Teachers' Perceptions of STEM Education within an Independent Australian School

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Abstract: Research studies have reported that teachers have poor attitudes toward STEM education and lack the knowledge and confidence to implement effective STEM programs. However, teachers' perceptions of STEM education have not been widely explored within an Australian context. An online survey featuring multiple-choice, Likert-scale, and short-answer items was administered to teachers at an independent Australian school. The results indicated that teachers valued STEM education and its impact on student outcomes. Themes evident in participants' self-reported barriers and challenges suggested that limitations in their knowledge and experience limitations hinder their ability to implement STEM education. Participants who reported high confidence were likely to implement STEM more frequently within their classroom and more likely to seek out related collaborative opportunities. It is recommended that teachers' limited knowledge and experience regarding STEM education be addressed through ongoing teacher capacity building. Th**is** study effectively addresses a gap in Australian STEM education research by focusing on teachers' perceptions and barriers and STEM educators' training should start with pre-service teachers.

Keywords: STEM, school, teachers, perceptions, STEM education, Australia

Introduction

Research related to education for Science, Technology, Engineering and Mathematics (STEM) is widely recognised as fundamental to national development, productivity, and economic competitiveness (Marginson et al., 2013). Around the globe, governments are investing resources to establish and improve policies for STEM education at all levels from primary school to university (Freeman et al., 2014). STEM education is commended for fostering 21st century skills such as critical thinking, problem solving, and creativity (Basham & Marino, 2013) and underpins the skills required for future careers. Some scholars have argued that STEM literacy should be included as a 21st century skill (Stehle & Peters-Burton, 2019). There is persuasive evidence that the strongest influences on students' decisions about entering STEM-related careers occur before they enter higher education (Batham, 2024; Nugent et al., 2015). Thus, Findley-Van Nostrand and Pollenz (2017) suggested that captivating the early interest of school students would support long-term progress in the STEM field and Tang and Williams (2019) have argued for emphasis on increasing practical competency in STEM fields within primary and secondary schooling.

The first author developed an interest in STEM education while working as a robotics and software development coach with primary school children. Her interest continued to develop as she subsequently worked in a variety of roles including kindergarten teacher, acting childcare director, educational leader, primary teacher, middle years teacher, junior technologies teacher, and digital pedagogy and innovation coach. Through these experiences she became aware of a disparity in the literature between teachers' perceptions of STEM education and the classroom delivery of STEM education (Chen & Lo, 2019; Lee & Jung, 2021; Talafian et al., 2019). This study emerged from those experiences.

Delivery of STEM education

STEM education experiences can influence the attitudes and aspirations of school students (Batham, 2024; Nugent et al., 2015). Hence, in the search for ways to encourage more students to consider further study of STEM it is necessary to examine the research literature about the delivery of STEM education in schools. A Malaysian study demonstrated that a Universal Design for Learning (UDL) model had considerable promise for inclusive STEM education (Nasri et al., 2021). The researchers developed STEM learning units focusing on environmental sustainability and conservation that were targeted at individual students through UDL and a design for multiple intelligence approach. Student attitudes toward STEM were assessed using a combination of an adapted Mahoney Student Attitude toward STEM instrument and individual interviews. They concluded that the UDL STEM program significantly improved and maintained students' attitudes toward STEM compared to a traditional classroom.

Interdisciplinary STEM, in which the individual disciplines strengthen and support each other, was the focus of a study conducted in the USA (Burrows et al., 2018). Middle school students were presented with an open-ended complex problem of water quality in a local river. Findings indicated that engaging with an authentic problem provided opportunities for students to connect more effectively with STEM learning. Authenticity is an increasingly common theme among STEM programs as is broader integration with other areas of knowledge such as Arts. Chen and Lo (2019) studied the delivery of a STEAM (Science, Technology, Engineering, Art and Mathematics) program to 30 students in a Hong Kong secondary school. The program focused on creativity and a human-centered design approach and succeeded in increasing outcomes for creativity and student learning attitudes. Although the program was developed specifically for the study and was not typical of STEM delivery in Hong Kong, the researchers found that teachers valued STEM despite having mixed attitudes toward its implementation in classrooms.

