stem.T4L Project: Lessons about improvements to self-efficacy, attitudes, and interest in STEM learning

This report provides an overview of the pilot stage of the stem.T4L project. The next report will discuss the effectiveness of one full project cycle on students and teachers.

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The stem.T4L Project was formerly known as STEMShare Community

Context of Pilot Study Report

NSW Department of Education STEMShare Community Project provides schools with greater access to new Science, Technology, Engineering, and Mathematics (STEM) learning resources and support.

STEM stands for Science, Technology, Engineering and Mathematics.
All schools around NSW will have access to STEMShare Community Kits that include a suite of digital age learning tools, providing virtual reality, 3D printing, film-making, and robotics experiences to help students develop skills for jobs of the future. STEMShare Leaders (SEO1) are in ten locations around NSW to assist in the implementation and delivery of professional learning of the STEMShare Community project. An online learning library designed to showcase and maximise STEM teaching and learning opportunities for educators was launched in July 2018. The online platform features STEM-specific resources, how-to videos and information regarding how to best utilise the STEMShare Community kits.

In July 2018, 37 schools from around NSW participated in the STEMShare Community pilot. The location of pilot schools stretched from Randwick, in metropolitan Sydney, to Boggabilla in rural NSW. The pilot supported schools in building teacher capabilities in STEM, developing collegial collaboration and a sustainable support network.
The key findings of the STEMShare Community pilot are found in this report.

Contents

1. Introduction

Studies suggest a decline in students' interest towards STEM learning worldwide, resulting in an insufficient number of students majoring in STEM (Kelley & Knowles, 2016; Ulicna, & Royale, 2015). For instance, in the U.S. a high percentage of students are not interested in pursuing STEM fields while there is a shortage of skilled STEM workers to support the growing economics (Langdon, McKittrick, Beede, Khan, & Doms, 2011; Rockland et al., 2010). In Taiwan, STEM teaching and learning seem to be still "in their cradle stage" (Tseng, Chang, Lou & Chen, 2013), and in Canada the approaches to STEM education appear to be less clearly articulated (Tippett & Milford, 2017). In 2012, West found that STEM enrolments in Australian universities were flat or declining and in 2015 Australia's National Innovation and Science Agenda Report (Australian Government, 2015) highlighted the need to improve STEM education in schools.

As such, the literature on STEM abounds with initiatives and reforms across the world that focus on the integration of STEM disciplines in K-12 education to increase the number of well-prepared and qualified students pursuing STEM careers (McDonald, 2016). Such emphasis on "STEM literacy" (Bybee, 2013) is driven by the changes in global economy that needs more skilled workers and qualified applicants in STEM careers (Faber, Unfried, Wiebe, Corn, Townsend, 2013; Hossain & Robinson, 2012). Over the last decade, researchers have vigorously investigated the effect of STEM education on students' interest and motivation towards STEM disciplines as well as their academic success and achievement, and problem solving and critical thinking skills (Kwon, 2017; Park, Nam, Moore & Roehring, 2011; Yildirim & Altun, 2015). For instance, some studies found that teaching concepts through technology increased students' motivation and interest and engaged them in STEM lessons (Jones, 2000; Kwon, 2017). Similarly, other researchers found that ICT resources such as visualization tools and interactive games promoted student interest in technology and science and increased feelings of self-competence with ICT skills (Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011).

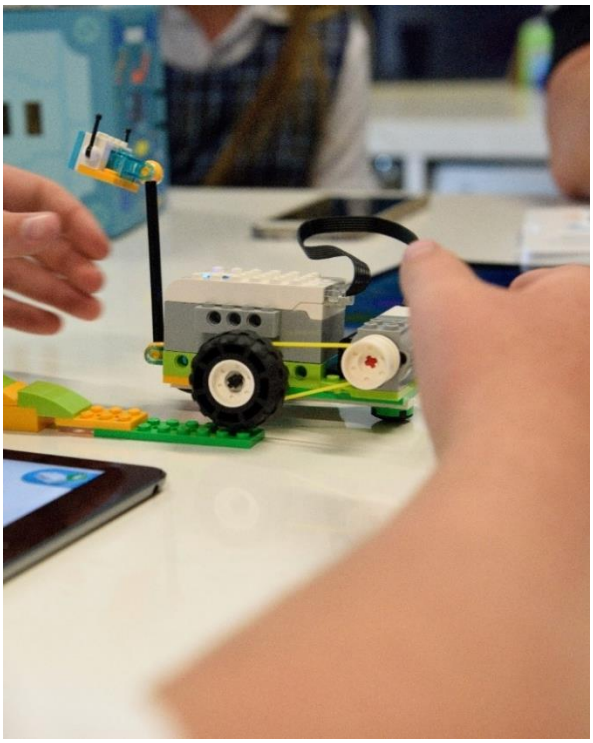
In line with the growing realization of the importance of STEM integration in K-12 education globally, the STEMShare Community Project aims to prepare a generation who are well-prepared for the work force and the technologically advanced 21st century society. This paper seeks to report on the data gathered from teachers, secondary, and primary students who participated in the pilot stage of the project. The guiding research questions in this study included:

1. *To what extent was the professional leaning effective in preparing teachers to implement the STEMShare Community kits? What elements of the professional learning was most praised? What were the aspects in need of further review and development?*

2. *To what extent did the STEMShare Community Project have an effect on teachers' and students' attitudes towards STEM, their interest and motivation to learn STEM, and their STEM self-efficacy beliefs?*

2. Method

To identify the extent to which the objectives of the pilot were achieved, the researcher used a mixed-methods approach drawing upon both quantitative (surveys) and qualitative data (focus group interviews). Surveys are mainly used in quantitative research to explore the characteristics of a specific group i.e. their abilities, opinions, attitudes, beliefs and knowledge (Frankeal & Wallen, 2003). Hence, three surveys were designed and administered through Qualtrics to three groups of respondents i.e. primary students (Year 4-6), secondary students (Year 7-12), and teachers. The Teacher Survey consisted of four sections. Section one was a preamble covering the aim of the survey and how to complete the survey. Section two aimed to collect demographic data on teachers including their years of teaching experience and the type of school they worked in. Section three used a five-point Likert response format (1 = strongly disagree to 5 = strongly agree) and included seven items that explored teachers' thoughts and ideas of the STEMShare Community professional learning. Section four, using the same Likert scale format, consisted of 16 items designed to measure three variables namely, attitude/perception, interest/motivation, and STEM self-efficacy beliefs. In addition to the Likert-type questions, there were comment boxes available to elicit teachers' feedback on specific aspects of the project such as the How-to-videos. The Primary and Secondary Student Surveys were similar to the Teacher Survey in that the three variables, discussed above, were measured in addition to two other variables called 21st century skills (e.g. problem-solving, creativity and innovation, communication, etc.), and teacher effectiveness.



A note on the importance of the variables under investigation is in order. Researchers argued that teachers need to develop both skills and attitudes toward STEM teaching (Al Salami, Makela, & de Miranda, 2017) because teachers with negative attitudes toward STEM might avoid teaching STEM and transfer their attitude to their students (Appleton, 2003, Deemer, 2004). Similarly, researchers found that students' attitudes toward STEM was linked with their belief in the benefits of pursuing STEM. (Baran & Maskan, 2010). In other words, the more positive students' attitudes are, the more likely they are to choose a STEM career. In a literature review by Yildirim (2016) it was found that 29.41% of the studies that were reviewed, examined the effects of STEM education on students' attitudes towards STEM fields. In 5.88% of these studies, STEM education did not have any effect on students' attitudes whereas in 23,53% of them positive effects on students' attitudes occurred. As such teachers' and students' attitudes toward STEM and the extent to which they felt an improvement in their attitudes after the conclusion of the pilot were measured as one variable.

In high school, students' own interests motivate them to enrol in STEM courses (Wang, 2013) as generally the more interested they are in a subject, the more involved they become in their assignments and putting effort

into their studies (Halpern et al., 2007). The literature shows that more and more researchers are measuring the effect of STEM education on students' interest and motivation and the majority of these studies suggest STEM education is influential in increasing students' interest and motivation (Yildirim, 2016). Hence, it was determined to measure the effect of the STEMShare Community Project on perceived changes in students' interest in STEM at the end of the pilot study. Also, some studies indicate effective professional learning programs increase teachers' interest and motivation in STEM learning and teaching (Murcia & Pepper, 2018). Whether or not participating teachers in the pilot study felt more interested in STEM because of the professional learning was another factor to investigate.

The last mutual variable in the Student and Teacher Surveys was STEM self-efficacy. Teacher self-efficacy is defined as teachers' beliefs in their ability to impact student outcomes (Berman, McLaughlin, Bass, Pauly, & Zellman,1977) and it has been associated with teachers' teaching practices, persistence, commitment to the profession, and teacher and student success (Settlage, Southerland, Smith, & Ceglie, 2009; Tschannen-Moran & Hoy, 2001). Similarly, teacher STEM self-efficacy is considered to be a predictor of ability to teach STEM-related content (Ford, 2007; Jarrett, 1999). Students' STEM self-efficacy, on the other hand, is defined as students' beliefs about whether they have the ability to succeed in STEM classes and fields (Deci & Ryan, 2000). Researchers propose that one way to develop students' success in STEM education and careers is to improve their positive self-efficacy beliefs (Dubetz & Wilson, 2013). Therefore, assessing students' and teachers' STEM self-efficacy and the extent to which STEMShare Community Project created a difference in their efficacy beliefs was among the measured variables.

