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Abstract: The Makerspace phenomenon has morphed into three readily identifiable types characterised by accessibility: dedicated, distributed, and mobile. The research presented in this paper describes a type of Makerspace that is defined by its purpose: to improve the confidence and ability of primary education students in STEM education. This approach is innovative and timely given the renewed interest and investment of the federal and state governments into STEM education. A new model of professional learning that is currently being validated in an extended, funded project framed this research that involved 9 female teacher education students and 71 schoolgirls in Years 5 and 6. Whilst a large set of qualitative data was collected, this paper reports on the progress and reflections of the teacher education students, and shares insights into their personal learning and development as teachers.

Background

Research has shown that over the 15 years since its inception, Science, Technology, Engineering, and Mathematics (STEM) continue to be taught separately in subject silos in schools (Blackley & Howell, 2015), and there is little or no integration or connections between the silos to emulate how professionals in the fields actually work. The desire and perceived need for increased numbers of students opting for STEM subjects in senior secondary and tertiary STEM-related courses have been a challenge for educators globally (Chubb, 2015).

Currently, there is renewed momentum for a national focus on STEM education in schools (Education Council, 2015). In the *Health of Australian Science,* the Office of the Chief Scientist (2012) advocated developing a culture in which STEM education is appreciated and both students and the teachers feel valued. STEM education can promote skills that are relevant in our information-rich 21st century Western economy, such as problem solving and evidence-based thinking. The creative and analytical talents of STEM graduates can be harnessed in business and other sectors, as well as in academic research. Australian STEM graduates in a wide range of careers report that their STEM knowledge and skills are helpful in both their work and personal lives (Harris, 2012). Furthermore, because the problem of declining numbers in student preferences in STEM is a national concern, young people's interest in STEM needs to be stimulated and maintained throughout schooling so that they choose to continue with studies in these fields at the university level and ultimately the skills shortage is redressed (Australian National Engineering Taskforce, 2010).

Authentically integrated STEM education would see the immersion of students in "rich tasks" drawing on a number of STEM subject areas as a preferred way of learning; however in this instance we propose an approach that sits outside of the traditional classroom. This approach incorporates the utilisation of the *Makerspace* phenomenon to provide opportunities for students to apply their subject knowledge to undertake a design process resulting in the creation of STEM-related artefacts.

Makerspaces are physical spaces that have been designed or set aside to support the maker in the creation, design, and building of new projects and technologies. Smith, Hielscher, Dickel, Soderberg, and Oost (2013) posit that Makerspaces are really about the community and connections that develop whilst the individuals are creating in the space. Anderson (2012) identifies Makerspaces and the Maker Movement as key parts of a third industrial revolution, where the variety of skills (cognitive and relational) gained from collaboration and project completion translate to workforce skills, contribute to the creation of new jobs and industries, and promote innovation. In the landscape of 21st century education, creativity, design, and engineering are making their way to the forefront of educational considerations, as tools such as robotics, 3D printers, and web-based 3D modelling applications become more readily accessible. Makerspaces are increasingly being heralded as a method for engaging learners in creative, higher-order problem solving through hands-on design, construction, and iteration (European Union, 2015).

Makerspace *in STEM* is the deliberate positioning of student learning in contexts that require the drawing together of skills and knowledge from the areas of science, technology, engineering, and mathematics to create, construct, and critique a product or artefact. Makerspaces in STEM use hands-on, creative ways to inspire students to plan, research, build, and create as they participate in projects (Cooper, 2013). Projects or artefacts are usually selected by the participant and are often unique in nature; although within the context of this project, the project was pre-determined. The "maker approach" can cater for a range of learning styles, especially kinaesthetic, as it is a hands-on approach that value-adds more traditional forms of classroom practice. This paper argues that Makerspaces can be more than tinkering if there is a strengthening of the *explicit connections* between the curricula of mathematics, science, and technology and the end product or artefact. Researchers of informal settings and the science of this space (such as Krishnamurthi & Rennie, 2013) identify Makerspace opportunities as informal science programs and define these as being less formal and intentionally different to more traditional approaches (Krishnamurthi & Rennie, 2013). They assert that this type of learning should be student-centred and presented in a way so as to provide choices to the learner, enabling them to explore as their interest prevails (Krishnamurthi & Rennie, 2013).

