Considering Young People's Dislocation From STEM Education: Looking Beyond the Narrow Focus of Teaching and Learning Practice Within School

Sharon Fraser[1*†], Nicoli Barnes[1†], Sue Kilpatrick[1†], John Guenther[2†] and Georgie Nutton[3†]

[1]School of Education, University of Tasmania, Launceston, TAS, Australia, [2]Faculty of Tertiary Education and Research, Batchelor Institute of Indigenous Tertiary Education, Casuarina, NT, Australia, [3]College of Indigenous Futures, Education and the Arts, Charles Darwin University, Casuarina, NT, Australia

Rural, regional and remote (RRR) communities and industries in Australia cannot currently produce or attract the workforce needed to survive, making skills and qualifications in science, technology, engineering and mathematics (STEM) increasingly important. Yet student engagement in STEM education in RRR schools remains low, with limited numbers of young people either moving into further STEM education post-secondary, or accessing readily available STEM-related jobs in RRR areas. Currently many rural children and young people are not exposed to, nor recognize the diverse ways in which STEM knowledge is required and used in their world. We propose that if young people are to increasingly engage with STEM and continue onto STEM-related careers, they must be able to see connections between their "school" learning of STEM and the STEM knowledge that is enacted in rural work and life. We also suggest that for this to change, there should be increased visibility of "place-based" knowledges, including Aboriginal STEM knowledges, in RRR communities to promote enhanced student engagement with STEM. In this paper we explore these ideas by drawing on Foucault and Bourdieu understandings to develop a methodological framework – the *Place-based STEM- alignment Framework* for the purposes of exposing alternate STEM knowledges. We argue that the nuanced and critical methodological approach applied in the development of the *Place-based STEM-alignment Framework*, is necessary in order to generate this analytical tool and provide data that will allow us the scope to "reset" current understandings of STEM knowledges. The framework design provides us with the methodological vehicle to identify possible reasons for the invisibility of STEM knowledge and practices in the local fabric of RRR communities and to examine enablers and/or barriers to engagement in STEM learning. The framework must be a practical tool for use in the field, one that can be used in RRR communities to engage, children and young people, in STEM, in a way that is meaningful and that aligns with their everyday experience of RRR life. Finally, the framework has to work to enable alternative perspectives to be exposed that will advance methodological considerations of STEM.

Keywords: STEM knowledge and practices, place-based knowledge, rural, regional and remote communities, place-based STEM-alignment framework, aboriginal epistemologies

INTRODUCTION

Concerns about students' disengagement from STEM education are not new (Timms et al., 2018). Evidence from international STEM assessments [e.g., Programme for International Student Assessment (PISA); Trends in International Mathematics and Science Study (TIMSS)] indicate that Australian students' achievement in STEM is either unchanged or declining (Thomson et al., 2019). These outcomes spurred the Australian government to develop the National Science, Technology, Engineering and Mathematics (STEM) School Education Strategy 2016–2026, which subsequently received endorsement from all state and territory governments. To achieve the goals outlined in this strategy, the Australian government, state and territory governments, industry, universities and professional bodies have committed substantial funding towards STEM education (e.g., Australian National Innovation and Science Agenda, 2015[1], $1.1 billion over 4 years). Initiatives aim to increase young people's excitement about and interest in STEM learning (engagement) at school and to improve their STEM knowledge and skills (achievement). The key characteristics of these initiatives include teacher professional learning and resources; industry-school partnerships; mentoring between schools; scholarships for STEM teachers and interested/capable students; learning and information resources for stakeholders; extension and extra-curricular programmes; and STEM fairs, camps and competitions (Education Council, 2019). As many of these initiatives are recent (post 2016), evaluation of their effectiveness remains ongoing, and it is too soon to determine their impact in achieving the goals of enhanced student engagement and achievement, although early indicators support the approach (Cherry et al., 2020).

An analysis of Australia's STEM education strategies (Murphy et al., 2018) indicated that while the strategies documented in the national strategy aligned with the STEM education literature, not all the important themes highlighted by educational research have been attended to comprehensively. Significantly, they concluded that while the strategies emphasized the development of students' STEM capabilities and STEM appropriate pedagogies and capacities of teachers, the importance of STEM dispositions and an acknowledgement of equity issues in engaging with STEM learning are less explicit. Positive dispositions towards STEM, including a positive self-perception of themselves as a STEM student and seeing the relevance of STEM in their future lives, are essential to student engagement in STEM learning during the school years and progressing onto STEM careers (Goodrum et al., 2012). Even more importantly, equity issues [e.g., participation of girls, rural, regional and remote (RRR) students; Aboriginal[2] learners and students with disabilities] in STEM education remain inadequately addressed. With respect to RRR Aboriginal students, our concern is to ensure that as a significant proportion of RRR populations, they are given appropriate consideration in discussions about STEM participation and achievement.

In the last 20 years, STEM education theorists have created a number of modelling schemes to underpin young people's engagement in STEM initiatives. Some of the more recent contemporary pedagogical models offered include Operationalizing STEM For All (Basham et al., 2010), Authentic STEM education (Hallstrom and Schonborn, 2019), Workforce education models for K-12 STEM (Reider et al., 2016), Practice based model for STEM (Sahin, 2015); Pedagogical innovations in STEM teaching (Balawi et al., 2016); and more recently Boundary crossing pedagogy in STEM (Leung, 2020). However, to date, there is little evidence of their having impact on the ongoing learning of young people (see for example recent PISA and TIMSS results) or their willingness to take up STEM opportunities beyond the limited choice provided by the STEM classroom. A number of factors can be identified as contributing to young people's disinterest in STEM, but two pertinent to this paper are not well researched. These include the fact that young people do not often have science advocates in their home, and that science pursuits are perceived positively when they receive support from important people in their lives (Aschbacher et al., 2010). Aschbacher et al. identified that young people rarely experience adults who enthusiastically encourage them to learn about STEM and to value scientific ways of knowing, or to pursue science related degrees or careers. They posited that programmes which support "better informed and science-comfortable adults in families, schools and communities" (p. 580) are essential to attracting young people to STEM learning and developing their confidence in and enjoyment of science. Hence, while a multitude of programs can be funded and rolled out indefinitely, if the premises and assumptions underpinning these are not supported in the extended school community, then long term, sustained change that also addresses issues of equity, social justice and self-efficacy is unlikely.

