Building Primary Pre-Service Teachers' Confidence and Competence to Teach Science: The Influence of Planning, Teaching and Reflecting on an Integrated Science Unit

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ABSTRACT

This study examined the influence of an integrated science unit, known as the Multidisciplinary Science and Technology Integrated Experience (MSTIE), on third year primary pre-service teachers' confidence and competence in teaching science. Working in pairs, pre-service teachers planned an integrated unit of work consisting of 12 -15 lessons with collaboration from their mentor teacher. The unit is then team taught during their three-week practicum. The topics for the unit were selected based on an integrated theme from physical, chemical, biological, or earth and beyond strands of science based on the needs of the school. The university-based academic program provided a frame for their planning and preparation of the science integrated unit of work, based on the Australian Curriculum, with a constructivist framework. Following the practicum, the pre-service teachers critically reflect on the experience as part of a summative presentation. A mixed method research approach was utilised, and indicated that the MSTIE program was a unique experience that strongly influenced pre-service teachers' confidence, competence, and skills in teamwork to teach science at primary level. We discuss implications for pre-service undergraduate teaching programs including professional experience models, strengthening pedagogical beliefs (in terms of teaching science and the integrated approach of teaching and learning science) and enacting effective classroom science teaching.

INTRODUCTION: CHANGING SCIENCE EDUCATION

It is our contention that primary school students need a strong foundation of science, and that science education and teaching and learning science in primary schools should have a strong integrated focus rather than learning isolated facts from texts. However, it has been apparent for some time that elementary science and its' teaching and learning in many countries has not been given adequate attention in the school curriculum (NRC, 2006.)

This chapter addresses the critical question in teacher preparation of how to increase the competence and confidence of pre-service teachers in teaching and learning science. There needs to be a deliberate effort, starting with undergraduate pre-service teacher education, to promote the relevance and utility of science outside the classroom and in daily life (Linn & His, 2000.) Internationally, research has shown that the majority of generalist primary teachers lack the confidence and ability to teach science (Murphy, Neil & Beggs, 2007; Hackling and Prain, 2005.) The main issues emerging from the science education literature are that pre-service primary teachers have minimal experience in science teaching while on professional experience and have negligible science content knowledge, leading to many primary teachers avoiding the teaching of science content (Angus, Olney & Ainley, 2007.)

21st century science education requires coherence, integration, inquiry, and logical sequencing so that what is learned can be used and applied in further learning. If good quality teachers with up to date knowledge and skills are the foundation of any system of formal science education (Osborne & Dillon, 2008), universities need to focus on the preparation of quality primary teachers who are confident and effective teachers of science.

One problem is that science content and pedagogy are increasingly failing to engage young people (NRC, 2006), and so innovative curricula and ways of organising the teaching of science are required. Yet, many innovative teaching approaches lack classroom impact because teachers may consider these proposals to be impractical due to the need for effortful planning and resourcing. Science teacher preparation in primary science should be based on intensive and sustained training around concrete tasks that is focused on subject matter knowledge connected to specific standards of student performance and embedded in a systemic context. It should be linked with inquiry based teaching practice and investigate classroom culture (Supovitz & Turner, 2000.)

Particular issues, usually characterised as *confidence* and *competence*, have arisen in relation to the pre-service teacher education of teachers of Science, Technology and Mathematics. Confidence refers to positive feelings based on self-awareness of knowledge of skills required to achieve curriculum requirements (Harlen, Holroyd, and Byrne 1995, Bleicher 2007.) There are many sources of low confidence including poor or minimal training, lack of knowledge or skills about particular curriculum components, awareness of difficulties in teaching certain content or low expectations about resources (Harlen, Holroyd, and Byrne 1995.) The second issue is competence, or understanding of discipline content and related pedagogical strategies, tools, resources and approaches (Davis and Smithey 2009.) Low levels of confidence or competence are associated with anxiety about the teaching of science (Ramey-Gassert and Shroyer 1992.) While the relationship between competence and confidence is complex, they both require attention during pre-service preparation. One means of addressing these issues that has received significant attention is deliberate application of science methods during practicum (Jung and Tonso 2006.)