The last 2 variables specifically designed for Student Surveys were 21st century skills and teacher effectiveness. 21st century skills are known as critical thinking skills, communication, collaboration, creativity, and problem-solving skills. As Silva (2009) explains the essence of 21st century skills is "an emphasis on what students can do with knowledge, rather than what units of knowledge they have" (p. 630). By the same token, a high quality STEM education should not only deliver STEM content knowledge but also develop 21st century skills that students need to be "scientifically literate citizens" (Saxton et al., 2014; Tytler, 2007). Four items were included under the 21st century skills variable to measure students' self-perceived improvement in these aspects. The last variable intended to measure teacher effectiveness in implementing the kits from the perspective of the students.

It is worth noting that although primary (Year 4 to 6) and secondary student (Year 7 to 12) surveys included almost the same variables, the survey items were different in terms of content and sentence difficulty to suit the intellectual faculty of both cohorts of students.

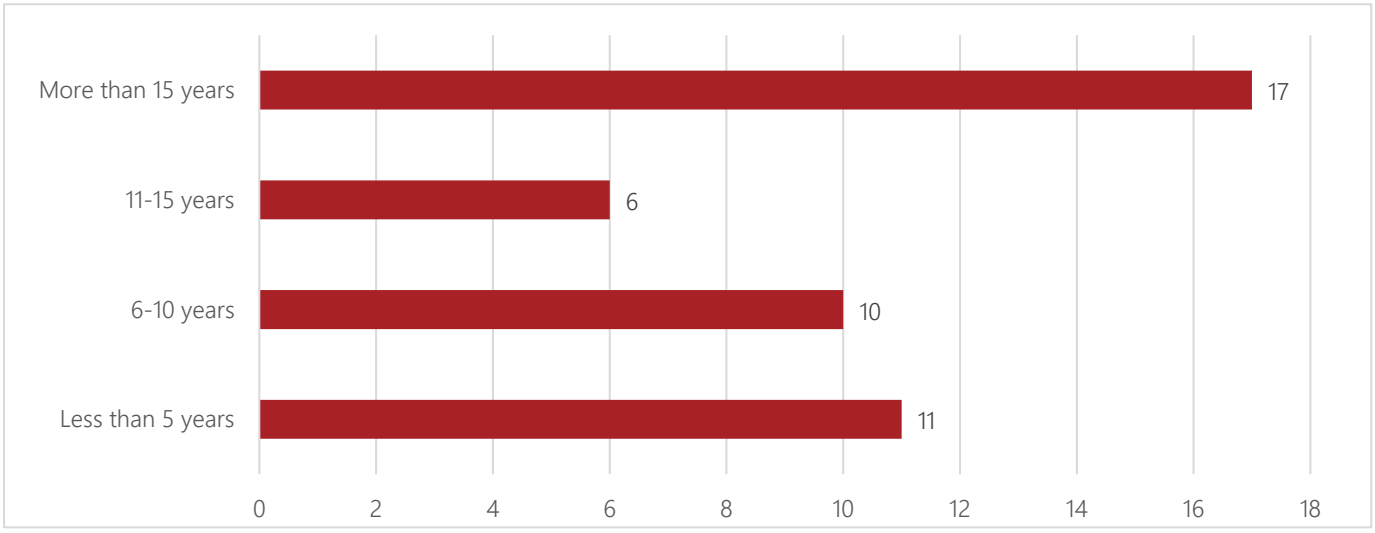
To design items that could accurately measure the above-mentioned variables, the researcher thoroughly reviewed the existing scales. The following scales were consulted, and the selected items were modified to target the aims of the pilot study: Science Teaching Efficacy Belief Instrument (STEBI; Riggs & Enochs, 1990); and School Student Attitudes toward STEM (S-STEM) Surveys (Faber, et al., 2013).

3. Results and Discussion

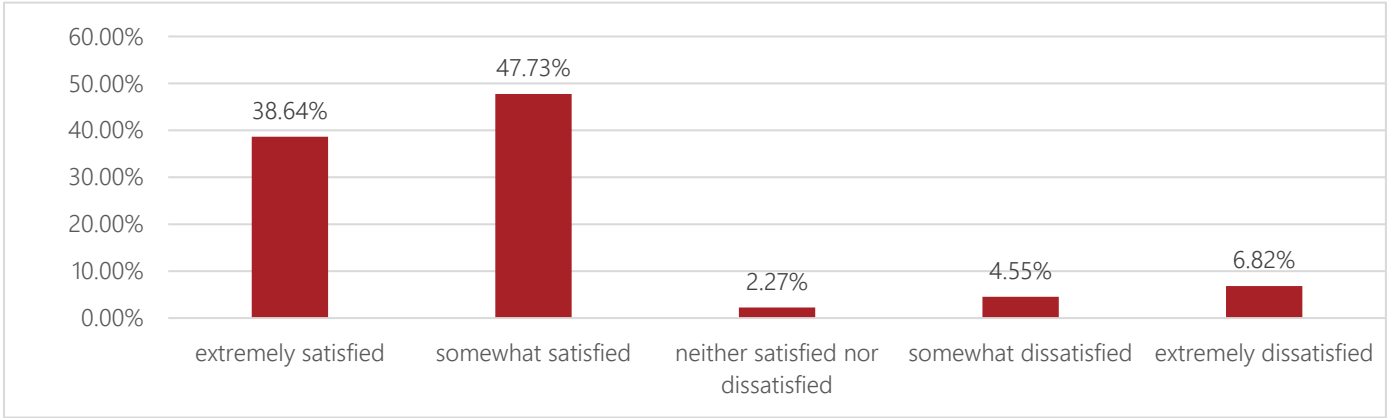
In this section, first, the analysis conducted on teachers' data gathered through the survey and focus group interviews will be presented and next the findings from the Primary and Secondary Student Surveys will be discussed.

3.1. Teacher Survey

The Teacher survey was administered to both primary and secondary teachers and was completed by 44 teachers (30 female, 14 male) of whom 34 taught in Primary schools, five School for Specific Purposes, three Secondary schools, and two Environmental Education Centre. The bar chart below demonstrates the years of teaching experience of the respondents.



There were two sections in the Teacher Survey; section A consisting of 7 items, focused on the professional learning provided to teachers as part of the STEMShare Community Project, and section B included the variables discussed above, namely attitudes/perception (3 items), interest/motivation (2 items), and STEM self-efficacy (8 items). Three items were also added to this section to measure specific aspects of the project including How-to-video, Leaning Challenges, and Social Media (e.g. Yammer).As the chart below suggests, a notable 86% were satisfied with their professional learning and only 11% appeared to be dissatisfied. The underlying reasons for teachers' dis/satisfaction were pinpointed in their commentaries, as will be discussed in the following section.



To better understand which components of the professional learning appealed to teachers, a comparison was made between the means of the items, and it was found that item 1 (i.e. I am satisfied with the resources and learning materials provided by the STEMShare Community Project) received the highest rating i.e. 86% (M=4.14). However, only 34% (M=2.84) declared themselves satisfied with their collaboration with teachers *outside of their school* (item 3). Interestingly, teachers rated "collaboration with teachers *at their school*" (item 2) significantly higher at 4.04, with 82% showing agreement with the statement. Some researchers found strong correlations between any improvement in teachers and their collaboration with teachers in other STEM disciplines (Brown, Brown, Reardon, & Merrill, 2011). This signifies the importance of collaboration between teachers where they can improve their practice by tapping into the knowledge of their colleagues (Talbert & McLaughlin, 2002).

Variable 1: Professional Learning	Mean
1. I am satisfied with the resources and learning materials provided by the STEMShare Community Project	4.14
2. I collaborated with other teachers *at my school* around the STEMShare Community Project	4.07
3. I collaborated with other teachers *outside of my school* around the STEMShare Community Project	2.84
4. The STEMShare Community leaders helped me to implement quality learning activities	4.00
5. I improved my teaching of STEM because of the professional learning	3.73
6. The professional learning further developed my understanding of STEM concepts	3.80
7. Engagement of my students increased because of my new knowledge	4.05

Items 5 and 6 were rated fairly low as well at 3.73 and 3.80, respectively, suggesting that the professional learning did not change teachers' STEM teaching skills and understanding dramatically. However, this finding confirms previous research that shows changes in teachers' practices require both time and effort (Guskey, 2002).

Items 7 and 4 received moderately high ratings at 4.05 and 4.00 respectively. 77% of respondents believed STEMShare Community leaders helped them implement quality learning activities and 84% agreed that student engagement increased because of their STEM teaching knowledge.

The second part of this section invited teachers to explain their reason for their rating and offer suggestions to further improve the professional learning. The data gathered from the commentaries was read over and over again to find the most recurring themes or ideas. The analysis yielded the following positive comments on STEMShare Community professional learning.