Significantly for this paper, inequities can be identified for Australian RRR students. RRR students tend not to choose to study STEM subjects, nor do they progress to further STEM education post-secondary school (Halsey, 2018). PISA 2018 results indicate that in both science and mathematics, students located in cities perform at higher levels than those in RRR schools (Thomson et al., 2019). While data for Aboriginal students in RRR areas is not disaggregated in the TIMSS reports, we are conscious that this may disguise an even bigger participation and achievement concern for those students. Possible reasons for these inequities will be explored later in the paper.

The issues related to the teaching and use of RRR-related STEM knowledges in RRR-based learning contexts [e.g., schools, technical and vocational education and training (TVET), university] has been explored extensively and has demonstrated that there is a metrocentric (city/urban-specific) focus embedded in this knowledge, which is replicated in policy documents, particularly in the Australian Curriculum (Roberts, 2016). Teachers responsible for presenting knowledge to RRR students, are often in schools for limited periods (Hall, 2012;

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[1]https://www.industry.gov.au/data-and-publications/national-innovation-and-science-agenda-report

[2]We use the term "Aboriginal" to describe First Nations peoples in Australia, but give particular reference to Torres Strait Islanders and more localized language groups (e.g., Warlpiri) or Nations (e.g., Kulin) where it is warranted.

TABLE 1 | Per cent of labour force participating in STEM occupations, Indigenous and non-Indigenous youth[2].

Non-indigenous youth by age group	RRR Australia	Australia
	Per cent of labour force participating in STEM occupations	
15–19	6	9
20–24	14	22
25–29	18	34
Indigenous youth by age group		
15–19	5	9
20–24	9	17
25–29	11	23

[2]*Percentages derived from 2016 Census (ABS, 2018), Occupations derived from (Department of Industry Science Energy and Resources, 2020) including health related occupations, derived from ABS (2019).*

Cuervo and Acquaro, 2018), tend to come from urban backgrounds (Handal et al., 2013), may be teaching out of area (Hobbs, 2013), and have little practical/firsthand knowledge or experience of RRR STEM knowledge or how to teach it (Rigney et al., 2020) in context with their students. The knowledge gaps of teachers increase exponentially when they engage with Aboriginal students, many of whom speak traditional languages or creoles, and have a culturally different embedded knowledge of STEM in their repertoire, very different to that which is privileged in a white, metrocentric, western knowledge system. As a result, in most RRR learning contexts, metrocentrically-focused STEM knowledges are privileged and RRR STEM knowledges have been ignored and/or become silenced (Guenther et al., 2015b). Curricula in RRR areas are often detached from current local contexts (Schafft and Jackson, 2011) and the development of place-sensitive, STEM-rich curricula therefore relies upon school leaders and teachers being sufficiently skilled in contextualizing learning so that it is relevant to their students (Fraser et al., 2019). Currently, therefore, many RRR children are not exposed to, nor recognize the diverse ways in which STEM knowledge is required and used in their everyday world (Avery, 2013; Matthews, 2015). If students are to continue to engage in STEM and continue on to STEM-related careers, they need to be able to see connections between their "home" knowledge of STEM, their school learning of STEM and STEM knowledge enacted in work (Avery, 2013). The current metrocentric—or "Westcentric" (Hughes, 2020)—curriculum privileges western knowledge systems over Aboriginal epistemologies. Research has regularly exposed this inequality including reports concerning RRR education nationally (Timms et al., 2018) and Aboriginal education (Guenther, 2021). For example, **Table 1** demonstrates the inequalities represented as youth participation in STEM occupations.

These data suggest that RRR young people are either missing out on opportunities for STEM careers or have to move to metropolitan areas to pursue STEM careers. They also suggest that by the time they reach 25, Aboriginal RRR young people are only one third as likely to engage with STEM occupations as their non-Aboriginal counterparts. Researchers and policy makers have achieved little in addressing this inequality: with a

metrocentric national curriculum remaining; few pre-service teacher education programmes incorporating a RRR focus (Guenther et al., 2015a); the ongoing difficulty of encouraging teachers into and sustaining their practice in and knowledge of RRR contexts.

This paper focuses on identifying the ways in which local and indigenous knowledge around STEM and STEM learning has been socially constructed and deployed in RRR communities, in order to challenge and/or support formal and urban-centric curricula and pedagogical approaches. The knowledge explicated by this exploration will then be used to support and promote the value of contextually based STEM knowledge in communities. We propose that to advance change within urban and RRR educational spaces and within RRR communities/ industries, a deep understanding of both the context and people in which the existing discourse survives (supporting the current, dominant STEM knowledges), is required. This discourse portrays the metropolitan, tacitly, as axiologically and ontologically advantaged, and by inference, epistemologically advantaged as well (Guenther et al., 2015b). As (Foucault, 1991; Foucault, 1998) argues, the challenge to such reified knowledge, can be taken up through a questioning of the existing dominant (STEM) discourse with its mostly positivist epistemological, ontological and axiological assumptions (Chesky and Wolfmeyer, 2015). That is, STEM can only be understood from a western knowledge position, where truth is empirically determined through deductive and quantifiable methods, built on European traditions of science and knowledge production that extend from Aristotle, through to positions which build on the likes of Bacon, Newton, Linnaeus, Darwin and Carnap (Guenther and Falk, 2019). With a broad understanding of what features/characteristics are embedded within and are influenced by the existing STEM discourse we can begin to explore what might need to be problematized and addressed in the current STEM knowledge, as it relates to RRR contexts.