Intensive workshops and STEM camps have been used to promote STEM education. Talafian et al. (2019) conducted research at an immersive Summer Space Camp within a low socioeconomic context in the north-east USA to identify links between the immersive program and increased potential interest in STEM pathways for participants. The researchers reported that students engaged in the program and developed identities favouring future STEM careers. However, they noted that an elective vacation STEM program would target students with existing high interest in STEM and be presented differently from typical schoolwork. Moreover, such programs are typically not available to students from low socioeconomic or minority communities.

Innovative programs like the Summer Space Camp can be mounted in school settings where support is available. A study of one such program in the USA found some parallels to the findings of Talafian et al. (2019). In that case, students with academic disadvantage did not perform as well as those who began the program with better academic records (Lee & Jung, 2021). The authors concluded that such programs typically lack opportunities for low to medium academic students with inadequate STEM backgrounds and that programs must be carefully designed to offer equitable opportunities for all students. Initiatives that build STEM self-efficacy and reduce STEM anxiety positively influence STEM study and career interest. (Ward & Franco-Jenkins, 2022).

STEM education in Australia

Over recent decades, Australian governments and industries have recognised the importance of STEM and related education. In 2003, a review of teaching and teacher education drew attention to declining senior school enrolments in STEM subjects (DEST, 2003). Later, a national business association recognised that, although a STEM-capable workforce is essential for innovation and success in the modern economy, young people are leaving schools and universities without the necessary levels of STEM knowledge and skills (Australian Industry Group, 2013). Barrington and Evans (2016) reported a decline in mathematics enrolment among high achieving year 12 students with just one in ten completing advanced mathematics.

Governments have recognised the problem and sought to enhance STEM education. A Queensland government report stated, "Innovation is key to economic growth and STEM is a key driver of innovation" (DETA, 2007) and outlined a 10-year plan to enhance STEM education at all levels. Australian education ministers endorsed a national 10-year strategy for STEM education in schools (DESE, 2015) with two major goals, namely that student's complete school with strong foundational knowledge in STEM and related skills and that they are inspired to pursue more challenging STEM subjects (Timms et al., 2018). The national strategy included the establishment of a STEM partnership forum to facilitate a more strategic approach by bringing together leaders from industry and education. The 2003 review identified a lack of adequately prepared teachers of STEM and uncertainty among primary school teachers about how best to teach STEM subjects (DEST, 2003). Efforts to address that problem included placing more specialist teachers in schools (DETA, 2007) and offering professional development for primary teachers to become STEM specialists (Timms et al., 2018). However, concerns have been raised that placing specialist STEM teachers in primary schools would seem counter to the national strategy (DESE, 2015) and limit the development of valuable STEM capabilities and confidence among all teachers (Pezaro, 2017). Although the end of the period covered by the 10-year strategy (DESE, 2015) is approaching, there are no clear indications of the strategy's success (or not) or future directions. This seems an appropriate time to take stock and review how teachers address STEM education.

Teachers' perceptions of STEM education

Teachers are the most essential school factor affecting student academic performance (Hattie, 2009). Hence, understanding teachers' perceptions of STEM and its implementation in classrooms influences the success of a STEM program. A South Korean study focused on teachers' perceptions and practices related to Science, Technology, Engineering, Arts and Maths (STEAM) education (Park et al., 2016). The study found that elementary teachers had more positive views of STEAM education than middle and secondary school teachers. Those attitudes correlated with teachers' perceptions of student success in the STEAM curriculum and resulted in elementary teachers addressing STEAM education more frequently than middle school or secondary teachers. The researchers noted that teachers viewed STEAM as an added workload with little administrative or financial assistance to support it.