A. Supportive STEMShare Community Leaders

One of the most frequently discussed topics was the strong support of the STEMShare leaders. Most teachers praised the SEO1s for their "helpful advice" and the "fantastic" and "amazing" support they offered, as the examples below show:

- *…. who came out and showed us what was possible with the VR kits was extremely helpful*
- *We have had one visit from our STEMShare leader who provided helpful advice*
- *We received great support from STEMShare SEO1s. Communication with everyone has been great.*
- *The support by SEO1's has been fantastic*
- *The visits from …and …. were a great support.*
- *The support from the trainers was excellent. They came into school 3 times to work with teachers and to support children using the kit. They were also very passionate using it with infants as well which was excellent.*
- *Amazing Support from the team*
- *A wonderful initiative and its great to have additional support teachers allocated to the role of STEM advisors to coordinate the project.*

B. Adequate and valuable resources

Teachers were impressed by the "wonderful" and "quality" resources put at their disposal such as online resources/videos:

- *The online videos that demonstrated how to set up the 3D printing kit, set up Tinkercad accounts and prepare files for printing were excellent and we have had a trouble-free experience printing our first projects.*
- *The online resources were excellent*
- *Online videos about what pieces of equipment were in kit and how to use them were good.*
- *It's excellent to be able to share, explore and experience the quality resources that have been carefully selected, organised and prepared for us.*

C. Logistics

Teachers also praised the logistics of the project:

- *We received the kit in a timely manner. Communication with everyone has been great.*
- *The programme was delivered the way it had initially been presented during the initial introductory Webinar around STEMShare and what it would involve.*
- *Well organised, interesting and accessible*
- *It has been enjoyable, stress free and informing.*

In addition to the above positive commentaries, teachers voiced some concerns and disappointment:

D. Insufficient training

Without a doubt the most criticised aspect of the professional learning was the limited training teachers received. Teachers commented that they needed more time with SEO1s and more training in general whether through instructional videos or hands-on activities. Some teachers also pointed out that they preferred the training *before* the kits arrived:

- *Although the support by SEO1's has been fantastic, it was significantly less face to face time than had been advised pre Pilot launch. There was the suggestion that SEO1s would be working in schools each week (in the classroom and with staff PL) to work with teachers.*
- *We had one PL session which covered all the kits available so it was a general session rather than specifically on our kit. It was interesting to see what the other kits were like but I think we needed more PL to get us started.*
- *The PL that I received was incidental and I got it as I needed it when I emailed or made phone calls. Don't get me wrong - it was very helpful and whoever I called was always available. But I think that it would be good to actually work through the Learning Challenge with someone before doing it with the students would be helpful.*
- *I feel as though we weren't given much training.*
- *Teachers require more professional learning about the contents of the kit and how to effectively use the kit in their classrooms. This professional learning needs to be hands on and provided BEFORE the kits arrive.*
- *It would have been good to have training before as we wasted a lot of time with the product but not being able to use it.*
- *It is a fantastic concept and program, however it is not a program that we as teachers can pick up and use. The challenges had to be re-written for kindergarten to use effectively and there were no straight forward instructional videos for students and teachers.*
- *We did receive some contact from support staff, however having them come out earlier on in the term would have made solving the problem and getting a new printer out easier and more beneficial. Neither the students or myself got to use the printer once. We did have some use of the online programs, however as I have little understanding or experience I found it challenging.*

Given that the criticisms directed by teachers mainly centred on the frequency of occurrence of the professional learning, it was not surprising to find most teachers recommending "further", "face-to-face", and "online" training, as well as more frequent visits by the SEO1s, as the examples below suggest:

- *Further professional development regarding use of kits.*
- *Send out the support staff that were promised*
- *Have some online or TC training at the start of each year*
- *More time with Stemshare leaders*
- *Have a group session at the beginning.*
- *Send a support staff from the project out in the first 2 weeks to spend a day with the teacher coordinating the program in the school. Run a course before hand to familiarise staff with the program and other teachers participating- especially for teachers working in remote schools.*
- *Perhaps more professional development and more explicit resources to accompany the Dash robots*
- *More face to face with Stemshare leaders, who are fantastic*
- *Have the STEMShare leaders more available*
- *I would like more opportunities to have the leaders visit the school to do demonstration type lessons and to provide feedback on my lessons*
- *Other schools had an expert come out and visit. It would have been good to utilize that as well*
- *More whole school professional learning.*
- *Next time we may see if trainers can come to the school to do a short PD with the whole school so all staff can get motivated by the kit.*

Most teachers did not seem confident enough implementing the STEMShare Community kits as they felt they needed more "guidance", "structure", "handouts", "structured lesson plans", "demonstration lessons", "ideas", "tutorials", and "videos":

- *A slide show presentation already done to follow*
- *Provide staff with handouts with step by step instructions. The information that I was provided with at a later date was excellent, thanks Ryan!*
- *There needed to be more guidance when the kits arrived. We weren't aware of any resources to support the use of the kit until half way through the term. The kits arrived with no documentation or support materials.*
- *More structure in how to use the kits.*
- *Some how-to videos because we were relying on word of mouth to train each other.*
- *Give us more structured lesson plans. The iPads could be labelled with the Dash Bots to help that link faster.*
- *The videos were great, but more was needed. A really positive start but more refining and discussion needed to make it a brilliant resource.*
- *Write programs for Early Stage 1 assuming no experience with robotics and including instructional videos for teacher and student use.*
- *Possibly a video or link up where the teacher/s work through the learning challenge with support.*
- *sample lesson plans*
- *A lesson outline, perhaps for more advanced students.*
- *A variety of ideas on how we can use each 'robot'. Maybe have a pdf file for each stage.*
- *Instructions for the equipment and structured lesson plans/ideas would be helpful in allowing students to utilise the equipment at their fullest potential.*
- *Demonstration lessons for students and teachers are always a positive experience for all.*
- *Access to video tutorials for both the use of the 3D printer and associated 3d modelling projects.*
- *It may be worthwhile having instructions included in the kit and lesson/project ideas that can be used as a starting point.*

Section B of the Teacher Survey, as mentioned above, consisted of 4 variables (i.e. interest/motivation (3 items), attitude/perception (2 items), STEM self-efficacy (8 items), and general (3 items). In this section teachers were required to rate the statements in relation to their experience of the STEMShare Community Project. As the table below shows, item 5, which was related to teachers' interest/motivation (i.e. I want to continue to improve my teaching and learning of STEM) was ranked at the highest end of the rating results at 4.77, with an overwhelming 95.50% agreeing with the statement. Interestingly, the second highest rating was given to item 11 that measured students' interest towards STEM from teachers' perspective. Again, a considerable 95% (M=4.68) was of the belief that students' interest in STEM has increased since their involvement in the project. These findings provided support for the immense success of the pilot study as they indicated a positive change in teachers' interest towards STEM teaching and learning as well as in students' interest, although from teachers' perceptive.

What further proved the positive effects of the STEMShare Community Project on teachers was the rating given to item 4 that measured STEM self-efficacy (M=3.73). Around 69% of teachers agreed that they were not confident with STEM before the project. However, as the rest of the items of STEM-self-efficacy on page 11 show, the means across these items were mainly at 4 and above, suggesting a considerable improvement in teachers'

confidence in teaching STEM. However, compared to other items of STEM self-efficacy, item 8 obtained a lower rating. At 3.84, only around 66% of teachers agreed that they were confident sharing the STEM resources that they created. Hord and Sommers (2008) argued that one of the characteristics of effective professional learning is teachers' willingness to share personal practice. The fact that the participating teachers in the pilot study did not feel confident enough to share STEM resources that they created might be attributable to the limited professional learning they received, as discussed above.

Items	Mean
1. I feel more positive about STEM learning	4.59
2. My interest in using technology has increased	4.27
3. Learning challenges provided an opportunity for me to integrate STEM learning into my classroom	3.93
4. I was confident with STEM before I was involved in the project	3.73
5. I want to continue to improve my teaching and learning of STEM	4.77
6. I used social media (e.g. Yammer) to share my experiences of the STEMShare Community Project with other teachers	2.51
7. I understand STEM teaching and learning better	4.34
8. I place more importance on STEM teaching and learning.	4.30
9. I know how to further improve my understanding of STEM teaching and learning	4.00
10. I found the How-to-videos effective in knowing how to use the kit	4.57
11. I feel my students are more interested in STEM	4.68
12. I can answer students STEM questions more effectively	4.00
13. I am more confident that I can teach STEM	4.25
14. I am more capable of explaining STEM concepts to my students	4.11
15. I am confident sharing the STEM resources that I create	3.84
16. Access to the STEMShare Community kits increased my confidence in using technology	4.27

As the variables below show, not only did teachers' self-efficacy and interest/motivation improved noticeably, as evident in the high ratings of these items, but their attitudes and perceptions positively shifted. The two items on the attitude/perception (M= 4.30, 4.59) indicated that more than 85% of teachers agreed with the statements, which again suggested a substantial improvement in teachers' attitudes towards STEM.

An interesting observation was that although teachers believed their professional learning did not significantly improve their STEM understanding and teaching skills, as discussed above, they rated almost all the items of Section B noticeably high signifying the positive impact of their involvement in the project, in general, in their self-efficacy, interest/motivation, and attitudes.