For Foucault, "discourse" is a risky, "perilous" "proliferation of speech" which is "controlled, selected, organized and redistributed according to a certain number of procedures, whose role is to avert its powers and its dangers to cope with chance events, to evade its ponderous, awesome materiality" (Foucault, 1971, p. 9). While we might baulk at the idea that STEM discourses are "perilous"—that we do not baulk possibly indicates the level of peril—we accept the possibility that the production of a STEM discourse is imposed on RRR communities from an externally imagined position of power. This position of dominance defines and promulgates a view of STEM and its value, which may not align to the epistemological and ontological positions of those in RRR areas of Australia and may in part explain the reasons for inequalities shown earlier in **Table 1**.

However, Foucault goes on to argue that while discourses exert power they also simultaneously act as "a hindrance, a stumbling point of resistance and a starting point for an opposing strategy." (Foucault, 1998, p. 100), that "undermines and exposes it, renders it fragile and makes it possible to thwart' (p. 101). The need to expose the STEM discourse to scrutiny means alternative discourses need to be exposed in order to challenge the dominance of an existing discourse. A dominant discourse is

contingent on the existence of other silenced or "counter" discourses (Humphry, 2013). Therefore, the need for an exploration of both the dominant and the counter RRR community STEM discourses, prompted the development of the framework. Ultimately, we want to be able to both "challenge" the current dominant discourse and "respeak" an RRR STEM counter discourse, through a thorough understanding of the existing dominant metrocentrically, white, western knowledge-based STEM discourse, while also exposing and celebrating the counter discourses existing in RRR communities that have become subservient.

POSITIONALITY

Before we propose any framework, we need to acknowledge that, while we have all been privileged to work and/or research closely with Aboriginal people in RRR communities across Australia, none of the authors come from an Aboriginal background. We want to emphasize that, regardless of our depth of experiences we are not Aboriginal and cannot therefore speak as Aboriginal people. However, within our work we *do* want to advocate on behalf of Aboriginal people and what we *can* do is to speak of our own perspectives and understandings of an Aboriginal world and Aboriginal experiences as "allies" (Clark et al., 2016). We also draw from the extensive work of Aboriginal and Torres Strait Islander academics who have written from their own positions. We are therefore writing this paper in the only way we can; as white Australians who support Aboriginal Australians as fellow humans who have worked alongside Aboriginal people and who are critically reflexive of our own research and teaching practice (e.g., Guenther et al., 2018).

OUR APPROACH

As many Foucauldian researchers have argued (e.g., Harwood, 2000; Carabine, 2001; Morgan, 2005), a Foucauldian approach allows for a wide range of methods to be accessed, there is no "fixed" method. They have suggested that Foucault rejected the idea of methodological steps and procedures in exchange "for a focus on the topic or research question, allowing researchers to determine the methodological techniques that best suit the purpose of the study rather than matching the study to a prescribed methodology" (Humphry, 2014, p. 34). This argument gave us the freedom to develop the *Place-based STEM-alignment framework* as a methodological tool, the aim of which is to unearth unacknowledged/unspoken STEM knowledges and practices and align these STEM counter discourses with community needs. As is the case in any research project, and in reflecting a Foucauldian approach, our first step in the process of developing the framework was to discuss the best methods to use to explore the existing ways in which STEM was understood in communities, in industry and in education. This was done with attention to the methodological expertize of the team.

THE PROCESS USED TO DEVELOP THE PLACE-BASED STEM-ALIGNMENT FRAMEWORK

The process used to develop the *Place-based STEM-alignment framework* reflects a team requisite to challenge the language of our methods as well as the ontological and epistemological positions we each brought to the project, best described as Thinking with Theory (Jackson and Mazzei, 2018). In brief, the process seems simple:

1. Brainstorm suggestions for appropriate theoretical and methodological understandings.
2. Determine the most effective theorists, concepts and tools to be used to understand the research question, interrogate and synthesize the literature, and to generate and analyse the data.
3. Combine the theory and methodology with an understanding of the literature.
4. Negotiate the framework.

The process was highly collaborative, with much negotiation between the five authors through many online meetings and emails with discussions, suggestions, rejections, acceptances, and rewording until the final framework was agreed at this point of time. It should be noted that the framework deliberately remains a dynamic and responsive "thing" that we can adjust as we respond to the necessary vagaries of the field as the research continues to unfold.

THE FRAMEWORK'S UNDERPINNINGS

The *Place-based STEM-alignment Framework* draws on a combination of conceptualisations from theorists. Initially, and most notably Foucault (1972) and Bourdieu (1977) are used to underpin the framework. The framework aims to investigate the research question: *How can locally embedded STEM knowledge and practices be used to address the dislocation of students from STEM within RRR communities?*

As an overriding understanding, we drew on Foucault's conceptualization of discourse and a discourse analysis, as it will provide us with a broad perview of what is considered as part of the STEM discourse. As a poststructural approach, language is central and held in a discourse that responds to the waves of influence that surround it, which change over time, and which are dependent on the politics of the moment. Understandings of the "truth" embedded in a particular discourse, are therefore both partial and contextualized.

> *One problem with the model of language as a system is, of course, that the system is not static but is constantly changing [...] over time [...] and within a single interaction [...] new meanings are being created, and [...] the language is being used to do things [...] language is constitutive: it is the site where meanings are created and changed (Taylor, 2001 in Wetherell et al., 2001, p. 6)*

In supporting this stance, a Foucaultian understanding draws on much more than just "talk." Discourses are the "practices that systematically form the objects of which they speak" (Foucault, 1972, p. 49) and therefore allow the inclusion of discourse elements such as structures, processes, artefacts as well as more typically accepted written and verbal forms of speech. These sit together to enable and, when explored, expose the ways in which something is spoken. (Foucault et al., 2006, p. 234) argues that within discourse (in this case, STEM discourse), there are also embedded practices which come with logical connections that determine what is allowed to be known as "true" and "false" and this happens through "rigorous organization" and "faultless structure." Discourse "calls up a set of extremely solid beliefs, and progresses by a chain of judgements and reasoning, and is a sort of reason in act [. . .] it is its organizing form" (Foucault et al., 2006, p. 235). What can therefore be expected when a discourse analysis occurs is, as Morgan (2005), p. 330 suggested "an alternative vision of the world of education."