A phenomenological study of factors high school STEM teachers in California conducted by Robertson (2019) perceived as contributing to the success of female students. He found that female students benefited from various factors including praise and encouragement, access to female mentors and role models, and introduction to STEM at an early age. Teacher confidence in STEM education was a significant contributor to success. Another study conducted with 430 kindergarten teachers across six provinces of China explored teacher attitudes and confidence toward integrated STEM education in a classroom setting (Tao, 2019). The mixed methods study found that the teachers placed a high value on early integration of STEM education but lacked the confidence to implement integrated STEM within their classrooms. There were regional differences, with teachers from eastern China reporting higher confidence levels than those from central and western China. This may be attributable to socioeconomic differences with central and western regions being relatively less economically developed than eastern China. It was noted that teachers' level of education had no direct correlation with their confidence in teaching STEM.

Successful implementation of STEM education depends upon teachers' knowledge and confidence. In their study of teachers of STEAM in Hong Kong, Chen and Lo (2019) found that, despite students' achievements and increase in creativity, teachers were left feeling overwhelmed because they had limited knowledge to support students and were ill-equipped to teach either specialised or integrated STEAM content. The implication is that professional development should be available to teachers who are required to adapt to teaching unfamiliar topics. An Australian study tracked 27 primary school teachers through a blended professional learning program where participants had no prior experience with makerspaces or 3D design (Stevenson et al., 2019). There were significant increases in teachers' confidence and enthusiasm following professional learning, demonstrating the value of targeted professional learning and collegial support during subsequent implementation.

Prior literature and its limitations

The sources reviewed above suggest that most teachers believe that STEM education is needed and positively impacts student outcomes. However, they also reveal that teachers face challenges in implementing STEM education. Lack of relevant professional learning and experience can limit the confidence and capabilities of teachers implementing STEM education in the classroom.

Within the Australian context there has been limited research on teachers' perceptions of STEM education. There is little evidence that the shortfall in students completing their education with appropriate STEM knowledge and skills has been successfully addressed. Hence, there would be value in improved understanding of teachers' perceptions of STEM and how that affects the provision of STEM education. This study addresses this gap by exploring the perceptions of STEM among teachers in a Queensland Independent School.

Goals of the research

Providing more profound insights into teachers' perceptions of STEM education has the potential to inform school leaders, STEM educators better more widely, and teacher educators regarding how STEM education might be advanced in Australian schools. A clearer understanding of teachers' perceptions of STEM education could inform the development of teacher professional learning for STEM education and curriculum materials for use in classrooms.

The primary research question for the study was How do teachers in an independent school perceive STEM education? The question offered the opportunity to refine understanding of teachers' perceptions of STEM education and explore factors that may influence those perceptions in ways that enhance STEM education. A secondary research question: What barriers and challenges do teachers face when implementing STEM education? This allowed the exploration of factors that influence the teaching of STEM education in Australian schools.

Method

For this exploratory study, a mixed method was adopted for a single independent school case study, to gain rich information from a small participatory group. A concurrent design was adopted with data collection using an online survey method that enabled a qualitative study to be nested within a quantitative study (Leavy, 2017). It is an effective method for simultaneously collecting quantitative and qualitative data including participants' thoughts and perceptions (Leavy, 2017; Punch, 2009). Quantitative data were collected using a mix of multiple-choice questions, and items using rating scales or a Likert scale. Qualitative data were collected using short narrative-style responses. Items presented as multiple-choice included gender, years of teaching experience, level taught, and role in the school. Items using rating scales include five options from never to daily for the frequency of STEM inclusion. Likert-scale items invited a rating from low (1) to high (5) for experience with inquiry-based learning or enjoyment of STEM teaching. The survey comprised thirty-seven items in various formats, was completed anonymously, and required about 20 minutes. No identifying information was collected.

Using mixed methods allowed for a more comprehensive understanding of the data regarding practices around STEM education and participants' perceptions (Leavy, 2017). The research design included a secondary qualitative component nested within the primary quantitative component (Cresswell, 2015).