The Makerspace in STEM (MIS) project was based on two theoretical pedagogical pillars: experiential learning (trial-and-error, learning-by-doing, student-centred), and social constructivism (new knowledge is developed through collaboration, social interactions, and the use of language).

Females in STEM

With pre-service teachers' reluctance to engage with science and mathematics during their teaching degree, and often reporting a lack of confidence in personally doing mathematics and science, there is a need to provide additional opportunities for them to develop skills and positive dispositions in the STEM space (Appleton, 2003; Hackling, Murcia, West, & Anderson, 2014). Although research indicates that pre-service teachers and some primary school teachers lack knowledge in STEM education, there is additional evidence to suggest that girls and women do not engage in STEM activities in the same numbers as their male counterparts (National Research Council, 2012; US Department of Commerce, 2013). For many decades internationally, there have been gender differences in participation/enrolments, achievement and attitudes in STEM-related subjects, which suggests that Australia has an equity issue in education (Parker, Rennie, & Fraser, 1996). In the Bachelor of Education (Primary) at Curtin University over 85% of the students are female (Blackley & Sheffield, 2015), with lecturers anecdotally observing a deficit of skills, knowledge, and confidence in STEM education. These attitudes and under-developed skills can translate into the classroom, resulting in a cycle of poor STEM engagement. This is particularly concerning as there is considerable pressure to better position Australia globally in this field. In order to redress the skills shortage in STEM, it is necessary to stimulate interest in STEM education.

Recently, the Office of the Chief Scientist (2014) and the Australian Mathematical Sciences Institute (Roberts, 2014) noted the very low and declining percentage of females undertaking advanced science and mathematics subjects in Year 12. In 2011, only 28% of STEM-employed Australians were female, with this figure dropping to 14% for engineering students (Professionals Australia, 2014). Similar figures prevail in the US where Nobel Laureate Carol Grinder notes that not only is there a deficit of women entering the STEM pipeline, but also that the pipe is leaky in that women experience many practical, psychological, and social barriers to continuing and advancing in their STEM careers (http://www.news.com.au/finance/work/women-in-stem-industries-time-to-fix-the-pipeline/story-fnkgbb3b-1226873381168). Given both the low levels of females employed in STEM-related careers and the high proportion of female primary pre-service teachers, the focus on supporting and developing female STEM teachers is crucial. The communication and collaboration between female STEM teachers and females employed in STEM-related industries is key to raising the profile of females in this space, create communities, and sharing of expertise.

Introduction

The *Makerspace in STEM (MIS) Project* that is reported on in this paper, describes the engagement of female pre-service teachers (PSTs) and a female engineering student (ES) in a STEM Makerspace project hosted in Year 5 and 6 classrooms at a Catholic all girls' school in Australia. The project is framed by a new model of pre-service teacher learning: the *Reflective Identity Formation Model* (Sheffield & Blackley, 2016).

The project sought to:

- create a dynamic and integrated approach to STEM education through the use of the Makerspace concept*;*
- enable PSTs to authentically engage with students in school settings to increase their work-readiness;
- facilitate cross-faculty collaboration in the Education and Engineering communities by targeting PSTs and ESs; and
- highlight and develop the 21st century learning skills of: collaboration, communication, creativity, and problem solving.

The research questions were:

1. How did pre-service teachers engage with and participate in the MIS project?
2. How did the *Reflective Identity Formation Model* support PSTs' confidence and ability to mentor the schoolgirls in the MIS project?

Method

Research Design

A qualitative research methodology was used to explore the phenomenon of pre-service teachers' developing professional identities as teachers of STEM. An exploratory case study was employed to examine participant engagement with and reflections on a single, re-iterated Makerspace STEM project. As Creswell (2013) describes, a case study is a robust investigation, based on comprehensive data collection, of a bounded system. In this case the bounded system is the process underpinned by the Reflective Identity Formation Model. An exploratory approach is typically used when little is known in a particular area of research and/or the topic is complex (Barker, Pistrang, & Elliot, 2002), both of which apply to the research undertaken in this pilot study. The aim of the case study was *interpretative* – What is the story of the pre-service teachers' involvement in the MIS Project?

