education is developed that includes STEM as a new general capability in the National Curriculum.

A STEM Practices Approach

PARTNERSHIPS IN STEM

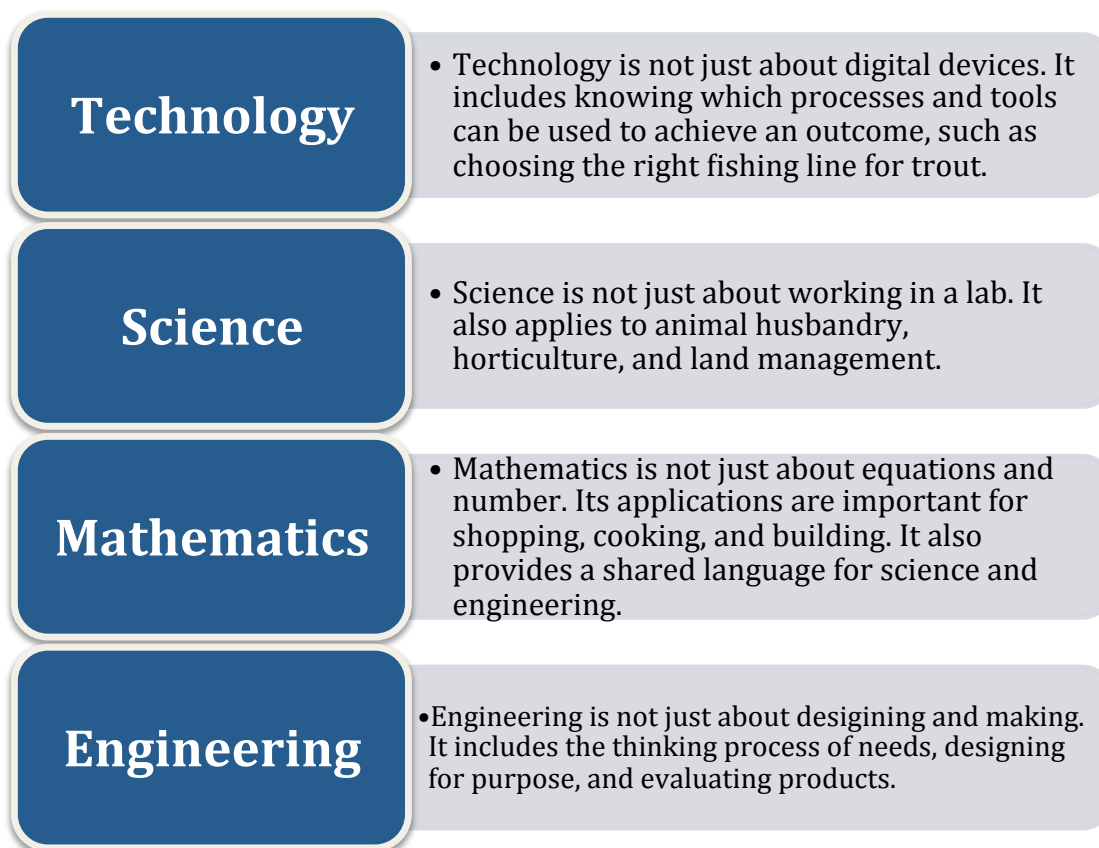


A STEM practices approach connects students and families to STEM in their community and considers ways STEM is valuable to them. For example, students are able to understand STEM in their local community through local industry. Educators respond to the needs of students and the community by teaching STEM practices (for examples, spatial reasoning), rather than teaching content knowledge in isolation. A national framework for STEM education, that includes STEM as a general capability in the National Curriculum, provides schools with scope to include STEM in day-to-day practice. This approach is a change in direction from current STEM education which focuses on teaching STEM content knowledge in individual discipline areas, often in a way that does not respond to the needs of individual communities.

STEM education and STEM practices

Although STEM is derived from the acronym science, technology, engineering, and mathematics, STEM is greater than the sum of its parts. The acronym often causes people to focus on traditional and misconceived ideas about each discipline area separately. The confusion has the effect of making the acronym almost meaningless (Siekmann, 2016). STEM loses meaning to students as it becomes disconnected from everyday life. As such, we need to rethink how we view STEM, as shown in Figure 1.

Figure 1: Beyond the traditional ideas of the disciplines



STEM applications are everywhere, in day-to-day tasks and careers both technical and professional. Many disadvantaged communities utilise STEM practices in applied situations. Take for example a farm. Farms test ideas in agriculture, find the right tools for a job, design and evaluate processes, and analyse yields and finances. They could not operate effectively without STEM.