Because the broad "culture" of a particular space influences the way in which discourses are able to operate, we have also chosen to draw on the theoretical understandings of Bourdieu in combination with Foucault. Like Foucault, Bourdieu challenges us to break with the dominant doxa of language to challenge the language/knowledge/truth it contains (Grenfell, 2009).

Mills (2008), like us, argues that Bourdieu's social reproduction theory has "transformative potential" (p. 79). We will use this potential by accessing his understandings of: field, habitus and capitals. Field will be used to determine what makes up the "norms of a particular social sphere" (Edgerton and Roberts, 2014, p.195), within the specific "social context and settings" (Mills, 2008, p. 85), what we have termed the "ecology'" of the STEM field. Edgerton and Roberts (2014) argue that power within a field comes from a combination of the habitus and capitals that are held by individuals, and the level of ability that these give them to function within the rules of the game within that field. Fields are organized around dominant habitus and capitals so that those who have the dominant versions of habitus and capitals are in the best position to utilize them in the sphere, while others are reduced to trying to play the game.

In our framework we will be able to explore the existing STEM field, with its dominant knowledges and practices, and compare these to those discourses that have been silenced in the "struggle" of the game. We will be taking advantage of the dynamic nature of these games to produce a "[situation] of rupture and transformation [where] there is no longer acceptance of the rules of the game and the goals proposed by the dominant class." (Mills, 2008, p. 87). Habitus will allow us to explore those embedded beliefs, habits, values, conduct, speech, dress, and manners (Mills, 2008, p. 80) that people apply to STEM understandings and which manifest through an unthinking uptake by the individual as "a learned set of preferences or dispositions by which a person orients to the social world." (Edgerton and Roberts, 2014, p. 195). (Grenfell, 2009, p. 18) identifies the capitals as providing the "currency" that can be used within a particular field and which only becomes capital when it is recognized within a specific field. Bourdieu identified three types: cultural, social and economic. These, acting in concert with each

other and with habitus, determine the inclusion or exclusion of individuals through the power they enable, and determine who can wield that power. In the STEM field we will therefore be looking for the capital, be it cultural, social or economic, that is recognized as having value and that can be used to "trade" within the STEM field: Cultural capital – to see the impact of both the dominant and the counter discourses embedded within the broad cultural understandings of RRR communities. Cultural Capital concerns cultural background which is shaped by both thoughts and actions (Edgerton and Roberts, 2014, p. 19), and identifies the legitimated culture of the dominant class ["those that control the economic, social political resources" (Grenfell, 2009, p. 83)]. It is made up of made up of embodied (internal), objective (products) and institutional (sanctioned) states (Grenfell, 2009; Edgerton and Roberts, 2014); and social capital – which Bourdieu refers to as "trust networks that individuals can draw upon for social support" and the "usefulness" of these resources when they are accessed through "networks of relations" (Grenfell, 2009. Pp. 21–23), to explore the networks and the qualities that surround and influence the accepted and silenced knowledges of STEM.

The addition of Bourdieu to a Foucaultian critique gives us a broader understanding of discourse and provides the theoretical tools to allow an exploration of the dominant and silenced discourses that are present in the STEM context. Foucault's and Bourdieu's theories of power and culture are "interrelated in some compelling ways" (Schlosser, 2013, p. 31). Scholsser argues that the links between the two theorists can be combined "to add weight to emprical analyses" in researching in criminology areas, while sociologists Akram et al. (2015) highlight that Bourdieu and Foucault can work in concert to offer different but related approaches to considering and critiquing other theorists' conceptualizations of power. Numerous other researchers have also found the combination of Bourdieu and Foucault valuable for varying contexts, including Alex and Hammerstrom (2008) in nursing; and Blackmore and Hodgkins (2012) in disability, so the combination would not be inappropriate in developing a framework that critically allows us to explore and challenge the current STEM discourse.

In combining these Foucaultian and Bourdieurian, theoretical understandings into a methodological tool, the framework will allow us to produce:

(1) A thorough knowledge of the existing dominant STEM discourse that is a spoken "truth" in RRR contexts:

   1) The principles (the thinking that sits behind the discourse),
   2) The conditions (what supports the existence of the discourse),
   3) The practices (the specific strategies that make the discourse function);

(2) An understanding of the silenced/counter RRR STEM discourse and what it might be possible to respeak in a counter discourse from this silence through an identification of the principles, conditions and practices existing in RRR communities; and
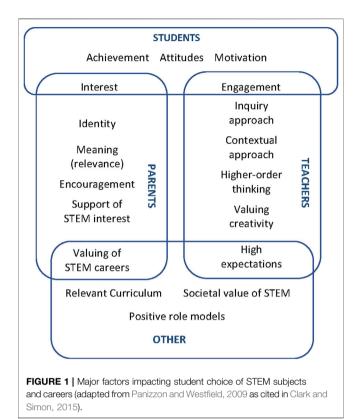
(3) The links between discourses (both the dominant and silenced/counter) through the people who are exposed to it in RRR settings *via*:

1) Their habitus and its influence on individuals and communities "STEM" understandings,
2) The social capital existing in a community's "STEM" field and its influence on STEM understandings and,
3) The cultural and social capital of a community that influence STEM understandings.

What we present in the following discussion is the methodological framework that we have developed to enable us to undertake this discursive exploration. The framework facilitates an examination of the dominant STEM discourse, identifying the reasons for the neglect and invisibility (the silence) (Humphry, 2013) of certain types of STEM knowledge and practices in the local fabric of RRR communities to provide an alternate interpretation of what is known concerning STEM knowledge and how it is known in these spaces. The aim of developing the framework is to identify and expose any silenced discourse, and to explore how any silenced discourse is supported by hidden resources, incorporated into the culture, processes and routines, artefacts and structures (Horvath, 2000) of RRR communities.