Participants

There were two participant groups in this pilot. Group 1 that was comprised of ten volunteers from the Primary Bachelor of Education degree (2nd year, female students, on-campus at Curtin University) and one student from the School of Engineering (2nd year, female, on-campus at Curtin University). Group 2 that was comprised of Year 5 and 6 girls (n = 71) from a Western Australian Independent Catholic girls' school, situated in metropolitan Perth.

Method

There were two key phases in this study: Training workshop (Phase 1) and Implementation (Phase 2). Phase 1, which prepared the PSTs for the Makerspace project, was designed so that female PSTs worked alongside the female engineering student in a two-hour training workshop. This initial workshop was specifically designed to help the PSTs develop their confidence and skills in the STEM aspects of the selected project. The three components of this workshop were:

- creating the product that they would be mentoring the primary school students to complete; tinkering with the base equipment; and exploring modifications that could be made by augmenting the base materials;
- understanding the related STEM concepts, in particular the electric circuit, supported by the ES; and
- designing key questions to scaffold primary school students to apply and reflect on the science and technology knowledge and skills learned in the classroom; and determining the pedagogical practices that would support the students to develop an increased understanding of STEM concepts and what it means to work in the STEM space.

In Phase 2, the PSTs mentored groups of 4 – 6 primary school girls in making the Makerspace product using their knowledge and experience from Phase 1, and the questions they prepared to scaffold and prompt the children. The two phases constitute parts of a new model of professional learning: the *Reflective Identity Formation Model* (Figure 1) that we believe enhanced pre-service teachers' confidence and competence to mentor school children in STEM activities.

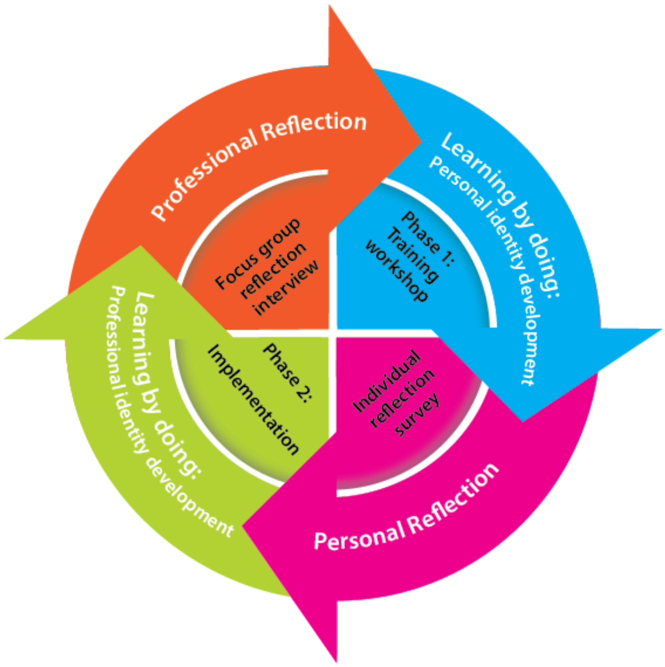

Figure 1: Reflective Identity Formation Model (Sheffield & Blackley, 2016).

Phase 1 of the model focussed upon the PSTs' personal identity as a S*TEM-consumer* as they were expected to learn how the components of the artefact interacted to result in an operational product. Over the course of a two-hour workshop, the PSTs in collaboration with the engineering student engaged with a socio-constructivist approach ("learning by doing") to construct an origami flower and then create a circuit that would allow an LED bulb to illuminate the centre of the flower (Figure 2). The members of the research team facilitated the session by grouping pre-service teachers (PSTs) and the engineering student to enable them to:

(1) Become familiar with the project as it would be presented to the school students;
(2) Identify the science, technology, and engineering concepts and terminology of both the base project and potential extensions;
(3) Develop and record a series of questions that the PSTs would refer to when they are mentoring school students on site to prompt and probe; and
(4) Develop the PSTs' confidence and competence to extend the base project.

Figure 2: STEM Makerspace pilot artefact.

The training workshop was immediately followed up with a reflective survey that provided an opportunity for each participant to consider their strengths and weaknesses in making the artefact as well as how they could mentor the primary school students to construct their individual products, rather than using a didactic, direct instruction approach. The survey data also gave the research team insights for ways in which the training workshops could be improved for future, funded versions of the pilot.