However, such examples are not described as STEM when the focus is limited to separate discipline areas. In order to make STEM meaningful, content knowledge cannot be siloed, rather it needs to be situated in the relevance of a community and in everyday life. This is where a STEM practices approach is useful. It connects all students with STEM in a way that is meaningful to them.

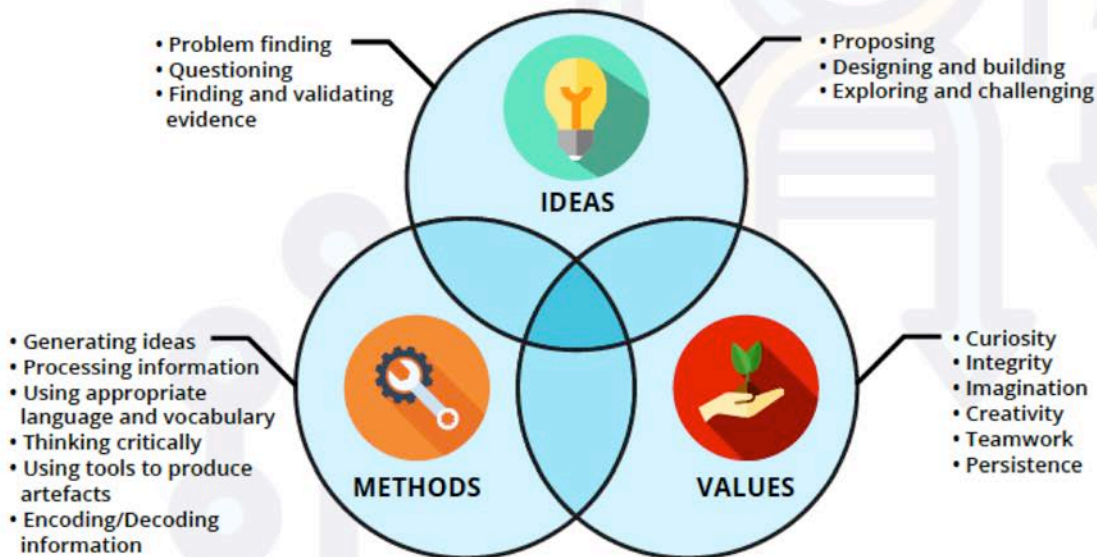
STEM FOR ALL YOUNG AUSTRALIANS

A FRAMEWORK FOR ACTION

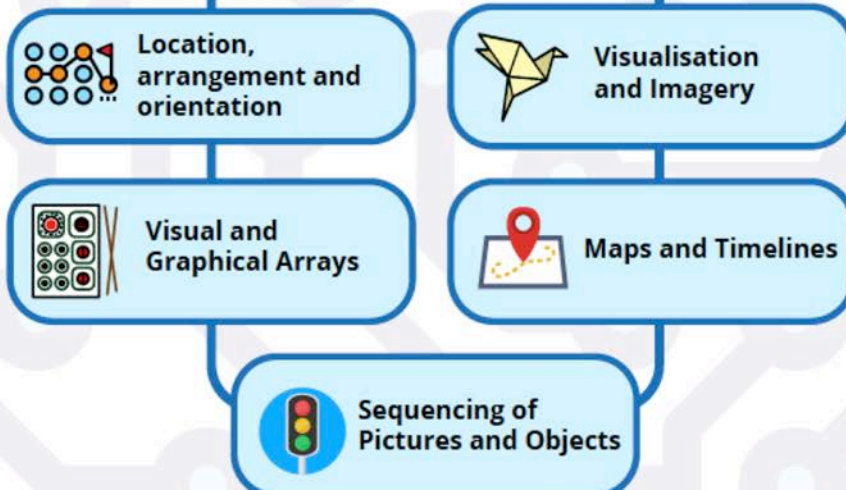
Helping children live in their world, by responding to the needs of their community.

STEM PRACTICES

Improve education for Australians in science, technology, engineering and mathematics.