Data collection

The study site was a co-educational, independent (non-denominational, not-for-profit) day school in Queensland admitting students from 15 months old to Year 12. Enrolments included 37% of students with language backgrounds other than English. The school Index of Community Socio-Educational Advantage (ICSEA) was 1123 (compared to a state average of 1000), indicating that students were from relatively advantaged backgrounds (ACARA, 2023).
Ethics clearance was sought from, and granted by, the university ethics committee as low risk (ETH2023-0420). To eliminate any appearance of influence or persuasion from the primary researcher, a school director emailed an open invitation to all school staff from Kindergarten to Year 12. The invitation explained the purpose of the study, staff members' right not to participate or to withdraw at any time, and that clicking the button to submit the completed survey would constitute informed consent to participate. Twenty-three participants completed the digital survey.

Data analysis

Table 1 *Research Design Overview*

Phase	Procedure	Product
Case selection and survey development	• Developing survey questions informed by gaps within the literature	Survey within Microsoft teams
Mixed method data collection	• Emails sent to all members of the school • Individual surveys completed	Raw survey responses
Quantitative and qualitative data analysis	• Collecting data using scale rating (phase one) • Transcript of all short responses (phase two) • Coding key features within the short responses (phase three)	Extrapolate key words and compelling extracts Frequency testing and Chi-square (X^2) testing

	• Collecting data to develop broad themes (phase four) • Final consolidation of themes (phase five)	
Integration into report	• Themes to be integrated into the report and drawn together for analysis (phase six)	Aligning themes with literature for analysis of the research question

Table 1 provides an overview of the processes of collecting and analysing data for the study. Descriptive statistics were adopted to describe and summarise the quantitative data (Babbie, 2013; Fallon, 2016). Frequency analysis was a suitable first-cycle method for summarising the occurrences of responses within categories. Following descriptive statistics, chi-squared (X^2) was applied to test the significance of associations among categorical variables (Babbie, 2013; Cresswell, 2015).

Thematic analysis techniques were adopted to identify, analyse, and report patterns and themes within the qualitative data. Braun and Clarke (2006) recognised the effectiveness of thematic analysis for research conducted in a survey format if each concept within the survey links back to the overall research question. Descriptive coding was a suitable first-cycle method for the narrative responses. It was used to identify keywords within the qualitative data and key barriers and enablers in teachers' perceptions of STEM education (Miles et al., 2014). That was accomplished by summarising the short response passages from the survey and assigning short labels, most often a noun, to the data by searching for patterns, themes, and topics (Saldana, 2015).

Following descriptive coding, the qualitative data were coded using vivo coding, identifying words or short phrases from the participants' phrases, retaining the micro-culture and participants' own language choices, rather than the researcher creating codes from their understanding (Saldana, 2015). According to Miles et al. (2014), vivo coding is effective when exploring all forms of qualitative data, particularly for beginning researchers aiming to prioritise participants' voices. The thematic analysis explored the collated codes, extracted data, and categorised it into initial themes (Braun & Clarke, 2006). Themes were reviewed against the entire data set to ensure that the research questions were addressed. Participant quotes are in italics and are identified by participant number [P7].

Results and discussion

Table 2 presents frequency data for the demographic items on the survey. As is typical for the national teaching workforce, most respondents (70%) were female. Years of teaching experience ranged from novices (1 to 5 years) to highly experienced (>20 years) with the majority in the mid-range (11 to 15 years). Most of the respondents (70%) reported having no formal qualification in STEM with the few mainly working with older students.

Table 2 *Respondent demographics*

	School level				
	Early childhood	**Primary school**	**Middle school**	**Senior school**	**Total**
Gender					
Male	0	3	4	0	7
Female	1	7	6	2	16
Total	1	10	10	2	23
Years of teaching experience					
1-5 years	0	1	3	0	4
6-10 years	0	0	1	0	1
11-15 years	0	6	1	1	8
16-20 years	0	1	0	0	1
> 20 years	1	2	5	1	9
Total	1	10	10	2	23
STEM qualifications					
None	1	8	7	0	16
Bachelor	0	1	1	0	2
Grad. Cert.	0	1	1	1	3
Masters	0	0	1	1	2