Variable 2: Interest/motivation	Mean
1. My interest in using technology has increased	4.27
2. I want to continue to improve my teaching and learning of STEM	4.77
3. I feel my students are more interested in STEM	4.68

Variable 3: Attitude/Perception	Mean
1. I place more importance on STEM teaching and learning	4.30
2. I feel more positive about STEM learning	4.59

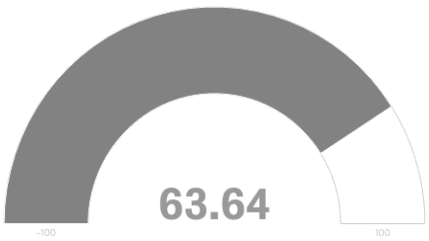
Variable 4: STEM Self-efficacy	Mean
1. I understand STEM teaching and learning better	4.34
2. I am more capable of explaining STEM concepts to my students	4.11
3. I am more confident that I can teach STEM	4.25
4. I can answer students STEM questions more effectively	4.00
5. Access to the STEMShare Community kits increased my confidence in using technology	4.27
6. I was confident with STEM before I was involved in the project	3.73
7. I know how to further improve my understanding of STEM teaching and learning	4.00
8. I am confident sharing the STEM resources that I create	3.84

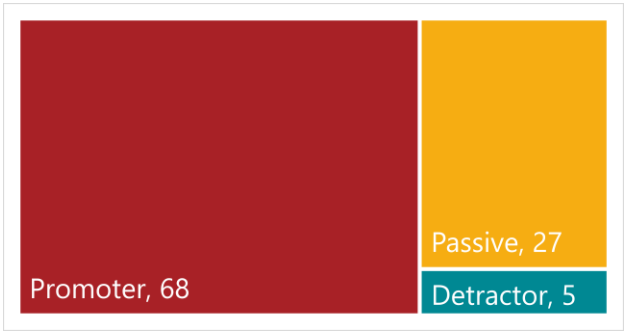
Variable 5: General	Mean
1. Learning challenges provided an opportunity for me to integrate STEM learning into my classroom	3.93
2. I used social media (e.g. Yammer) to share my experiences of the STEMShare Community Project with other teachers	2.51
3. I found the How-to-videos effective in knowing how to use the kit	4.57

The lowest rating across the items of section B was given to item 2 in the General category that measured teachers' use of social media to share their experiences of the STEMShare Community Project with other teachers. Around 67% of teachers disagreed with this item and another 12% were on the fence. This finding further confirmed teachers' lack of collaboration with teachers outside of their school, as explained above.

At the end of the Likert-type questions teachers were invited to participate in a Net Promoter Score (NPS) activity and rate the likelihood of recommending STEMShare Community kits to other teachers from 0 (not at all likely) to 10 (Extremely likely). The NPS is determined according to a well-regarded formula established and tested by

its creators. Stakeholders who answer with a 9 or 10 would most likely recommend to a friend, so they are promoters. Stakeholders who answer with a 7 or 8 are neutral, so they are passives. Stakeholders who answered between 0 and 6 most likely wouldn't recommend to a friend, so they are detractors. The NPS range is between -100 to +100 where a NPS above 0 is considered "good", +50 is "excellent" and above 70 is "world class". As the gauge chart below shows, the NPS for teachers participating in the pilot stage was 63.64, which is exceptionally strong as it suggests there are only 5% of respondents as detractors and an impressive 68% are promoters of the STEMShare Community kits. Also, less than one third of the population falls into the passive category, who are satisfied but not enthusiastic, and can turn into promoters with an extra support.





68% of Teachers are promoters of the STEMShare Community Project

Although NPS yields important information, it is best understood in the context of other data points and considerations. Hence, the teachers were invited to explain their rating and provide comments on any other aspects of the project. The commentaries were extremally positive and indicated teachers' overall satisfaction, as shown by the high NPS. Teachers justified their rating on several grounds that are explained below:

A. Student positive response

Most teachers pointed out that they were pleased with the STEMShare Community Project as they received a positive response from their students. They argued that their students became "highly engaged", "more confident", and "motivated" as they worked with the kits and the kits proved to be a "fun and different" way of learning:

They argued that their students became "highly engaged", "more confident", and "motivated" as they worked with the kits and the kits proved to be a "fun and different" way of learning

- *All students no matter of age or physical / intellectual disability are able to access & engage*
- *The students were HIGHLY engaged throughout the whole process regardless of their ability.*
- *The students' enjoyed the lessons. They felt more confident using the technology after the lessons*
- *Love the kit and the opportunity it gives to students.*

- *Provide great opportunities for our students*
- *The children have been highly engaged and motivated.*
- *The variety in the kit keeps students interested and they gain different skills as they learn about each robotic concept.*
- *Because they were highly engaging for the students*
- *The program increases student engagement, help better explain concepts and provides students the opportunity to problem solve via the development of prototypes on the 3D printer.*
- *The student response was very positive.*
- *The STEMShare kits have been fun and the students were extremely engaged. They also worked together to solve problems.*
- *STEMShare is a brilliant initiative in encouraging schools to promote STEM learning. It is also highly engaging for students.*

B. A state-of-the-art way of learning

The second reason teachers outlined for rating the STEMShare project highly, was the excellent opportunity it created for teachers and students to trial "a state-of-the-art way of learning" and to experience STEM activities and technologies:

- *Provided us with a great opportunity to try these technologies*
- *This has been a wonderful opportunity. Stem and robotics is a school focus, but as we are a SSP it is tricky to know what technologies are useful in our setting this project allowed us to trial the technology across all classes*
- *The project has enabled me to learn new software and implement its uses in class for Major Project Development.*
- *I have enjoyed implementing an engaging unit that incorporates ICT and concepts that would otherwise not be incorporated in normal classroom time.*
- *The equipment provided students with a state-of-the art way of learning to code and work with robotics.*
- *It's really important to learn the technology students will be needing for their future employment.*
- *It has been a hugely popular initiative at the school and I believe it is something that is necessary if we are to consider ourselves 21st century schools. We need to equip students with the skills necessary in an always changing work environment.*
- *Great to have a go with the new resources.*
- *They are a great tool for experimenting with STEM technology*
- *Because it is a great way to access resources for STEM.*

C. It is free

What was fascinating and unique about the project, according to the teachers, was the fact that the kits were free. Teachers were delighted to be given the opportunity to try the kits before buying them or have access to resources that their school normally would not have:

- *Allowed access to equipment that would be too costly to purchase*
- *It's an amazing way to experience a large range of STEM activities without the school having to burden all the cost. This stuff is awesome, but expensive and most schools would not be able to expose their students to all this stuff if the school had pay for it themselves.*
- *I think the STEMShare kits are a fantastic opportunity to explore different STEM resources, to trial resources before purchasing, to collaborate with local schools on our STEM journey and to trial different STEM units of work.*
- *It is free with support in school.*
- *Because I think the STEMShare kits are a fantastic way for schools to try-before-you-buy STEM equipment and have the support and access to Learning Challenges which we've never had before.*
- *serve a purpose in the "try before you buy" idea.*
- *It has been fantastic to have access to these resources that we would not have had otherwise.*
- *I think the STEMShare program is a great idea for schools to trial and get to know the products and possibility for uses before committing to buying.*

An open-ended question was also added to measure the effectiveness of the How-to-videos and learning challenges. Most comments were favourable and stressed that the videos were "detailed", "informative", "very easy to follow", "a good source of knowledge and inspiration" and "met the needs of all learners of stem". Some teachers also offered suggestions to improve the videos such as including "a troubleshooting section", creating videos for "special education", and "tailoring the videos to stage 1". A few comments also suggested that not all teachers were aware of these videos or had access to them. Also, one teacher mentioned that the learning challenges were not very explicit and there needed to be "more explanation and variation between the age groups":

- *Extend to lower grades*
- *Learning Challenges - They were pitched a little high I though*
- *The How-to-videos were very easy to follow and ensured setting up our 3D printer was a trouble-free process. Perhaps shorter, more child-friendly videos could be created for students to watch?*
- *The videos were helpful.*
- *I love the videos helpful!*
- *Was not aware of How-To videos*
- *Perhaps add a troubleshoot section.*
- *The how-to videos were a great resource. Very detailed!*
- *I haven't seen these as yet as I was only made aware if them a week ago. Had I known about them, I'm sure they would have been most useful.*
- *Some for special education*
- *A video on how to use the camera would be great.*
- *more of them and more depth needed in a recognise dept program format*
- *As previously stated, they were not appropriate for early stage 1.*
- *Just that they were hard to find at first. They give good clues about what is going to be covered.*
- *Our internet was too slow to effectively play videos at school, worked fine on my home internet.*
- *The how-to videos were fantastic.*
- *informative*

- *The learning challenges on the pilot website were not very explicit. I believe they needed to have more explanation and variation between the age groups instead of a 'one size fits all' challenge.*
- *They were a good resource to use. I would like to see more learning challenges in the future readily available.*
- *I wasn't aware these videos existed.*
- *The how to clips were great as they met the needs of all learners of stem, especially beginners*
- *More how-to videos.*
- *we did not receive*
- *They are a good source of knowledge and inspiration to build on*
- *Haven't had access to the how-to videos.*
- *I never had access to these/didn't know they existed*
- *These have been great as on-demand professional learning.*

To conclude the Teacher Survey, a comment box was provided to elicit any further feedback on the project. The majority of teachers who commented highly appreciated the opportunity to take part in this "brilliant initiative" and yearned they "could have the kits for longer":

- *We have loved trialling the 3D printer and are now considering purchasing one for the school. We look forward to trialling the other STEMShare kits in the future.*
- *Thank you for allowing us to participate in this pilot. It has been very worthwhile. We have a story in T4Lnews next week which links to our website http://bourndaeec.nsw.edu.au/2018/08/30/stemshare-legends/*
- *My experience with STEMShare has been very positive.*
- *Thank you for allowing us to be part of this project*
- *Loved every minute of it.*
- *Very well run. Thank you for the opportunity that the students otherwise would not have had.*
- *There is a lot in the kit for a small school.*
- *Great resource. Students love the Dash robots and the Lego. The least favourite were the Blue Bots. They were too basic for my students. The level of coding required was basic. My students had more advanced skills than that.*
- *a great project and delighted we were part of it*
- *Overall, I am looking forward to seeing it progress and was extremely happy to be a part of the program.*
- *STEMShare is a brilliant initiative.*
- *Thanks for providing this opportunity to our school*
- *Wish we could have the kits for longer*
- *After remembering about the support material and looking through it, I can say that this too is a very well-prepared resource. It is clear that a lot of thought has gone into making the project work and make it as easy as possible for teachers to access and use. I am very impressed and excited to continue using the other kits!*
- *Would highly recommend this resource to any teacher*
- *Extremely valuable experience, it's a shame we can't keep the kits for longer.*

Everything is provided, the support has been excellent, and It would have been impossible to have done this without the kit as school doesn't have the resources. It has also been interesting seeing what other schools in our cluster have done with their kits. Seeing their work and collaborating has motivated us to get the other kits and explore what can be done with them with our students.