In Phase 2 (Implementation) the participants had the opportunity to develop their professional identity as *teachers* by mentoring the creation of the Makerspace artefact with groups of 4 – 6 primary school children. The "learning by doing" in this phase focussed on the pedagogical approaches used to manage the groups, scaffold and question students, and informally point out the science concepts involved in the artefact. The PSTs were paired up to work with each group of students: one PST took on the mentoring role for the school students, and the other PST observed the session, and annotated a specially designed chart to record the children's ways of working as well as social interactions and elements of the affective domain. The school girls were supported to make the base design product, describe how they managed to complete the product, and were encouraged to use additional available materials to extend their basic product (such as incorporating a switch into the circuit). At the conclusion of the implementation day, a collective debrief and focus group interview were conducted with the PSTs and engineering student for them to reflect on their professional identity. The school students were asked to complete a simple survey at the end of the 90 minute session, and the data summary was emailed to the PSTs the following week so that they could also reflect on the impact they had on the students as an addition to their initial reflection of their professional identity.

Data instruments and collection

Whilst a large and varied data set was collected during the pilot, two sets directly related to the PST participants and the research questions will be presented in this paper. In Phase 1, the PSTs undertook a focus group interview (see Appendix A for the stimulus questions) to reflect on the training workshop (audio recorded). In Phase 2, at the end of the implementation day, the PSTs took part in a second focus group reflection (audio recorded). The questions that were used to garner the group's reflections were:

1. How do you think the session went? Why?
2. What did you notice about how the girls worked?
3. What, if anything, would you do differently next time?
4. What is your level of confidence in mentoring a STEM Makerspace at this point?
5. How could you be supported to feel more confident?
6. Do you think that the use of STEM Makerspaces is effective for engaging girls?

Initial Coding was used to break down the qualitative data obtained from both the survey responses and the focus group interview and to closely interrogate the resultant discrete parts (Saldaña, 2013). As a First Cycle, open-ended approach, Initial Coding was appropriate for this study as it was a pilot and the proposed codes were tentative and provisional (Saldaña, 2013). Further, In Vivo Coding was used to perform this Initial Coding as this verbatim coding refers to words or short phrases from the actual text found in the interview transcripts (Saldaña, 2013). Due to the small participant group (10 PSTs), this coding was done manually by one of the research team and then verified by another team member.

Findings

Phase 1: Learning by Doing – focus group interviews reflecting on the training workshop

(1) *What prompted you to sign up to this project? How did you feel at the beginning of the training session?*

The keys themes that emerged in response to the first question were: wanting to increase personal knowledge of STEM education; wanting additional classroom experience; and pursuing personal interest in STEM education. Three feelings were consistent amongst the participants: excitement, interest/curiosity, and eagerness.

> *It sounded like a great opportunity for me to learn how to engage students during science sessions, something I lacked confidence in my ability to do. At the beginning of the training session I felt excited to learn how to use the provided electronics equipment, as I had not had much opportunity to explore these tools myself before.* (PST 4)

(2) *Was working with the engineering/pre-service teacher students beneficial for you? Please explain.*

All PSTs responded that working with their peers was very beneficial; however, four of them did not value the input of the engineering student.

> *It's always helpful to work with others in the same or different discipline as you because often you'll find yourselves bouncing ideas off each other or even picking up on things that you wouldn't have if it was a solo project. It also prepares us for our careers because if you can build a good rapport with teachers and professionals around you, you have more of an opportunity to find resources and techniques to enhance the learning experiences in the classroom.* (PST 7)

(3) *After completing the training, how confident do you feel mentoring a small group of girls on a school site to complete the base project?*

The participants stated that they were reasonably confident with mentoring the school students to complete the artefact and added that additional practice on their part would increase their confidence level; however there emerged some specific concerns: asking well-constructed, probing questions to prompt the school students, and being nervous in demonstrating their artefact to the school girls.