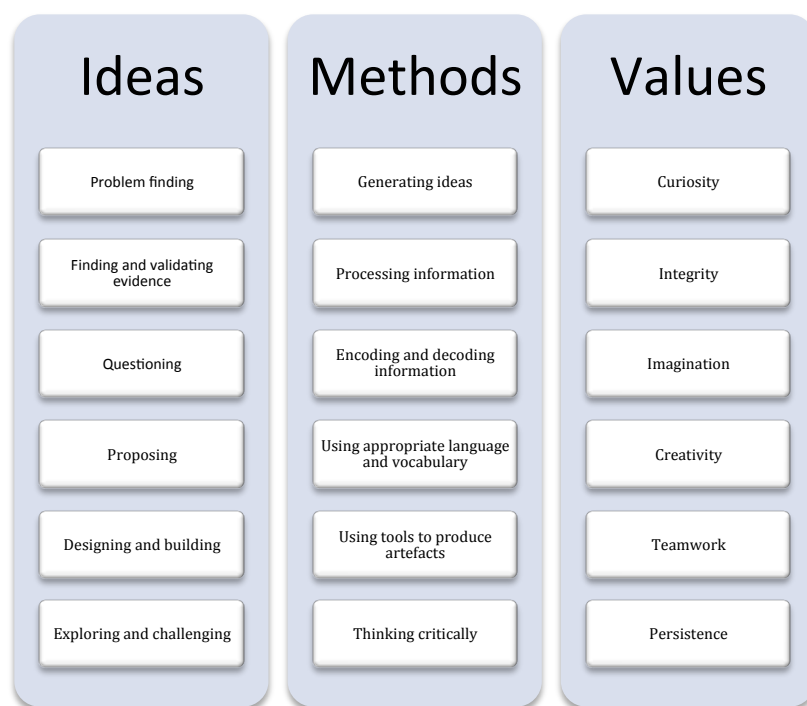
The biggest predictor of success in STEM: Spatial reasoning



The case for STEM practices

A STEM practice is the use of an idea, method, or value to achieve a goal (Lowrie, Logan and Larkin, 2017). STEM ideas include problem finding, finding and validating evidence, questioning, proposing, designing and building, and exploring and challenging. STEM methods include generating ideas, reasoning spatially, processing information, encoding and decoding representation, using appropriate language and vocabulary, using tools to produce artefacts, and thinking critically. STEM values include curiosity, integrity, imagination, creativity, teamwork, and persistence. As represented in Figure 2, each idea aligns with a method and value.

Figure 2: STEM ideas, methods and values



There are numerous examples of STEM Practices, including: spatial reasoning; problem generating; problem posing; designing and making; and testing and hypothesising. Many of these terms would be well known to classroom practitioners. *They are transformed into a practice is when ideas, methods and values are considered.* Some STEM practices have particularly high associations with today's STEM professions. That is, if you are good at these practices, you are more likely to go into one of these professions. The most accepted example is spatial reasoning; the best predictor of success in STEM. We argue that the capacity to reason spatially will become increasingly important for tomorrow's professions and workforce.

Spatial Reasoning as a STEM Practice

Before considering spatial reasoning as a STEM practice, it is important to understand the spatial constructs. Spatial reasoning involves mentally manipulating the spatial properties of objects and considering how these objects relate to each

other (see Figure 3). It involves being aware of space, representing spatial information and applying reasoning to interpret the spatial information (National Research Council, 2006). We use spatial reasoning to park our car or give directions, and in many careers including photography and construction. As represented in Figure 3, spatial reasoning involves a number of properties our functions: location, arrangement and orientation; visualisation and imagery; the sequencing of pictures and objects; visual and graphical arrays; and maps and timelines.