3.2 Teacher Focus Group Interviews

Qualitative researchers draw upon interviews to collect in-depth information on participants' experiences around a specific topic. Interviews are conducted in individual settings or in group where group interviews are often called focus group interviews (Kvale & Brinkmann, 2009). In order to analyse the interview data, thematic analysis, which "is a method for identifying, analysing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p.79), was used. The steps followed in conducting thematic analysis include: transcribing verbal data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report (Braun & Clarke, 2006).

In the pilot stage, three focus group interviews were conducted with teachers from metropolitan and reginal schools. The size of the focus groups ranged from three to six teachers with interviews lasting between 30 to 50 minutes in duration. All teachers actively engaged in the discussions and enthusiastically shared their experiences and thoughts.

3.2.1 Major benefits of the STEMShare Community Project to students

A. Increased student engagement

The first question was on the benefits of the project to students. All teachers were of the belief that the kits promoted student engagement. The joy and excitement of being exposed to different types of technology was a unique experience for most students that contributed to their active engagement in the learning process.

Teachers confirmed that the experience was absolutely positive as they could see "kids happily doing work, not reluctantly". One teacher commented that the kit even made maths more engaging. Another teacher agreed and added that even reluctant students in math were motivated to participate in the activities:

- *Our students were really engaged in the whole unit but there was also some students that usually are very reluctant to participate in maths but it was a perfect platform for them to take risks and develop their mathematical skills without knowing they were doing that so it was really nice.*
- *It made maths more engaging and some kids that normally really struggle with maths were really engaged in it.*

"I think engagement's been key for us with the virtual reality kit. It's one of those things that we haven't experienced a lot of the program side or the creative side of it.... So they've been using it for writing. They've been using it for history. They've been using it across different key learning areas and they want to use it and take that to the next level with their learning so it's actually inspiring them to take their learning a bit further."

- *....so they had to work out how many movements within a particular distance that they did or then to measure a particular distance using the Blue-Bots. So again it was just more engaging so they were more interested in doing that, in setting it up and having it fail and then trying again to see well why didn't that work?*
- *There's a real value especially for some children that struggle with learning because even the other day I had a couple of teachers walk in while I had a group. They couldn't get over a couple of the kids that really struggle in school and class how well they were doing and how motivated they were and they were just focused on the task and they were able to complete the task and that's brilliant for their self-esteem as well.*

B. Improved teamwork and social skills

Another major benefit of the STEMShare kits as discussed by teachers was students' improved social skills and teamwork. Some teachers pointed out that sharing the kits required students to use group skills such as "communication", "letting go of the control", "leadership", and "speaking to each other respectfully". One teacher also commented on the reflection sheets and how they encouraged the idea of working together as a team:

"We used the reflection sheets that are part of the resources and that was really interesting to see as well because they had to give themselves that star rating and then say why and how the group worked together. So it was great that they kind of had to reflect on the group work as well."

- *The children worked in teams and it was interesting to see the opportunity for leadership as well and that sense of perseverance where they had to try and tray and fail forward and try and try in order to make things work so that was very gratifying to see different people doing things different ways.*
- *Communication between the pairs was fantastic because they were actually helping each other and because they wanted them to hurry up so they could have their turn but they were still helping.*

- *…the social skills as well because they're working in groups and they get to problem solve with other people and the discussion and the language that goes into those sorts of things.*

C. A different style of learning

The third theme identified as the major benefits of the project for students was a learning style that was different as it encouraged "thinking laterally", being in change of learning, and moving from "passive users of technology"

"It's not teacher-centred. It's their group. It's student-centred and the teacher just supports, walks around. The group issues that come up you talk through that but apart from that they run it and I think they like that."

to "becoming active users", in "a student-centred" environment:

- *It's not teacher-centred. It's their group. It's student-centred and the teacher just supports, walks around. The group issues that come up you talk through that but apart from that they run it and I think they like that.*
- *just a different style of learning. Different style of learning about all those things or science related technology things, engineering, maths. Yeah I think kids have such an engagement with anything to do with technology these days so they're just going to really enjoy …*
- *The coding side gets them to think a bit laterally when they're actually using the coding to code. We've got the iPad robotics so when they're actually doing that they're thinking a bit differently to how they would normally think and they have to problem solve to get that.*
- *The kids are really learning these new skills of doing operations, processing, how to program. What happens if I put that in there? So it's a new language really.*
- *It was kind of like learning through play. They regarded it as play rather than a lesson which I thought was good to see.*
- *It's just kind of a really high engaging, fun, it's an informal learning setting more. I don't know if it felt a bit you know you can sit on the floor with them at times and it's this different way of interacting.*

3.2.2 Major benefits of the STEMShare Community Project to teachers

When it came to the benefits of the project to teachers, there was no doubt on the part of teachers that their confidence in using technology has increased. They explained how scary technology could be for teachers, specially beginning teachers. Yet, having the opportunity to use the STEMShare Community kits was "a really big eye opener" and helped them "feel more comfortable with technology" to not only use it but actually embed it into their practice. They also passionately talked about the professional learning and its contribution to upskilling staff.

- *Using new technology as a teacher can be quite scary. Like I know that before the first time we used it I hadn't sat down and tried to figure out how to use it so I was learning with them, but it was easy enough that it kind of took that fear away perhaps.*
- *I think they [teachers] find it very scary and oh, I can't do that. But just having that opportunity it develops their confidence, so they do feel like this is something I can incorporate and then once they've had a play they then start seeing the possibilities.*
- *I think professional learning for a lot of staff it really opened their eyes as to what's out there and the possibilities and who much fun it is for them as well as for the kids I think.*
- *I felt a bit behind. Like they were way more on top of the technology than I probably was. So, it was good for us to go oh it's okay, they'll be able to show me.*
- *And it was great discovery learning and that's what we expect the children to do so for the teachers to model that, the risk taking and we're going to be learning here together. I think that was really, really good.*
- *Leaders coming out, that's really improved everyone's access to it and I think teachers probably feel more comfortable with it. When we first got the kits it was work it out for yourself sort of thing and I think we all sort of went wow! And it's probably why it took a couple of weeks for everyone to get it out because we had it, which is fantastic, but we didn't know how to use it. Now we've got people who we can talk to and get in contact with come and run PDs and things like that.*

3.2.3 Challenges and barriers to implement the kits

On the way to effectively implement the kits lie challenges and impediments. The two main challenges discussed by teachers included the missing link between the kits and the curriculum and the difficulties with operational issues.

A. The missing link with the curriculum and syllabus

Teachers unanimously agreed that the kits need to be embedded into the curriculum, into "English", "science", and "maths" so they are not considered as one-off activities or just paly rather "as real-world stuff". As such they stressed that they needed "the bigger picture", "the direction", "the purpose", "the reason why they are doing this", and more "explicit links in each of the challenges to actual outcomes" or "the real-life jobs".

- *I'm not absolutely 110% sure how many curriculum links, incidental curriculum links, how it links into maths. I don't know.*
- *As I've said the syllabus is one that we need to work out how because even when you look at the new digital technology syllabus it doesn't necessarily hit the STEMShare kits and you need to adapt it in how you're going to use it so I'd say that's probably one of the big things*
- *It needed a more sequential bigger picture activity around it.*
- *Showing how you link that idea to the curriculum perhaps.*

- *There needs to be real links with real jobs. You know coding, a lot of people make a lot of money coding phones and engineering and robotics but in the curriculum, in the documents where people sit down at the desk and do the curriculum they need to say Yeah how is this real world stuff?*
- *That's what we need to learn how to do with the syllabus and with our continuums of learning to just work out how it works. And sort of I think at the moment it's not very clear how they want us to use it. We're sort of just experimenting. We're playing, we're piloting but I think if there's more direction about how we can use this more effectively in the classrooms I think teachers with the professional development will jump on board and go yeah, see the benefit.*
- *…so there needs to be that purpose that hey listen, we're not just doing this to, it's not just a string going down, where do we go to from there and I think that's what's got to be pushed. Base from beyond basics.*
- *So you're saying hey, the reason why we're doing this is because of this.*
- *It needs a purpose*
- *It's how to use that technology with the kids and incorporating it in the curriculum and that's the next step.*
- *It has to be embedded into your English, your maths, your sciences and I think everyone's sort of working out how to do that.*
- *Would potentially be more explicit links in each of the challenges to like actual outcomes. I think it needs to be more explicit with ideas and entire science program.*