STEM LEARNING: A BRIEF REVIEW

Young People and Their Engagement With STEM Learning

Empirical studies focussing on factors that contribute positively to student engagement with STEM education continue to grow. Such literature has highlighted the potential positive outcomes of effective STEM education (e.g., Milner-Bolotin, 2018), the impact of teacher pedagogies (e.g., Timms et al., 2018) and their capacity to teach STEM effectively (e.g., Hobbs et al., 2017), inclusive STEM education (gender, background) (e.g., Hogue, 2016; Watt et al., 2019) and the importance of students developing/ maintaining STEM-positive dispositions (Hatisaru et al., 2020). Much of the scholarship has focussed on the classroom environment with the student or the teacher being the key actors. Murphy et al. (2018) emphasized the pivotal role that students' STEM positive dispositions (attitudes and states of mind) play in their participation and performance in STEM. They emphasized the importance of teacher practice and pedagogical choices for motivating students to engage in STEM learning: "STEM self-concept, the value the learner placed on STEM and STEM education, learner autonomy, and educator-learner and learner-learner relationships, are some of the most powerful influences on learning motivation in STEM education" (p. 125). However, through a secondary analysis of PISA results (2006), Woods-McConney et al. (2013) found that the level of students' engagement in science (a STEM proxy) was strongly related to their participation in science-related activities; pursuits which the authors contended, provide students with the autonomy to participate in authentic and relevant science endeavours. Panizzon and Westfield, 2009 (2009, as cited in

FIGURE 1 | Major factors impacting student choice of STEM subjects and careers (adapted from Panizzon and Westfield, 2009 as cited in Clark and Simon, 2015).

Clark and Simon, 2015) also stressed the need for STEM curricula to be relevant to young people, and for them to be supported to develop and sustain an interest in STEM and to see the relevance and value of STEM/careers (**Figure 1**).

Significantly, Panizzon and Westfield (2009) noted the importance of students having access to positive role models in their world and being part of a society that values STEM. Hence while the school, its resources and educational practices have an important role to play in influencing young people to continue with STEM study and STEM careers, the STEM education literature challenges us to look beyond education to the community and society at large and the extent to which young people are able to access STEM discourses.

We suggest, however, that there is a need to take a step back from research of this nature. We do not understand what knowledge is privileged as "truth" in the RRR STEM discourse, nor do we understand *how* these elements allow successful, positive connections to place-based STEM knowledge, allowing and inspiring young people to take on STEM study and careers. By analyzing the discourse and how it functions in the STEM space, we can begin to address the enablers and challenges that the discourse presents. We propose that the *Place-based STEM-alignment Framework* be used as an exploratory vehicle, to explore school/teacher/young people/ community/industry discourses to expose any embedded understanding that may (or may not) be perpetuated in the discourse and expose those tactics of a discourse that allow it to be acted upon in both positive (STEM is made positive/ relevant) or negative (STEM is rejected as an option) ways.

Ways of Knowing, Being and Valuing of STEM Knowledges and Practices

RRR education (schools, TVET, higher education) can offer young people the opportunity to develop skills useful to their future lives (Houghton, 2019), however, school curricula in RRR areas are often detached from local contexts (Avery, 2013) and time. Although RRR students may understand STEM concepts that they have learnt outside school within their community, such learning may not necessarily align with the established school STEM curricula, particularly if there is a perceived divide between, for example, vocational and academic education (Abrassart and Wolter, 2019) and western and Aboriginal epistemologies (Nakata, 2010). The ways in which community members understand, talk about, model and practice STEM within RRR contexts have been acquired over a considerable time, beginning in early childhood, socialized within the family and continually restructured through encounters with the broader community (Deslandes et al., 2019). Schooling provides a general disposition ("cultured habitus") towards STEM learning, for example, which may not resonate with individuals in the community. The gaps between children's local rural knowledge (Avery and Kassam, 2011) and school science can be bridged through place-conscious pedagogies which serve to legitimize local STEM-knowledges (Rioux et al., 2018; Rigney et al., 2020). If the concept of STEM learning offered by the school is not embraced by the community, students are likely to lack encouragement to take up or continue STEM study.

Aboriginal Knowledges, Standpoints and STEM

The literature, written from an Aboriginal Standpoint on issues of STEM teaching and learning is surprisingly scant. In what follows we have been careful to only include references to works that have an Aboriginal or Torres Strait Islander as the primary author.

Rigney's contribution to STEM has included a focus on digital inclusion (Rigney, 2014) in classrooms and more recently on mathematics within Culturally Responsive Pedagogies (Rigney et al., 2020), and more specifically applying Creative and Body-based Learning (CBL). In their study Rigney et al. found that for Aboriginal students engaged with CBL "there was a decrease in student dissonance in the classroom and a stronger community of learners" (p. 1168). This was in part due to the inclusion of "culturally responsive content" (p. 1170) and the creation of "active and creative endeavors" (p. 1172). Rigney (2017) article on Culturally Responsive Digital Schools raised the issue of access to technology (see also Radoll, 2012), but went onto argue that access is not enough without empowerment and without finding ways to "Connect e-learning to ways that take into account the sovereign status, self-determination, and digital entrepreneurial goals of First Nations communities" (p.12).

Matthews' work on "Maths as storytelling" (Matthews, 2015), like Rigney's CBL, encouraged expression of mathematics through the "creation of symbols both pictorially and in dance" (p. 110), a process supported in trials conducted by the YuMi Deadly Center (Sarra and Ewing, 2014; Sarra et al., 2016). While not directly related, Nakata (2010) work on the cultural interface of Islander and scientific knowledge, similarly supported the idea of

storytelling to ensure a maintenance of Islander discourses of knowledge, though not to the exclusion of scientific knowledge which he sees as "another weapon for Islanders to wield in [their] own interests" (p. 56). For Matthews, his more recent work in Arnhem Land suggests that teaching of mathematics is inextricably linked to an understanding of local cultural system, which young people learn from an early age (Matthews, 2020).