> *I feel that I am ready to complete the mentoring, with a much expanded knowledge of the nature of electrical circuits than I had previously. I was concerned mainly that I did not possess enough understanding to explain or guide students to the answers they would need and this training eliminated that fear by consolidating my knowledge.* (PST 4)

(4) *How confident do you feel mentoring the extensions?*

The participant responses were evenly spread across *confident – confident with practise – not confident.*

> *I feel quite confident in mentoring the extensions, as completing the circuit myself gave me a good understanding of how it worked and support from the other pre-service teachers helps.* (PST 2)
>
> *With additional practice outside of the allocated training day, I am now feel confident about mentoring the extensions.* (PST 6)
>
> *Not very, only because I have had very minimal experience in schools and teaching.* (PST 9)

(5) *What do you think you might gain from your engagement in the whole project?*

Seven of the PSTs reported that they thought they would gain competence and confidence in teaching STEM, which they would not otherwise have access to within the structure of the degree.

> *I think I will have a greater insight on how to incorporate STEM into the classroom aside from a dedicated science/technology/engineering/maths block. As a teacher it is always a challenge to make links across the curriculum but projects such as this help in that goal.* (PST 2)

Five of the participants also expressed a desire to enhance their pedagogical skills, in particular prompting critical thinking and mentoring students rather than instructing them.

> *I feel the interaction with students in a hands-on activity is also quite different to the 'usual' classroom activities I have experienced and so far taught, therefore experiencing how to coordinate these activities will be a huge advantage for my future approach to teaching science and technology!* (PST 4)

Researchers' Reflection

There was a problem with the origami flower at the training session; it quickly became apparent that the instructions were complex and difficult to follow, which led to a high level of frustration that was not completely resolved by the end of the session. This became a reflective, "teachable moment" for the researchers, and during the lunch break, a robust conversation was had about the imperative of always trying out an experiment or instructions prior to using them with school students. PST 6 researched less complex samples of origami flowers using YouTube and then shared with rest of the group. The researchers perceived that this contributed towards capacity building and reinforced the notion of lifelong learners - the PSTs demonstrated an organic model of facilitated learning. PST 5 reflected:

> *I really enjoy science and I thought it would be a good experience to work with girls in science (two key focus areas for the government at the moment). At the start of the training session I was a little bit overwhelmed as the origami task was much harder than I anticipated, and this discouraged me to the extent that I couldn't make the circuit work. It was good to have a mental break and have lunch because I could process my thinking a bit and go back to the task. I managed to complete the circuit and add a switch which was a great achievement.*

The Facebook site served as a readily-accessible space in which the students could post videos and photos of other origami flowers, and members reported on their trial and error approach to creating a flower that could be used in the project (Figures 3 - 5).

Figure 3: Facebook posting

Figure 4: Facebook posting.

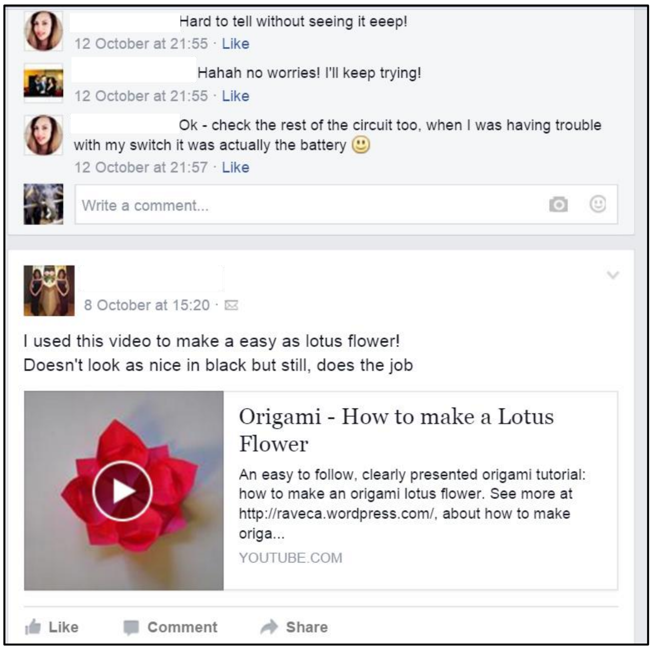

Figure 5: Facebook Posting.

The team continued to move in and out of the virtual Makerspace (the closed Facebook site), helping each other prepare for the implementation of the Makerspace Project in the school context. The Facebook site also allowed the team to establish collaborative partnerships and peer support prior to going to the school site. Not all of the posts were directly related to the origami and the circuit. These posts were indicative of the supportive and collaborative online community that was developing.