Figure 3: Spatial reasoning as a STEM practice

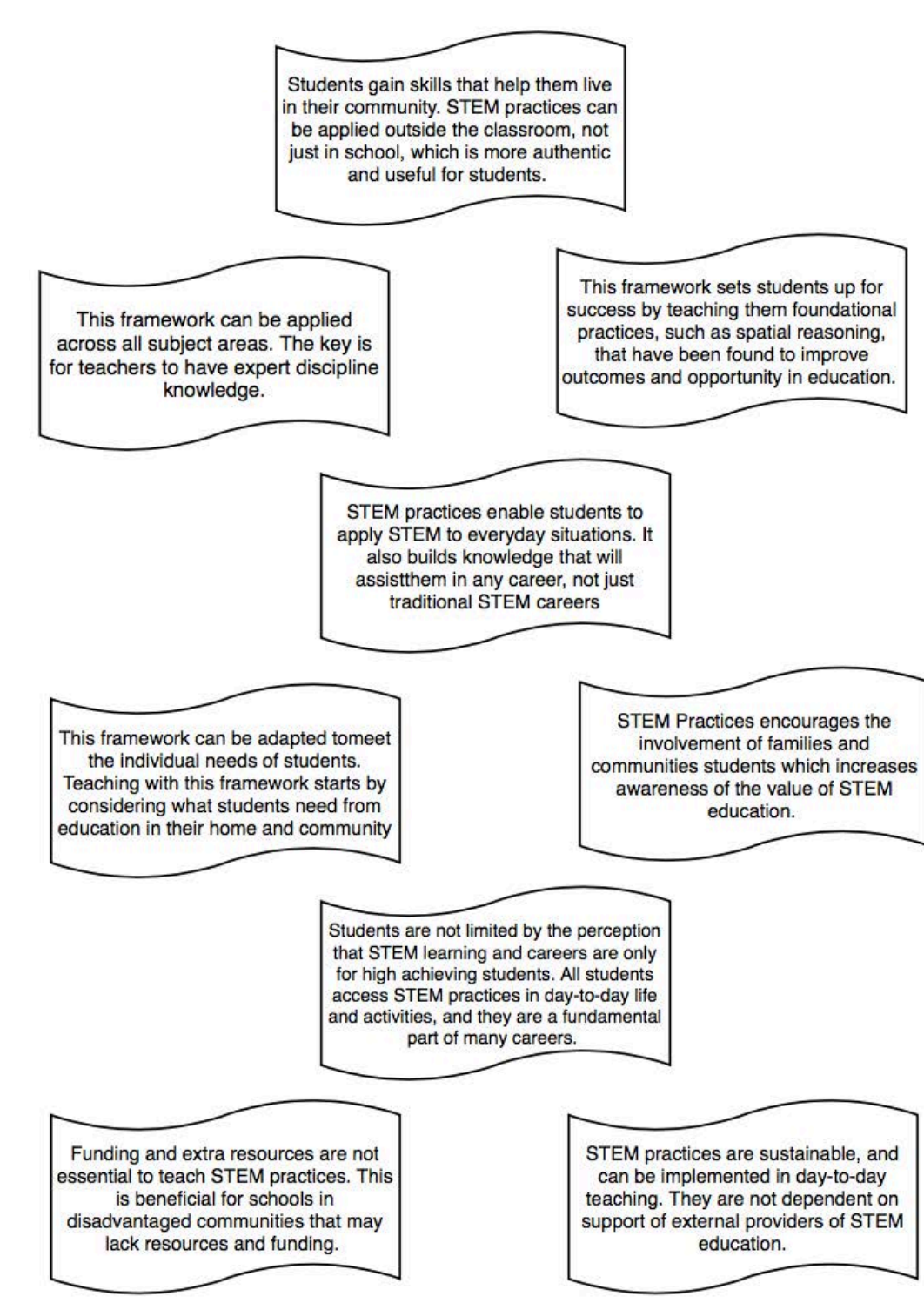


Why STEM practices in disadvantaged communities?

In disadvantaged communities, students have lower achievement rates in STEM, and less participation in careers traditionally perceived as STEM careers (Marginson, Tytler, Freeman, and Roberts, 2013). These traditional STEM professions, which include medicine and engineering, require high levels of mathematics and science—levels not easily attained by students in such communities. We argue that an increasing number of professions will require such knowledge into the future, however this knowledge will not remain specialised or localised within disciplines. As such, our rapidly changing world will require citizens to move across traditional

domains. The specialised content knowledge will always be essential to some professions, but occupations we have not yet conceived will require very different practices.