B. Operational aspects

Teachers referred to a wide range of operational challenges they faced in implementing the kits including "fitting in the time", "keeping track of pieces", "the charging, and knowing which iPad goes with which App or Dash-Bot":

- *Obviously, the connection with which iPad goes with which Dash-Bot over and over. No matter what we did it still became a problem.*
- *Being time poor is probably the biggest limitation to the whole thing. It took, with the WeDo, 10 to 12 minutes to just pull it apart and look under the desk and do everything else.*
- *The challenge was mainly fitting in the time.*
- *The challenges of having 10 things to 30 kids*
- *The containers are not adequate in encouraging the children to keep it.*
- *We were saying like maybe colour like a little lid or something for each compartment*
- *With the WeDo kits I think there should be 15 kits to go out and there should be a 16th just for spare parts because they will be lost but you do realise with that it's like anything if you're missing one part you cannot make it*
- *I'd say pieces was our biggest challenge.*
- *Even in a very structured way you still were losing pieces, which I found frustrating because we like our sets to maintain integrity.*
- *And it's a worry with Dash-Bots*
- *I just think with the WeDo keeping track of all the little bits I can just imagine how many bits are going to be missing even by the time we finish with it.*
- *You almost need like a labelled box*

- *Having 10, the average size in Stage 3 is 30, seems to me to be idiotic you know because all of a sudden, you've got three kids.*
- *the WeDo kits are good because they've got a little chart that shows what should be in each compartment and how many there should be but even yesterday someone went to use the kit - I haven't got this and I haven't got that.*
- *The charging, making sure everything was charged. Working out which iPads had which Apps, because a whole bunch yesterday the App, the Lego we do was down and then the other bunch it just had waiting as if it was updating or something.*
- *I found when the kits first arrived there was nothing in them to tell us what was in the kit so you didn't know what was what. You didn't know if you had it all but when I phoned they were really helpful.*

3.2.4 Suggestions to improve the project

To conclude the focus group interviews, teachers were invited to offer recommendations and ideas to further improve the project. They all had much to say and provided thought-provoking comments including adding more instructions for using Apps such as "Blockly App", creating "more straightforward lesson plans" for the "Dash" and "all of the robots", having "higher grade" and "lower grade" challenges for Dash-Bot, offering more PDs, having more people on the ground, increasing the number of "VR goggles", and having a "resource bank of ideas":

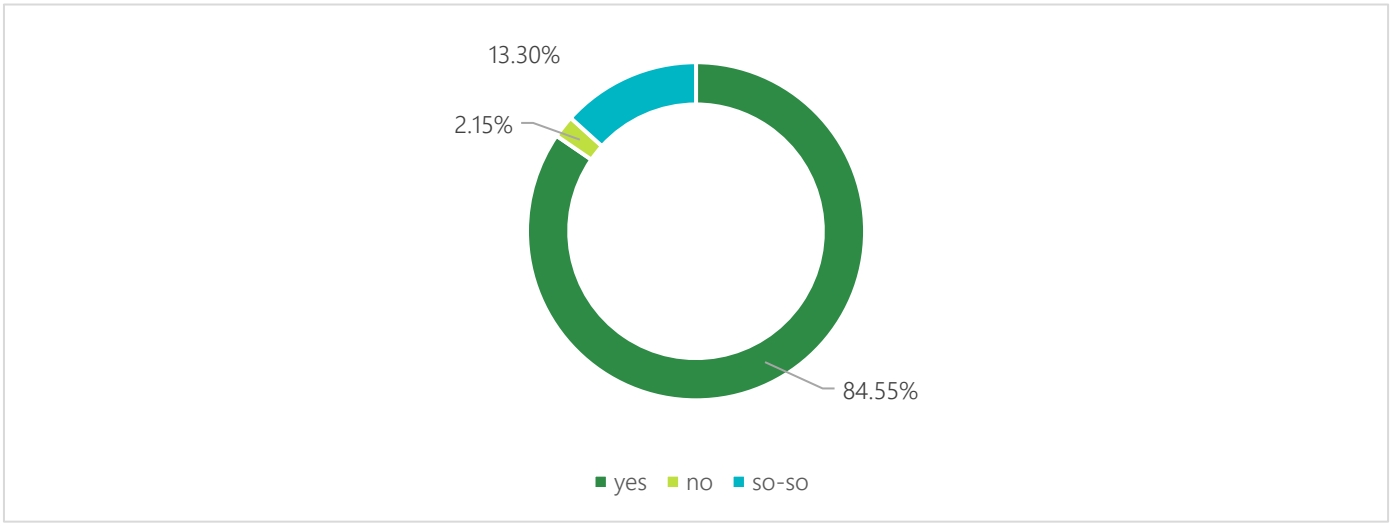
- *It would've been nice maybe if they included a little bit of time explaining how to use the Blockly App to the younger kids in the challenges, so we could try and boost their learning and understanding of that.*
- *There could've been maybe a little bit more explanation as to how to use those Apps and the particular benefits of those Apps would've been more beneficial, especially for the lower grades and for someone who hasn't used those robots before.*
- *Looking at like we do the Blue-Bots and the Dash I think there was less for Dash perhaps than there was for everything else. I don't think we had as much guidance necessarily. There weren't like lessons. I don't think they were like straightforward lessons.*
- *More explicit lesson plans for the Dash.*
- *Definitely more explicit lesson plans I think for all of the robots.*
- *A bit of like slight differentiation between the Bots. So instead of just saying like a one size fits all for the Dash-Bot maybe like say this is potential higher-grade challenge Dash-Bot and this is like a lower grade challenge or a low ability challenge for each Bot potentially.*
- *I think I personally would like a bit more professional development on what, I mean I don't know how much has been done with virtual reality but like how can I embed this in a more meaningful way? I think a bit more kind of almost specific examples of what's been done and the process of using the whole kit of virtual reality would be really helpful, particularly with the making because I mean we'll give it a play*
- *I've read through, watched videos, I still don't get it and so I need someone now to come out and that was what we were talking to get them to come out and actually work with us*
- *I think like we've only got 10 virtual reality goggles and I've got a class of 30 and so I mean we just make groups of three and we work with it but I guess depending on what we want to do with it one day having 10 or a smaller number of things. I guess yes we want to encourage group work but with things like the virtual reality where it's only one kid can actually use it at a time that's a bit limiting.*

- *That's one of the big challenges with virtual reality because it is not a group activity. It's a one on one activity to the virtual reality. So you can have the 10 doing the virtual excursion. You've got the other 20 sitting there not doing much.*
- *One of the other challenges with the VR kit is the limited number of Apps available. We don't have a lot of Apps so I think there's only 10 Apps on the thing.*
- *I think the biggest thing for me is the training. Because I think I'm quite confident with technology. But as I said I want to go deeper and I want to see what we can really do with some of the things in these kits.*
- *I think it's having the people in here that you can have the conversations with. You can ask the specific questions. You can slow them down and get that feedback that you need straightaway with an actual person who is an expert in their field.*
- *I'd agree that the training's really important. As I said before you need to know how to use it to be able to teach it*
- *And even videos of teachers like teaching with it as well.*
- *I think having that resource bank of ideas and how to use the, not necessarily use it, incorporate it in ideas or what you can do with it and how it fits in the syllabus.*
- *Also, for kindergarten, even though all the challenges were there and things like that all of it was still way beyond their understanding, so everything had to be brought right back. So even though the challenges were there for kindy I completely re-wrote them just to make it easy*

3.3 Primary Student Survey

The Primary Student Survey (Year 4 to 6) was completed by 466 students (230 female, 236 male), of whom 220 were Year 4, 132 Year 5, and 114 Year 6. Although 38 schools participated in the pilot study, the responses were found to be from 11 schools (i.e. Mowbray PS, Lane Cove West PS, Lansvale PS, Ryde East PS, Mount Kuring-Gai PS, Berowra PS, Matraville PS, Warialda PS, Wairoa PS, Mount Colah PS, Sydney Children's Hospital School) and the rest of the schools did not take part in the surveys.

As shown below, a significant number of primary students (84.55%) answered "Yes" to "did you enjoy working with the kit?", expressing their sheer enjoyment with this experience. Only 2.15% appeared to dislike the kits and another 13.30% were sitting on the fence neither agreeing nor disagreeing with the statement.



Unlike the Teacher and Secondary Student Surveys, the Primary Student Survey had a four-point rating scale that ranged from 1=Not at all to 4=Very much. Hence, the mean of each item, calculated through Qualtrics, was out of 4. As Table 1 below shows, the highest mean (M=3.59) belonged to item 2 and the lowest ratings were given to items 10 and 8 at 3.14 and 3.17, respectively.

Items	Mean
1. I found using the kit easy	3.26
2. The kit was really fun and interesting	3.59
3. I understood how to work with the kit	3.43
4. My teacher was really good at explaining how to use the kit	3.35
5. I felt in control of what I was doing	3.28
6. When I was using the kit, I knew what I had to do each step of the way	3.36
7. I found the kit very useful	3.37
8. I understand how the STEMShare kit helps me learn	3.17
9. I liked that I learned new things from the kit	3.46
10. My teacher used the kit to help me learn	3.14

As mentioned above, the surveys were designed to measure respondents' thoughts and ideas of several variables. Below, the items of the Primary Student Survey are categorized based on the variables they intend to measure for further analysis. Variable 1 focused on students' attitudes and perception towards STEMShare kits. As mentioned above, the highest rating was given to item 1 of this variable with an impressive 91% agreeing with the assertion. Also, 86% (M=3.37) found the kits very useful.