Phase 2: Learning by Doing – Implementation at the School Site

During the focus group interview at the end of the school day, the pre-service teachers were asked to reflect on their experiences in the classrooms, and how they were able to engage with the students to successfully facilitate the Makerspace project. The participants were able to articulate several differences between the engagement and performance of the Year 5 and 6 students related to their ability to demonstrate perseverance, resilience, and collaboration. They enjoyed sharing their observations and becoming aware of the school students' behaviour as not being directly related to their teaching, and then to reflect on why the students acted in this way.

The Year 5 students had not yet been exposed to electric circuits in their science curriculum whereas the Year 6 students had covered circuits in Term 2 and had been doing origami in class. This surprised the PSTs, who commented that that the Year 5 girls seemed to know what to do, and that they were also prepared to try different combinations and make "mistakes". The PSTs also commented on the girls' persistence when things did not go right.

> *They knew they had to put all the parts together that they had – so they just experimented to connect all of the parts.* (PST 1)

The PSTs commented that the Year 6 students were more polarised in their engagement: they needed a lot more encouragement and were reluctant to make mistakes or they could name each part and knew how to assemble a working circuit. They also noted that the Year 5 girls were more willing to work collaboratively whilst the Year 6 girls tended to work independently, even if in the first instance they observed what their peers did before trying themselves.

> *There was one student who wasn't getting a concept as quickly as the other girls and I thought she looked afraid to ask her peers for help. So she spent a lot of time hanging back and observing what they were doing and then working it out.* (PST 4)

Researchers' Reflection

In the focus group interview several of the PSTs were very insightful about this opportunity to reflect on their own learning of science and pedagogy.

> *The project really made me adapt to a teaching style I am not used to seeing where the teacher takes a step back from the learning and the students discover it for themselves. Although I read about it a lot in units, I haven't really seen it done in classrooms that much; teachers tend to be so time poor that they end up giving the students the answers. It also gives an opportunity to really engage with science and engineering particularly with girls who are so under-represented in the field(s).* (PST 4)

The professional learning Makerspace project provided a unique opportunity to engage with a different approach to science education for both the school girls and the PSTs.

> *……engaging with the project consolidated the half-formed theories in my mind and made them complete, so in terms of my own learning it was invaluable. I feel the interaction with students in a hands-on activity is also quite different to the 'usual' classroom activities I have experienced and so far taught, therefore experiencing how to coordinate these activities will be a huge advantage for my future approach to teaching science and technology!* (PST 5)

The professional learning Makerspace project contributed to an increase in PSTs' confidence in science and teaching.

> *Practising my confidence, patience and resilience to work through problems by myself. I hope to gain the ability to guide students in their thinking about circuits, as I worked through many of the problems too which will help my questioning abilities during the session. I think this whole project is good in gaining self-confidence through achieving first the creation of the actual flower and circuit and then through being able to teach/guide the students to do the same.* (PST 1)

Discussion

This pilot study was unique in that is placed STEM Makerspace activities both in a higher education setting (School of Education) and in a primary school. Whilst there is a small amount of research available on the impact of Makerspaces within universities (Wong & Partridge, 2016), much of this is in regards to the Makerspaces found in engineering and design schools (Levy et al., 2015; Wilczynski, 2015) and academic libraries (Burke, 2015). In the context of this study, Makerspaces were semi-formalised and used as a pedagogical tool or approach to integrated STEM education.

Limitations of the Pilot Project

The organic nature of this pilot project, with additional methods and analyses of data other than those that had been pre-conceived, as well as the small number of participants (n = 10) are limitations of the study. However, with critical reflection of the research methods used in the pilot and adjustments to procedures, tools, and analytical processes, the ensuing yearlong study will suffer less from these limitations.

PSTs' Engagement and Participation in the MIS Project

Whilst the primary focus of the MIS project was on STEM education, its success can be attributed to an emphasis on the collaboration between the PSTs and the developing agency their experienced over their learning, thereby developing an organic community of practice (Wenger, 1999) that other researchers have also deemed to be a priority of Makerspaces (eg Kurti, Kurti, & Fleming, 2014; Martinez & Stager, 2013; Vossoughi & Bevan, 2014).