Table 3 presents frequency data from the Likert scale items. With fewer than 10% of responses rating items at 1 or 2 and mean ratings all at 3.4 and above, it is evident that respondents are mostly strongly optimistic about STEM education. Respondents enjoy engaging in and teaching STEM education (mean = 4.1) and are mostly confident about integrating STEM into the curriculum (mean = 3.9). Examining the coded data from the open questions revealed a lack of formal STEM education and limited experience as reasons for lower confidence in the ability to teach STEM. Respondents' comments in this regard included *"lack of education"* [P19] and *"I still need guidance and support as there is so much out there"* [P18].

Table 3 *Respondents' perceptions of STEM education*

	1 = very low – 5 = very high					
	1	**2**	**3**	**4**	**5**	**Mean**
Have you had experience with inquiry-based learning?	1	2	7	8	7	3.7
Do you enjoy teaching STEM education?	0	1	4	9	8	4.1
Do you enjoy engaging in STEM education yourself?	0	1	6	6	10	4.1
How confident are you at integrating STEM into your curriculum?	1	1	9	6	10	3.9
Does your school department allow for STEM integration into the curriculum?	1	2	10	5	5	3.5
How do you rate your ability to teach STEM?	1	2	8	7	5	3.6
If you are integrating STEM into your curriculum, have you seen a noticeable improvement in students' curiosity and inquiry?	0	0	9	6	8	4.0
If you are integrating STEM into your curriculum, have you seen a noticeable improvement in students' pathways as they travel through school?	1	3	10	4	5	3.4
Total (%)	2.6%	6.3%	33.3%	27.0%	30.7%	

When comparing confidence for STEM integration and reported integration of STEM or learning technologies against years of teaching experience and gender, males (71%) were more likely to indicate high confidence than females (37.5%). That result is consistent with previous research. van Wassenaer et al. (2023) found that males typically score higher for positive attitudes to STEM and Lee et al. (2019) also found that male teachers reported higher perceptions than females in all aspects of STEM.

Proportionately more teachers in their earlier career stages (1 to 5 or 6 to 10 years) appear to be integrating STEM and technologies compared to those in mid-career (11 to 15 years). Somewhat anomalously those with more than 20 years of teaching experience also appear to be more likely to integrate STEM and technologies. At all experience levels, the integration of technologies is reported to be more frequent than the integration of STEM. That is consistent with other research that found most teachers employ technology in their teaching (Lechhab et al., 2023). The school where this study was undertaken has SMART interactive boards in each classroom and all students from years 1 to 12 have one-to-one devices. The presence of these technologies in classrooms provides a strong signal to teachers that their use is expected and removes significant barriers to use. Under those conditions, it is somewhat surprising that some teachers admit to integrating technologies tokenistically or as infrequently as monthly.

Exploring STEM integration and enjoyment according to the level of STEM qualification and confidence for teaching STEM. With one exception, those with STEM qualifications reported higher confidence levels for teaching STEM and were more likely to report integrating STEM in their classrooms, collaborating with others to do so, and enjoying STEM education, both for themselves and when teaching. A link between studying in a field and enjoyment in engaging with it is consistent with prior research (Thomas & Watters, 2015). In the open responses, comments from respondents with STEM qualifications included *"I love STEM", "I enjoy teaching this way, I've studied specialised technology",* and *"this way of learning appeals to me".*

Respondents without STEM qualifications were more likely to report enjoying STEM and integrating it more frequently, including with collaboration, if they had higher levels of confidence. These findings are consistent with prior research which found that higher-confidence teachers valued sharing and collaboration (Lassonde et al., 2009). In their responses to the open questions, respondents supported collaboration *"to ensure that we are making the most* *of one another's knowledge and experience"* [P14] and because it allowed them *"to understand best how to use technology to enhance the learning experience as opposed to it being a tokenistic/afterthought of an application*" [P15]. Coggins and McGovern (2014) supported that collaboration is central to success and professional growth. Respondents in this study reported that they used collaboration to utilise teacher knowledge better, create authentic learning experiences, and thereby enhance student learning outcomes. In summary, when the quantitative data are considered with the qualitative data it is clear that respondents without STEM qualifications and with low confidence and enjoyment in STEM were likely to implement STEM, with or without collaboration, less frequently than those with qualifications and higher confidence and enjoyment.