The second variable intended to measure teacher effectiveness from the perspective of students. Surprisingly, the two lowest rated items across the survey belonged to this variable. Although 85% of respondents (M=3.35) agreed that their teacher was good at explaining how to use the kit, they struggled to consider the kits as a means of learning.

Given the strong agreement of students with these items, it can be concluded that the primary students had an overall positive attitude towards the STEMShare kits and they found the kits to be useful, interesting, and fun.

Variable 1: Attitude/Perception	Mean
The kit was really fun and interesting	3.59
I found the kit very useful	3.37

Variable 2: Teacher Effectiveness	Mean
My teacher was really good at explaining how to use the kit	3.35
My teacher used the kit to help me learn	3.14
I understand how the STEMShare kit helps me learn	3.17

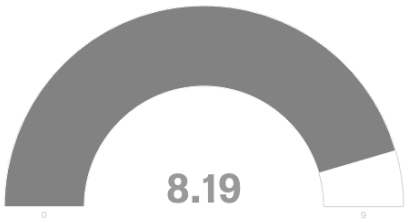
The third variable under investigation was students' mastery experience (i.e. performance accomplishments), which is the primary source for student development of positive self-efficacy beliefs (Bandura, 1997). As the table for variable 3 suggests, students rated all the 4 items of mastery experience well above 3 (i.e. over 85% agreement) indicating their confidence and sense of achievement in successfully executing the kits, which could have an impact on their positive attitudes and perceptions towards the STEMShare kits.

The last Likert-type question in the survey was related to variable 4 for which students were asked to assess the contribution of the kits to the development of certain skills (i.e. 21st century skills). As researchers argue technology- integrated learning environments create students who can think critically, solve problems, collaborate with others, and better engage in the learning process (Lacey, 2010). As the table above shows, an overwhelming 88% (M=3.49) mentioned the kits helped them "create things". "Collaboration and sharing" also received a high rating of 82% (M=3.29) and in the third place, 75.75%, was "communicating with others" (M=3.11). Although "solving problems" received the lowest rating, 67%, (M=2.83), the rating still indicated more than half of the students believed the STEMShare kits had a positive effect on the development of their problem-solving skills.

Variable 3: Mastery Experience (Self-Efficacy)	Mean
I understood how to work with the kit	3.17
I felt in control of what I was doing	3.28
When I was using the kit, I knew what I had to do each step of the way	3.36
I found using the kit easy	3.26
I liked that I learned new things from the kit	3.46

Variable 4: 21st Century Skills	Mean
Solve problems	2.83
Communicate with others	3.11
Collaborate/share with your classmates	3.29
Create things	3.49

As a summative exercise, primary students were invited to rate the kit between 1 (very bad) and 10 (very good). As the gauge chart below shows, a mean of 8.19 is considerably high suggesting students' support for the STEMShare kits.



In order to access students' thought process promoted by this task, the respondents were required to provide a commentary for the following assertion:

The STEMShare kit made me feel…

The responses were illuminating and highly positive, which further proved the effectiveness of the STEMShare Community Project. To analyse the written comments in this section a word frequency analysis was conducted in Excel. As the table below shows "(very) happy", "fun", "learning a lot", and "excited" had the highest frequency count. Interestingly, the only negative emotions, as described through words, included feeling "dizzy", "bored", "confused", and "stressed", which had a significantly low frequency count (N=13). It is worth noting that the words receiving a frequency count under 1 are not included in the table.

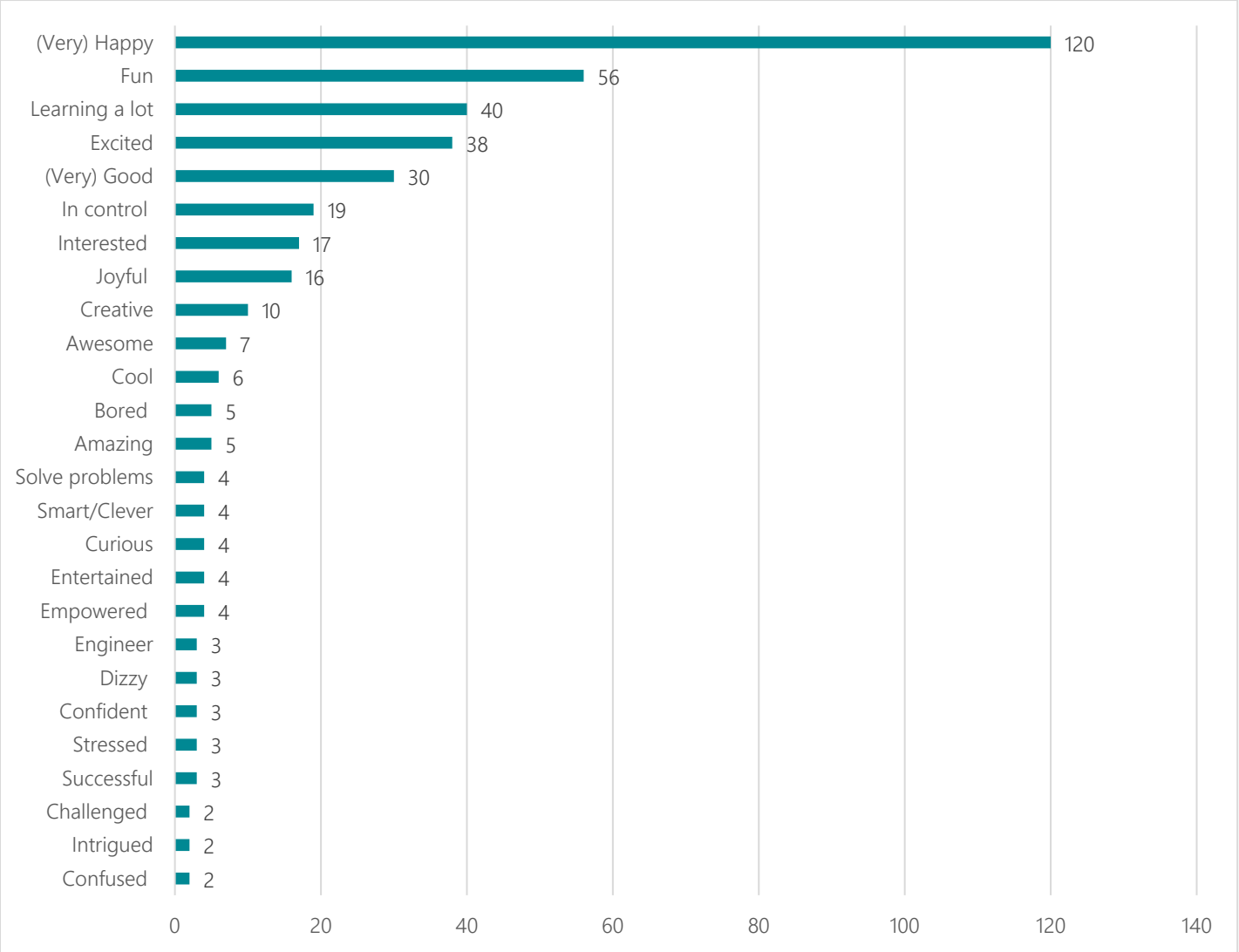


Table: Frequency count of words describing students' feelings towards STEMShare kits.

Some examples are provided below to shed light on students' ideas and thoughts towards the STEMShare kits.

- *Using the kit made me feel interested about the things surrounding me. It also made me feel curious because It made me want to know more. I was a little disappointed though, because I would really like to move around.*
- *The STEMShare kit made me feel in control but my friends also felt in control because we all took turns doing each thing*
- *That I can communicate more.*
- *It was really fun creating new things with the kit.*
- *It made me feel like an engineer and like a robot*
- *It made me feel happy because I got to build something and communicate with others and learn*
- *IT WAS SO COOL! I loved it and I did a lot of creative ideas and making creative things and solving problems, I hope we do it again!*
- *A bit frustrated at first but then i got the hang of it*
- *Like an inventor and also we got to modify our creations*
- *So-so. It didn't explain how to use certain tools, and didn't tell us about and drawing or hidden tools. I found that disappointing.*

3.4 Secondary Student Survey

29 secondary students (21 male & 8 female) responded to the Secondary Student Survey. The survey consisted of 15 five-point Likert type items (1= "Strongly Disagree," 2 to 5= "Strongly Agree"), and three open-ended questions. The demographic data indicated that 17 students were year 11, four Year 8, four Year 10, three Year 7, and one Year 9, and they were from three schools (i.e. Canley Vale High School, Cambridge Park High, and Boggabilla Central School).

As the table below shows, all items received an average rating above three, meaning that the respondents were inclined to have a "neutral" towards "agree" position on the items. The highest rating was given to item 1, which measured STEM-self efficacy (M=3.90), with 75.5% agreeing that they were more confident using technology. Interestingly, the lowest rating was given to another STEM self-efficacy item (item 14) that measured students confidence using technology *before* their involvement with the STEMShare Community Project. Although only 35% (M=3.28) believed they were not good at using technology before, another 48% were neutral. Given the high number of students (75%) agreeing with item 1, it was concluded that a rise in most students' confidence in using technology occurred.