All of the PSTs in the study reported that they found the project to be valuable and enjoyed participating, despite the challenges they faced. The "value" of the project was described as: more teaching experience, learning on the job, being involved in research, developing new skills, and collaborating with their peers and the staff at the host school. The opportunity to engage with the STEM Makerspace allowed the PSTs to construct new knowledge as they built, evaluated and publicly shared their artefacts (Blikstein, 2013). The PSTs did initially indicate that they had concerns about the activity and were worried that the girls would ask questions that they could not answer. They had expressed a range of concerns: some were anxious about their lack of science content knowledge and skills, whilst others were worrying about the pedagogical issues of working with the Year 5 and 6 girls. Perhaps this was exacerbated by the researchers' insistence that the PSTs do not instruct or show the school girls how to make the circuit or the flower, rather they present the finished product (the one they had made at the training workshop or an improved version they had made at home) and then ask the girls if they could make something similar with the materials provided in the bag. The reasoning for this was to ensure that the Makerspace ideologies were upheld.

The PSTs were encouraged to use the questions they had formulated during the training session, and were supported to pose other prompting and probing questions on the day by the research team. They were able to implement the questions and teaching practices compatible with the project and Makerspace viewpoints. This resulted in the school students engaging in the task, problem solving, creating and formulating ideas whilst being supported by the PSTs in their role as mentors. The PSTs experienced professional learning while participating in this authentic integrated STEM Makerspace activity in a school environment, supported by the female researchers.

Reflective Identity Formation Model

The model was created to frame the project with the goal of scaffolding the PSTs to develop their personal identity and professional identity as a STEM educator by collaboration and reflection. It used an activity-based, learning-by-doing approach that the PSTs reported as an effective way to improve their STEM knowledge and skills. The model also incorporated a series of reflections to encourage PSTs to consider how the activities have improved their STEM and pedagogical skills and knowledge, how their prior beliefs or experiences have been challenged, and how they would modify their actions in the future. A challenge for the researchers was to capture the PSTs' experiences and reflections in a timely manner, particularly after the implementation at the school site. Despite fatigue, both after the training workshop and the school implementation, the PSTs' enthusiasm to reflect, recount and be heard was undiminished. The model allowed the PSTs, and the researchers, time to develop personal skills and reflect upon these before implementing the activity in the school setting whereby they would need to embrace their professional, teacher identities. As such this trial of the model has indicated that it could readily and effectively be used for an extended MIS project that would incorporate three different Makerspace activities.

It was interesting to track the Facebook site activity over the course of the project; it appears that the PSTs naturally adapted their personal Facebook practices to this professional experience, tempering their language, choice of photos, and emoticons. The spontaneity and speed of posts and comments affirmed their developing thoughts and allayed their fears, possibly in a way that would not have been possible otherwise. The research team, although reading the posts, had minimal interactions with the group via the site; the intention was that it would be the students' space and managed by a self-delegated peer.

Extension

This study was a pilot to develop the model and to investigate how the PSTs could engage in STEM Makerspace projects and how their professional identity as teachers could be developed. The small size of this project is an acknowledged limitation; data from a larger participant group may prove contrary to the reported findings. The Reflective Identity Formation Model continued to be validated in 2016 in a Curtin University-funded project that, over the course of the school year, saw three iterations of the cycle, focussed upon three different STEM Makerspace projects. Participants from 2015 were invited to participate again, and also to mentor new PST participants in the year-long project. The positioning of pre-service teachers as mentors is also significant as they tend to face the same attitudinal hurdles as the classroom teachers, and this approach enables them to develop their confidence and competence in STEM education. This mentoring was a new dimension to the initial study, and was observed with interest. Increased numbers of female engineering students were recruited with the assistance of one of the research team who is the Director of Engineering Education Development, and the use of a closed Facebook site constituted a *virtual* Makerspace used by the entire team, in tandem with a physical Makerspace that resided in the Engineering Pavilion. Forty-five higher education students (PSTs and engineering students) registered to participate in the 2016 project.

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Appendix A

1. What prompted you to sign up to this project? How did you feel at the beginning of the training session?
2. Was working with the engineering/ pre-service teacher students beneficial for you? Please explain your answer
3. After completing the training, how confident do you feel mentoring a small group of girls on a school site to complete the base project?
4. How confident do you feel mentoring the extensions?
5. What do you think you might gain from your engagement in the whole project?