Maggie Walter's contribution to our discussion on Aboriginal STEM arises from her work on Aboriginal statistics and data sovereignty. While neither of these explicitly discuss student learning of STEM at school, in the former work (Walter and Andersen, 2013) she applied an ontological lens, which is helpful in understanding perceived "Deficit Indigenes" (Chapter 1), noting that:
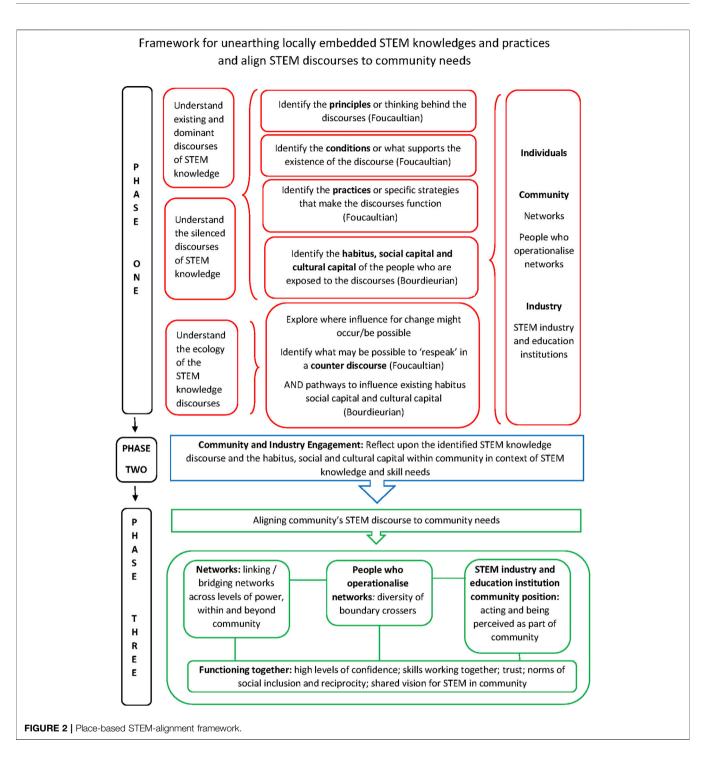
> The ontological frame is a presumption of pejorative Aboriginal racial/cultural difference and a norm of Aboriginal deficit . . . [where] The questions generated from this ontological frame are "what" questions. . . [but] From an Aboriginal ontology the more important question is not what differences exist, but why? (p. 35)

Importantly, she has challenged the methodologies not the methods, associated with quantitative research. Data Sovereignty, according to (Walter and Suina, 2019) "centers on Aboriginal collective rights to data about our peoples, territories, lifeways and natural resources and is supported by Aboriginal peoples' inherent rights of self-determination and governance. . ." (p. 236). This is important when we consider aspects of curriculum, knowledge resources, pedagogy and testing regimes which may be pre-defined within a colonial ontological, epistemological and axiological frame of reference (see also Matthews, 2019): "Indigenous decision-making is a prerequisite for ensuring Indigenous data reflects Indigenous priorities, values, culture, lifeworlds and diversity" (Walter and Suina, 2019, p. 237). The extent to which Aboriginal and Torres Strait Islander students, their parents and their communities "own" the instruments of STEM teaching and learning undoubtedly has an impact on young peoples' uptake of STEM opportunities in schools and beyond.

The focus of much of the above is on the epistemological positioning of Aboriginal knowledges within STEM knowledge, and with perhaps the exception of Walter's references to an ontological framework and Matthew's brief reference to (axiological) values, little consideration is given to positioning STEM from an Aboriginal Standpoint. Engineering does not rate a mention in the Aboriginal authors we have discussed, which might come as a surprise given the rich history of developing production and medical technologies (Keen, 2004, pp. 89–93) for which historian Bruce Pascoe has argued (Pascoe, 2018). We suspect that there is much to "unsilence" and to "unhide" in the field of Aboriginal engineering knowledge as it relates to STEM in schools.

Gaps in Existing Research

As the existing STEM educational research is largely focussed on STEM learning in educational settings, with teacher capacity and increasing student engagement in STEM at the forefront, it provides little information about the extent to which students' lives outside of

FIGURE 2 | Place-based STEM-alignment framework.

school influence their interest and/or achievements in STEM study. We also know little about how students' backgrounds or experiences of STEM outside of school inform their conceptual understandings of STEM. In this paper, our intention is to extend the focus for the discursive exploration of STEM beyond the student, the teacher and school as being predominantly responsible for learner engagement in STEM, to explore the "ecology" of the STEM discourse, rooted in the community. We focus on the interactions and interrelationships that occur throughout the system, which create or silence a young

person's particular understanding of STEM, and hence their STEM self-concept.

THE PLACE-BASED STEM-ALIGNMENT FRAMEWORK

The *Place-based STEM-alignment framework* is provided in **Figure 2** below. In this section of the paper, we walk the

reader through the three phases of the yet to be tested framework to enable an imagining of how such a framework can be used as a methodological tool for looking beyond the narrow focus of teaching and learning practice within schools, to explore the reasons for students' dislocation from STEM learning more broadly.

The proposed framework brings two other lenses to bear on the research: a) community-based participatory research (CBPR) which emphasizes academic researchers partnering with people in communities to foster a better understanding of existing needs and community-based influences to improve outcomes (Blumenthal and DiClemente, 2013); and b) Critical Indigenous Methodologies (Denzin and Lincoln, 2008) which enables academic researchers to work in appropriate ways with community members.

CBPR incorporates a partnership approach at its heart (Israel et al., 2012). It builds different stakeholders, such as community members, community leaders, industry representatives, education providers and researchers, into the research process. Its aim is to enhance understandings of the area being studied and integrating the understandings and lived experience of those involved in the research to benefit the community and impact policy and/or social change (Israel et al., 2012; Liamputtong, 2020).

Critical Indigenous Methodologies (Denzin and Lincoln, 2008) privilege the voices of community (Guenther et al., 2017). Within Aboriginal communities of the Northern Territory (NT) in Australia, community-based researchers form the backbone of the methodology – they are cultural brokers. They are recognized as being essential to gaining an understanding (often using Aboriginal languages and creoles) of how people perceive issues in the context of research. They are also important for translating knowledge from the research back to communities – accordingly they are integrated into the research design.