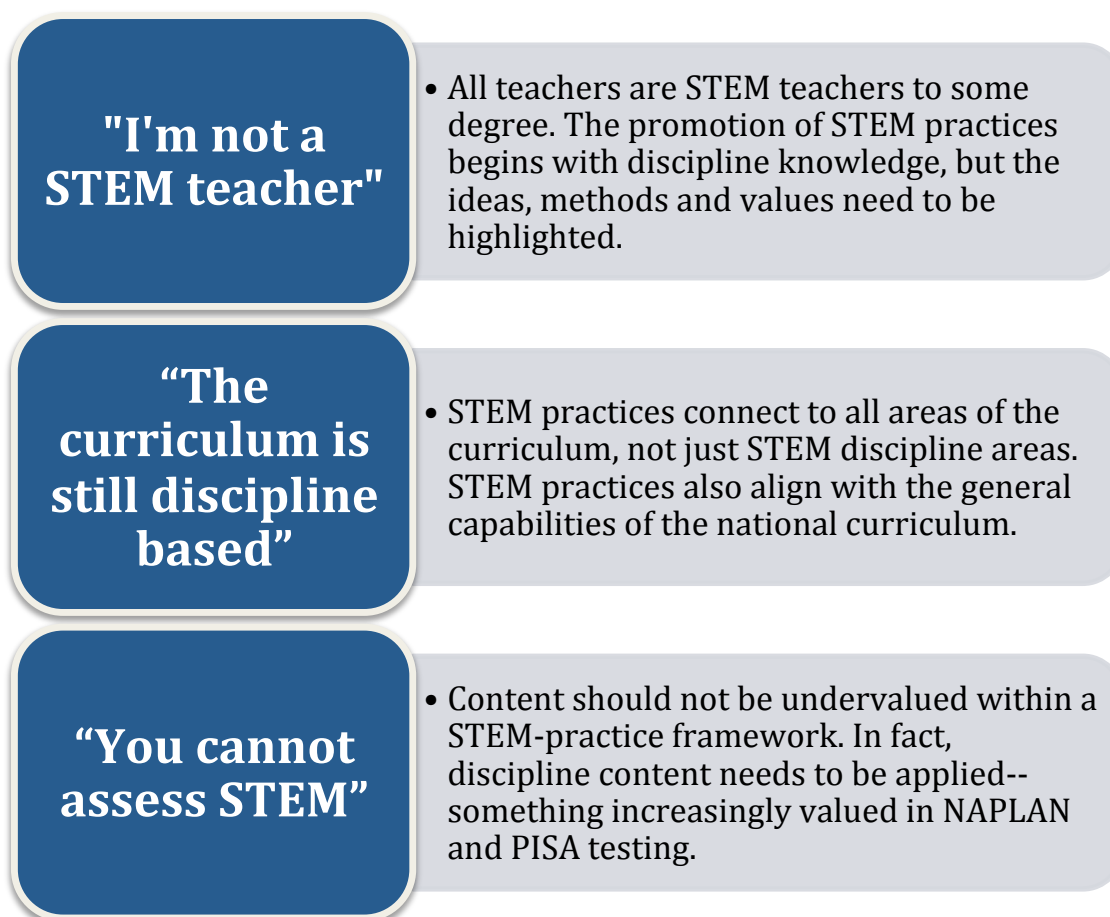
A STEM practices approach also responds to the needs and challenges of STEM education in disadvantaged areas in the following ways:



Teaching STEM in the classroom

With the STEM acronym comes concerns about teaching STEM. Teachers have many concerns about what STEM will mean for them in the classroom, particularly in terms of curriculum and assessment requirements. However, a STEM practices approach means teachers still meet these requirements, and overcome many of the concerns teachers see themselves facing in STEM education. Some of these are outlined below in Figure 4.

Figure 4: Common misconceptions about teaching STEM



A sustained, embedded approach to STEM Education

Educators need a way forward that emphasises a focus on STEM in day-to-day teaching. Currently STEM education is not incorporated in schooling in a sustained way. Curriculum and assessment expectations do not allow this as STEM is not highlighted as a priority. This is despite many documents outlining the importance of STEM and the role of schools in Australia's future prosperity. Changing the current approach is crucial given the importance of STEM to Australia's future.

To increase the emphasis on STEM education, Australia needs a recognised national framework for STEM education. A key part of this would be to include STEM as a general capability to the National Curriculum. This will enable schools to incorporate STEM in a more sustained way in day-to-day practice. Such an approach responds to calls to increase the focus on the general capabilities to meet the future needs of Australia's workforce (Torii & O'Connell, 2017). This addition is not asking teachers to add more content, it is to indicate how STEM can be incorporated across everyday school practice. Without the addition of STEM as a general capability, it is unlikely that the growing need for STEM in schools will be addressed.

A STEM practices approach provides a guide to how a national framework may look in schools. By focusing on practices rather than content, teachers are able to respond to the diverse needs of their school and community. This aligns to the philosophy of the curriculum, focusing more on capabilities rather than content knowledge.

Drawing on the example of spatial reasoning as a STEM practice, the capacity to reason spatially, is becoming increasingly important for tomorrow's professions and workforce. Some STEM practices have particularly high associations with today's STEM professions. That is, if you are good at these practices, you are more likely to go into one of these professions. Developing these practices are therefore crucial to Australia's future. In disadvantage communities, this is particularly important because students have lower achievement rates in STEM, and less participation in careers traditionally perceived as STEM careers (Marginson, Tytler, Freeman, and Roberts, 2013). An approach such as this is crucial to meet the needs of Australia's future workforce in all communities.