Items	Mean
1. I feel more confident using technology	3.90
2. I can understand STEM (Science, Technology, Engineering, Mathematics) better	3.52
3. I am more interested in learning STEM	3.59
4. I have a better understanding of the importance of STEM subjects	3.38
5. I am confident that I can be successful in STEM	3.31
6. I feel STEM subjects are useful for everyday life	3.41
7. I know STEM will help me understand the world around me	3.55
8. We live in a better world because of STEM	3.38
9. I feel I am more motivated to choose a STEM-related career	3.38
10. I would like to participate in another STEMShare Community Project	3.69
11. I was really interested in STEM-related subjects before using the STEMShare kit.	3.31
12. My teacher was really good at explaining how to use the kit	3.79
13. My teacher used the kit to help me learn	3.62
14. Before participating in STEMShare Community Project I was not good at using technology	3.28

However, as the rest of the items of STEM self-efficacy suggested, less than 50% of respondents agreed that they could understand STEM better and were confident that they could be successful in STEM. Given the direct connection between self-efficacy beliefs and the motivation to pursue a given goal, e.g. a STEM-related field, (Bandura, 1997), a stronger emphasis on STEM integration seems to be needed, especially in secondary schools, to increase students' interest and motivation and to further enhance their STEM self-efficacy beliefs.

What provided support for this argument was that even the short-term pilot study of the STEMShare Community Project could create a difference in students' motivation and interest towards STEM, as the means on variable 2 suggested.

Item 4 of this variable received the lowest rating (M=3.31) across the items measuring interest/motivation. In other words, only 37% were interested in STEM-related subjects before using the kits. However, it was found that 41% (M=3.38) felt more motivated to choose a STEM career (item 2) and 58.62% (M=3.59) grew more interested in learning STEM (item 1) because of their involvement in the STEMShare Community Project. Also, the mean of item 3 (3.69), indicated that 55% of respondents were interested in participating in another STEM project. By comparing the means of item 4 (3.31) and items 1, 2, and 3 it can be observed that students' interest towards STEM has slightly increased.

Variable 1: STEM Self-efficacy	Mean
1. I feel more confident using technology	3.90
2. I can understand STEM (Science, Technology, Engineering, Mathematics) better	3.52
3. I am confident that I can be successful in STEM	3.31
4. Before participating in STEMShare Community Project I was not good at using technology	3.28

Variable 2: Interest/Motivation	Mean
1. I am more interested in learning STEM	3.59
2. I feel I am more motivated to choose a STEM-related career	3.38
3. I would like to participate in another STEMShare project	3.69
4. I was really interested in STEM-related subjects before using the STEMShare kit	3.31

Variable 3: Attitudes/Perception	Mean
1. I have a better understanding of the importance of STEM subjects	3.38
2. I feel STEM subjects are useful for everyday life	3.41
3. I know STEM will help me understand the world around me	3.55
4. We live in a better world because of STEM	3.38

Variable 4: Teacher Effectiveness	Mean
1. My teacher was really good at explaining how to use the kit	3.79
2. My teacher used the kit to help me learn	3.62

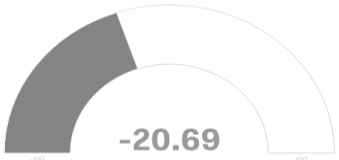
Variable 5: 21st Century Skills	Mean
1. Communicating with others	3.38
2. Solving problems	3.45
3.Teamwork and collaboration	3.66
4. Leadership	3.45
5. Creativity and Innovation	3.79

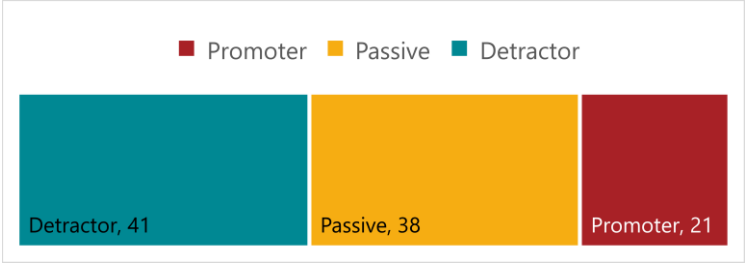
A glance at the means of variable 3 revealed that only around 40% of respondents took a positive attitude towards STEM or reported an improvement in their understanding of STEM. What was interesting to know was that the majority of respondents seemed to be on the fence neither agreeing nor disagreeing with the items of variable 3. For example, more than half of the respondents took a neutral position on items 2 and 4 of variable 3. This could mean students did not feel they had enough information to make a decision on these items, which again might be an indicator of their low STEM-self efficacy beliefs.

Amongst the 21st century skills, item 5 (creativity and innovation) received the highest rating at 3.79, with 65% of respondents agreeing that they developed their creativity and innovation "a great deal" and "a lot" because of the STEMShare kits and another 20% selecting a "moderate level". Similarly, as discussed above, 88% of primary students believed the kits contributed mainly to their ability to "create things". In addition, both primary (M=3.29) and secondary students (M=3.66) chose "collaboration and teamwork" as the second skill positively influenced by the STEMShare kits. Leadership and solving problems relieved an equal rating at 3.45 by secondary students.

Both items of the Teacher Effectiveness variable received a moderate rating, with around 58% of respondents showing agreement with the statements. Although item 1 of this variable had the second highest rating across the Secondary Student Survey, primary students rated this item significantly higher, with 88% agreeing.

As explained above, the range of NPS is between -100 to +100 and a NPS above 0 is considered "good". The NPS of secondary students was -20.69, however, detractors (41%) were twice as many as promoters (21%) and a notable 38% were passive.





Only a limited number of students provided a reason for their rating as suggested below:

- *I chose this rating because I feel that i'm not a great influence to the young audience. Also not a great talker.*
- *I really like it so much, I think it is a great project that is involve in innovation and creative thinking for all of the kid which is a plus plus.*
- *It's interesting*
- *I don't recommend anything but food to anyone*
- *It helped me a lot with learning about STEM which I think is very important.*
- *Because I don't like it*
- *Because its half and half*
- *Because I don't like it*
- *It's new for me and it's helping me with my project*
- *Because it's fun*
- *It is interesting*
- *Cos this is a fun thing to do and I have a lot of fun using this*
- *I feel as if they deserve it*

4. Concluding Remarks

This paper was a report on the pilot study of the STEMShare Community Project. The analysis of the data provided sufficient evidence that the pilot stage was largely successful as it positively changed students' and teachers' STEM attitudes and interest and created a substantial improvement in their STEM-self efficacy beliefs. However, it was also found that teachers had limited collaboration with teachers *outside* of their school. This was further confirmed by the low rating given to the item on "sharing experiences of the STEMShare Community Project through "social media", where only 21% showed an agreement. Yet, teachers appeared to have more collaboration with teachers *at* their school.

A notable 86% of teachers appeared satisfied with their professional learning and ranked "the resources and learning materials" provided at the highest end of the rating results, which could be regarded as one of the strengths of the professional learning.

The ratings of the items of STEM self-efficacy suggested a considerable improvement in teachers' confidence in teaching STEM because of their involvement in the STEMShare Community Project.

In other words, while 69% of teachers believed they were not confident with STEM before the project, 81% felt more confident teaching STEM at the end of the project.

In line with an increase in teachers' STEM self-efficacy, it was observed that teachers' interest in STEM improved significantly. In fact, the highest rating across the Teacher Survey was given to "interest in continuing to improve teaching and learning of STEM", with an overwhelming 95.50% agreeing with the statement, conveying their passion and enthusiasm for STEM. Also, the second highest rating belonged to students' interest towards STEM and it was found that 95% of teachers thought there has been a rise in students' interest.
Given the high ratings of most of the items, it was not surprising to see a very strong NPS that suggested 68%

Similarly, the two items measuring teachers' attitude/perception were rated high, with more than 85% of teachers agreeing that they felt more positive about STEM and placed more importance on STEM teaching and learning.

of teachers were promoters of the STEMShare Community Project. The thematic analysis conducted on the qualitative data also revealed that teachers were impressed by the STEMShare Community kits. They observed an increase in "student engagement" as well as an improvement in students' "teamwork and social skills". Apart from their positive comments, teachers appeared to be slightly concerned that the STEMShare kits were viewed as one-off activities and somewhat discontented from the curriculum. They thought a stronger emphasis should be placed on the purpose of implementing the kits and a more explicit link should be established between the learning challenges and the actual outcomes.

The data from the Primary Student Survey indicated that 84.55% enjoyed working with the kits and only 2.15% appeared dissatisfied. The highest rating was given to an item measuring students' attitudes toward STEMShare Community kits that suggested 86% found the kits very useful. Also, the four items related to STEM self-efficacy received high ratings with an agreement of 85% and above. Similarly, the data on the Secondary Student Survey showed that students' STEM self-efficacy improved as 75.5% agreed that they were more confident using technology. Although the ratings on STEM interest/motivation was not significantly high for secondary students, they suggested a slight increase. While only 37% of secondary students were interested in STEM-related subjects before using the kits, 41% felt more motivated to choose a STEM career and 58.62% (M=3.59) grew interested in learning STEM. In addition, both cohorts of students felt the STEMShare Community kits had a strong influence on the development of their "creativity and innovation" and "collaboration and teamwork".

As the findings suggested there were clear trends in the data that supported the effectiveness of the STEMShare Community Project and its positive impact on teachers and students. It is hypothesized that teachers and students will make more significant gains in STEM education as they involve in the STEMShare Community Project for a longer period of time, which will be investigated further.

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