Phase 1: Understanding Discourses

The focus of Phase 1 is to understand both the dominant and silenced discourses of STEM knowledge in RRR communities and the ecology of these discourses. Consistent with our Foucauldian and Bordieuan informed methodological approach, these understandings would be drawn from those within community – individuals, networks and STEM industry and educational institutions. Our CBPR approach is not just shaped by Foucault and Bourdieu, but also by Critical Indigenous Methodologies, which seek to decolonize the assumptions of non-Aboriginal outsiders. Hence, our community-based researchers hold an important role—particularly in the NT sites—to ensure that local epistemological, axiological and ontological positions are represented appropriately. Critical Indigenous Methodologies are used within a Foucauldian Discourse Analysis framework to determine truth and falsehoods, what can be said and be known, and what remains unsaid and unknown about the place-based STEM knowledges.

The taken-for-granted assumptions about place-based knowledge and the ways in which RRR people speak about STEM can be deconstructed and critiqued. Accessing

Bordieuan understandings allows analysis of a number of elements: the ways in which discourse is being used; the reciprocal relationships between individuals and their connections within community; the habitus that RRR people hold in relation to STEM knowledge (e.g., What attitudes and dispositions do RRR people hold towards STEM? What STEM knowledge do people have, value and in what knowledge do they place a sense of worth?). Looking at discourse through the lenses of cultural capital, we will see how current and counter STEM field knowledge has become a part of the local cultural fabric of knowledge (e.g., When is it time to harvest?) and identify the formal and informal norms that exist and govern the way STEM is embedded in RRR communities.

When using the framework within communities, academic researchers would take the lead in several areas requiring specific research expertize. They will lead the ethnographic research as a whole, including the generation of data which includes mapping the change in STEM focus and skills in community over time, interviewing community members and both creating and supporting the production of digital stories which help unearth STEM knowledge.

Community and Industry Links to STEM

The change in STEM focus and skills can be mapped both spatially and temporally, and subsequently (Phase 2) shared visually with the community for confirmation and clarification. These data sets can be generated from internet searches, job descriptions, reports and nationally and locally generated curricula for example, and from Elder and senior community members' narratives (including the narratives of community-based researchers), that are connected with STEM knowledge and practices. The data will be categorized and shared visually as multiple, layered maps and flowcharts which enable the sharing and easy interrogation of such complex information in simplified, accessible form (in Phase 2). These maps/flowcharts would be used to build a picture of the STEM discourse in current by the "dominant" knowledge holders, as well as providing an avenue for identifying any "missing" or silenced discourses that exist. Both "discourses" will be constructed from the principles, conditions and practices identified within the data sources.

Community Interviews

Academic and community-based researchers would also lead the process of interviewing members from community involved in health, agriculture/primary industry, education and community leaders to ensure that the understandings of diverse community participants are unearthed. The purpose of the semi-structured interviews is to identify the ways in which STEM is understood and discussed within community and to understand why and what conditions have resulted in these ways of thinking.

Digital Stories

Young people acting as "STEM anthropologists" and community-based researchers, will gather data through digital storying with and from their family and community, and act as co-contributors to the analysis of STEM from their stories and images. *Digital Stories* are a methodological tool

that involve the creation of short stories (3–5 min responses to a given topic) combining the art of telling stories with multimedia objects (picture, video, and sound). Digital stories are autobiographical, giving personal accounts and are produced by the author (young person or community member), rather than relying on multiple inputs. Individuals share self-aware and reflective "stories" about their lives that are meaningful to them (Rossiter and Garcia, 2010), and to explain their complex stories in a compelling and accessible manner for diverse audiences. The use of digital stories has been widely and successfully used by many projects in for disadvantaged populations and is especially effective for research with RRR communities (Red Dust and VAMP tv). The production of digital stories for this project will focus on STEM knowledge held within the community.

Together these data generation methods will contribute to the sharing and critique of locally- embedded STEM knowledge, practices and dispositions. Each method will unearth multi-dimensional, hierarchical and unstructured data which will be analysed and interpreted continuously throughout Phase 1. During this phase, the researchers' role is to determine which data are most useful to enabling an understanding of the ecology of STEM knowledge discourses within community, whilst being truthful to unearthing and exposing both the dominant and silenced STEM discourses. Output of Phase 1 will be a social network map and associated illustrative digital stories for STEM discourse identified in the community. The social network map will be enlarged, and use colours and shapes to highlight the roles of various social groups and education and industry bodies in shaping the discourse. These maps and stories will be shared with the community in Phase 2.

Phase 2: Engaging Community

In Phase 2, data sets generated and analysed in Phase 1 are shared with the stakeholders. A community forum or similar would be the ideal format for the sharing and critique of the dominant and locally embedded STEM ecology (knowledge, principles, conditions, practices, and dispositions) gleaned in the earlier phase. Community members would join academic and community researchers to reflect upon the identified STEM discourse and the habitus, social, and cultural capital within community in the context of the STEM field and the knowledge and skill needs within community that arise from this analysis. Participants come together with their own expertize, experience and interests aiming to reflect, clarify and increase awareness, in a forum based upon mutual trust and respect for place-based ways of knowing, being and valuing of STEM knowledges and practices.

During the forum, academic and community researchers share the processes by which data were generated, the ways in which these data were analysed and the meaning that has been derived. Small group stakeholder discussions about these data are carefully facilitated to encourage and support open and honest conversation between community members who may normally have little opportunity to talk openly about STEM knowledges and practices and their importance for their lives and the community. Ultimately, the goals of the forum are to foster an

awareness of the existing "place" of STEM within the community and a recognition of the key issues affecting how STEM is recognized, valued and communicated, and to enable community members to recognize the links between localized STEM knowledge and practices, and those dominant understandings of STEM which are prevalent in formal education. STEM discourse social network maps will be updated with any new information uncovered at the forum.