Value of STEM education

All respondents shared positive perceptions about the effect of STEM education on student learning with all recording ratings of 3 or higher (mean = 4.0) on the item regarding perceived improvement in students' curiosity and inquiry. Coding of the responses to related open questions identified learner traits, learner engagement, and learner experience as common themes. Respondents wrote about increased capacity, empowerment, higher order thinking, transferable skills, excitement, interest-based, expansive, and revolutionised learning. Comments from respondents included:

- *"I feel students are more engaged and willing to take risks. ... positivity impacts the progress shown by all students."* [P7]
- *"support development of creative thinking and higher order thinking skills .... Integration of units would support learning of concepts."* [P8]
- *"Preparing students to be 21stCentury learners and capable, innovative contributors to a modern world"* [P15]
- "*STEM has the opportunity to revolutionize the way students are learning."* [P10]
- *"It better supports students to learn more concepts and ways of understanding, and better prepares them to be educated and higher performing adults in years to come."* [P 19]

These findings are consistent with prior research that reported teachers' positive views about the value of STEM education (Tao, 2019). Teachers in this study generally reported positive perceptions of STEM and willingness to try to implement it through such means as

- *"VR learning enhancement"* [P 15]
- *" Pre-designed programs that are online"* [P 5]
- *"through literature, based learning to give an authentic and hands-on experience that helps the child make connections and gather real world experiences"* [P 20]
- *"student voice and choice, inquiry-based learning*" [P 18]

Despite almost half (11) of the respondents reporting low confidence for integrating STEM (Table 5) all but one (see Table 4) reported implementing STEM at some time, ranging from tokenistic to daily. In summary, their attitudes to STEM education are positive and the data suggest that they are willing to try for implementation despite limited qualifications and confidence (Stevenson et al., 2019).

Enablers

Respondents value STEM education and its implementation, but personal and systemic factors affect their ability to implement it. Factors that respondents perceived as enabling their efforts to implement STEM education included: School expectations being the same as curriculum, funding and resources, administration, confidence, knowledge and experience.

The enablers reported most frequently were personal factors, namely, experience, knowledge, and confidence with systemic factors such as resources, administration, funding being reported less frequently. Relevant comments from respondents included "*I enjoy teaching this way ... I have studied a technology speciality as part of my teaching degree ... commenced teaching as a technology specialist"* [P11] and *"I did learn STEM at university ... graduated last year…literally knowledge to support the planning of STEM learning experiences"* [P8]. Prior research supports the notion that teacher confidence and motivation will increase as teachers engage in further STEM education (Wong & Maat, 2020) and that teachers with more STEM experience are more positive about exploring interdisciplinary topics, problem solving, and a broader set of 21st century skills (Lin et al., 2023).

Barriers and challenges

Whereas the key enablers for STEM education were personal rather than systemic, barriers and challenges were mixed with personal (experience and knowledge) and systemic (resources and funding) items intermingled in the top four. Interestingly, resources were the most often mentioned systemic factor among enablers and barriers. Understandably, a lack of resources (and funding to acquire resources) will impede teachers' efforts at STEM education and, once personal enablers are established, if resources are limited, they will not offer the support necessary for teachers to engage their knowledge effectively. What seems clear is that both personal and systemic factors are essential for STEM education. Comments recorded by respondents included "*My own ability to use the resources can hinder my confidence in implementing it in the classroom. … it requires heavy scaffolding for me to implement"* [P3] and *"time to learn and practice ourselves*" [P17]. Knowledge and access to resources are necessary for building the experience and developing the confidence required for successful STEM education.

In response to a question about attempts to overcome barriers and challenges, respondents mentioned *"self-education … meeting with colleagues", "spacing out innovation … allow more time and support from specialist teachers"*, and *"technology has let me down"*. Teachers' willingness to attempt to overcome barriers and challenges is consistent with their positive attitudes toward STEM education and its value for their students. Research identifies that lack of teacher education and/or experience can hinder the confidence and capabilities of teachers implementing STEM education within the classroom (Park et al., 2016; Stevenson et al., 2019; Timms et al., 2018).

Teachers' wants for STEM education

Teachers are key contributors to successful education (Hattie, 2009). Where they face personal or systemic barriers to success such as those identified above for STEM education, they can suffer reduced morale . Hence, it is critical to ensure that teachers have the support necessary for their success and that of the students with whom they work. The final item on the survey invited respondents to indicate what they wanted for STEM education in the independent school context. A key theme from their responses was professional growth, including access to support (resources and curriculum learning opportunities) and mentorship or coaching from a suitably qualified and experienced STEM teacher. They also desired support for developing "*integrated STEM projects and units of work*" and expanding available resources including appropriate classroom spaces such as a *"dedicated junior maker space."*

Consideration of the data presented in Figures 2 and 3 identified knowledge and experience as leading hindrances to the successful implementation of STEM. Respondents with STEM qualifications and high confidence reported a desire for further professional growth. Lau and Jong (2023) noted similar findings from exploring stages of concern with STEM education. They suggested relevant professional learning opportunities are key to developing teachers' readiness and confidence for innovations.

The findings reported from this study should be considered against its limitations. Firstly, the respondents were drawn from a single independent school in south-east Queensland. These teachers self-selected to participate, which introduces a potential bias and may not represent teachers elsewhere. Although there was substantial consistency among these respondents their perceptions of STEM may differ from those of teachers in schools from different systems, e.g., State, Catholic, or Lutheran. Moreover, the location of the study was a Kindergarten to Year 12 school and may differ from typical primary or secondary schools. A further limitation is the small sample size. The 23 respondents were from a staff of approximately 100 all of whom were invited to respond. Thus, the self-selected respondents may have had a stronger than typical interest in STEM. Moreover, distribution across the school was uneven with most (20 of 23) responses from the primary or middle school. Future research could investigate how teachers` and pre-service teachers' perceptions towards STEM education may change, after completing training and implementing a designated STEM program. Finally, further analysis regarding teacher perceptions of STEM education could be conducted across broader Australian education systems and schools, or globally. This would provide a generalised interpretation of the attributes and perceptions of teachers.

Conclusion

By addressing teachers' perceptions of STEM education within an independent Australian school, this study has demonstrated that teachers value STEM education and its contribution to student outcomes. However, teachers' ability to implement STEM education is negatively affected by factors such as their limited knowledge and experience and lack of appropriate resources. Teachers with higher confidence levels, often associated with relevant qualifications and experience, were more likely to implement STEM education and do so collaboratively with peers. This study recommends that teacher education programs, Principals and administrative leaders support the sustainability and development of STEM capacity among teachers. In Australia and elsewhere there is also some ambivalence towards STEM as a single curriculum area and curriculum policy should be strengthened if significant inroads are going to be made. Because this study was conducted with a small sample of teachers on a single site the findings may not be directly applicable to other contexts. However, the findings point to trends that could be usefully explored in other and broader contexts to determine whether the same considerations apply more broadly.

The study effectively addresses a gap in Australian STEM education research by focusing on teachers' perceptions and barriers. Given that the limitations of teachers' knowledge and experience of STEM are presented as key barriers to implementation, there would be value in offering appropriate professional learning opportunities and mentoring for teachers to acquire relevant knowledge. Investment in curriculum resources to support classroom implementation of STEM would assist teachers in developing experience and confidence for teaching STEM. Tracking the effects of such interventions over time would be valuable to see how teachers and pre-service teachers' implementation of STEM education develops in response and explore what interventions might be more successful.

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