Phase 3: Aligning Community's STEM Discourse to Meet Community Needs

Phase 3 draws on the communities' social capital resources to develop new shared understandings of STEM knowledges and practices that can form the foundation of a counter STEM discourse that reflects the realities of the use of STEM in the range of settings that exist in a community, including in industry, everyday life and cultural practices. Community networks can be mobilized to share values and norms and develop a shared sense of community identity and trust, which can facilitate individual development (Bergstrom et al., 1995; Kilpatrick et al., 2003).

Phases 1 and 2 would expose not only the STEM discourses of a community, but also the networks (groups, spaces and places) where the discourse occurs, who the leaders in those networks are, and who "crosses the boundaries" between various networks and groups. Each community will be different. A community STEM social network map of interactions around STEM developed in Phases 1 and 2 will be expanded to assist identify points, places and people where change might most logically arise, with the aim of aligning STEM discourse with community needs. This map enables a visualization of the relationships between people and or between organisations with a view to informing innovations that could bring about change; it would provide information about the community's:

1) informal *communication network* incorporating patterns of interaction between members about STEM;
2) *information network* which identifies whom community members go to for advice relating to STEM issues;
3) *problem solving network* which identifies whom community members go to help solve issues being experienced relating to, incorporating and/or drawing from STEM knowledge and practices;
4) *knowledge network* which identifies who is aware of (or not) of those who have STEM knowledge and expertise;
5) *access network* which identifies who has access to those with the STEM knowledge and expertize; and
6) *career network* reflecting those who are likely to be helpful in advancing the STEM goals of community members.

Maps of this nature can be visually very powerful, incorporating the names of people/organisations linked through lines which indicate connections between members of the community. This STEM social network map would assist to identify points, places and people (recognized as nodes) where discourse is shared or silenced, invisible and inaccessible to some

or many within the community. It is anticipated that industry and education actors from the community will feature among the boundary crossers with this network, who can be activated for the purpose of initiating and sustaining change, and supporting the innovations that will take place in community, industry and education settings.

DISCUSSION AND WAYS FORWARD

The *Place-based STEM-alignment Framework* has been developed as the first phase in addressing the research question, *How can locally-embedded STEM knowledge and practices be used to address the dislocation of students from STEM within RRR communities?* It is underpinned by theorists Foucault and Bourdieu and seeks to apply their theoretical understandings alongside Critical Indigenous Methodologies in a community based participatory research. At the time of publication, it remains a theoretical construct, not yet piloted with RRR communities. As researchers, we are satisfied that the aligned theoretical perspectives will reveal how the STEM discourses present in community can enable an informed consideration of students' dislocation from STEM learning in educational contexts. We argue that research undertaken in this manner will provide a nuanced understanding of place-based STEM knowledge and how it is enacted in RRR communities—essential knowledge for underpinning change aimed at impacting educational practice, and student engagement in STEM.

Communities and community members would potentially benefit from this recognition, articulation and explication of their STEM practice, thus supporting and advocating STEM aspirations, education and innovations of community members. They have the potential to contribute to a changing narrative in support of the STEM careers of RRR students through the critique of dominant STEM knowledge, juxtaposed against place-based STEM knowledge, and incorporated into school curricula. This process will address young people's disconnections from their school STEM experience. As a result of this phased approach and the authentic and respectful acknowledgement and application of place-based STEM understandings and community-aligned discourses, teachers can potentially be supported to provide localized STEM-rich curricula. Through engagement with the *Place-based STEM-alignment Framework*, teachers will be encouraged to engage with parents/caregivers and local businesses and industry, professionals and community leaders to contribute to community support for local STEM learning for their children. Local knowledge, learning on country, cultural maintenance and place-based innovation will be legitimized, more highly valued and contribute to place-conscious and culturally responsive education (White and Reid, 2008). Young people will come to better recognize STEM in the environment and be enthused by a STEM-rich curriculum incorporating authentic and locally relevant learning activities.

Importantly, both community-based and academic researchers benefit from new skills and knowledge by working together as a community through the implementation of the framework. Community-based researchers will develop CBPR skills which enable them to engage in an increasing range of knowledge work that is a product of universities and consultancies. Both academic and community-based researchers will learn to adapt their practices to incorporate more ethical ways of working with communities, consistent with a Critical Indigenous Methodological approach.

Finally, we believe that the increased visibility and accessibility of contextualized STEM knowledge in RRR communities will promote interest and enhanced engagement of learners with school-based STEM. For those interested in impacting students' dislocation from STEM, the framework presents a practical tool to be used in RRR communities to empower them to engage, children and young people in STEM. The understandings unearthed and shared through its used will contribute to an exploration of how this increased awareness can be used to create a school-community partnership for the purpose of influencing educational practice and young people's increased engagement in STEM learning. Being guided by the place-based STEM-alignment framework, these school-community partnerships can develop place-based collaborative educational programmes drawing upon locally-embedded STEM knowledge and practices. The purpose of these educational programmes would be to increase RRR students' interest and engagement in STEM and impact their current underachievement and participation rates in STEM. Their impact would be measured in the short term by appropriate data generation methods (e.g., survey and interviews with students/teachers; focus groups with school-community partnerships) and longitudinally through comparison of data generated through PISA and TIMSS.

CONCLUSION

The *Placed-based STEM-alignment Framework* was developed as a more nuanced approach to examining RRR student dislocation from STEM learning by looking beyond the lens of teaching and learning practice. In our proposed framework, current STEM discourses and local place-based STEM discourses are mapped, observed and documented in textual form by both academic and community researchers. Together these data (maps, stories and interviews) will enable the identification of the varied and diverse discourses imposed on, held or silenced within each community. It outlines a process by which the barriers and/or enablers to young people's engagement in STEM that may exist within community, can be unearthed, acknowledged and acted upon. It provides a way of investigating the *impact of STEM knowledges and practices* (those that may remain hidden or are silenced in community), upon the educational practice of teachers and student engagement in STEM learning. Such understandings offer improved pathways and sense of identity for RRR youth in further STEM education, training and careers.

AUTHOR CONTRIBUTIONS

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