DESIGNING EFFECTIVE PRACTICUM EXPERIENCES

Several strategies have been suggested to improve science-based practicum including inquiry approaches, co-teaching with experienced science educators, team-teaching, and integration of science content and pedagogy through university and school partnerships (Jung and Tonso 2006.) In particular, reflection in a teaching and re-teaching cycle is of critical importance (Eick, Ware, and Williams 2003, Davis and Smithey 2009.)

School-based practicum provides an opportunity for lessons and teaching strategies to be designed and enacted by a team of practicing and pre-service teachers to enhance the adoption of innovative teaching approaches. This is likely to impact on student motivation and understanding (Janssen, Westbroek & van Driel, 2014.) This is consistent with recent approaches to practicum in teacher preparation that emphasise collaborative models of learning (Groundwater-Smith, Ewing, and Le Cornu 2007, Grudnoff 2011.)

Collaborative approaches between pre-service teachers and mentors, combined with an intentional integration of knowledge about teaching and learning provides an effective means of assembling and understanding ideas about teaching and learning at university, and then applying these in school-based practice (Calderhead and Shorrock 1997.)

The design of practicum experiences is important, and there are calls to ensure that what is learnt on practicum is integrated with university-based learning (Eames and Coll 2010.) This is a complex process, another argument for thoughtful design that allows for individual development of teacher knowledge (Putnam & Borko, 2000.) The design has to afford making sense of challenges and new experiences that emerge during practicum by drawing upon different theoretical perspectives (Korthagen et al., 2006.) One way of achieving this is a team-teaching approach, working collaboratively with peers, rather than seeing classroom-based learning as an isolated and intensely personal experience (Korthagen et al., 2006.)

Making sense of the practicum experience involves integrating the diverse ideas that emerge from prior experience, teacher educators, mentors and other teachers and peers. The way a small community, made up of teachers, pre-service teachers, and academics, interacts and make sense of the experience will shape the resulting curriculum design and delivery process (Gunckel 2013.) Science learning experiences that are positive, meaningful and engaging are more likely to lead to increased sense of personal teaching efficacy (Hechter 2010.)

Team-based teaching and inquiry can make a significant contribution to teacher practical knowledge. This involves making assumed and implicit knowledge about teaching and learning visible, both through deliberate pedagogical design and implementation, and collaborative conversations. During practicum, these processes allow the sharing of perspectives and experiences of teaching and learning between peers and mentors (Hargreaves 1996.)

Reflective inquiry is likely to introduce wider perspectives to the process of making sense of the classroom experience (Fielding 2004, Richardson 1994.) The blend of perspectives encourages thinking deeply about practice, potentially lead to ongoing refinement (Cochran-Smith and Lytle 1999.) Team-based placement is more likely to encourage informal and formal reflective discussion. This is consistent with Cochran-Smith and Lytle's (1999) observation that knowledge of practice is constructed in the context of teacher action.

It is also important that pre-service teachers use content knowledge and understanding to formulate Pedagogical Content Knowledge (PCK) for theory to practice in classroom (Koh, Chai & Tsai, 2013.) Most teachers at primary school believe science teaching is predominantly didactic or discovery oriented. It is essential to change this understanding of science teaching to acquire targeted PCK and elements of a conceptual-change orientation. Teacher preparation needs to clearly focus to address both substantive and PCK as well as appropriate inquiry-oriented teaching beliefs about teaching science (Smith & Neale, 1989.)

The design of university and school-based learning experiences should also consider how collaborative critical reflection can be a primary element of teacher inquiry. Loughran (2002) makes the point that the framing and reframing of a 'problem' is a "crucial" part of knowing about teaching. Reflecting on experience has the potential to change or clarify understanding (Boud, Keogh, and Walker 1985.) Kemmis (1985) takes this further by claiming that reflection can influence the process of practice-based decision making and action. Pre-service teacher interactions and collaborations with practicing teachers are likely to provide insight into one's own and others' experiences and perspectives. Further, this process provides impetus for more engaged and collaborative approaches to teaching and learning (Cook-Sather, 2014.) The teacher mentor plays a key role by leading the team to a professional vantage point, scaffolding aspects of the epistemic frame of professional development. The mentor affords the team to develop a professional, practice-based, learning orientation (Nash & Shaffer, 2013.)

In sum, effective pre-service preparation can be afforded by a collaborative teacher inquiry process as the means to generate teacher practical knowledge in science education. Working collaboratively with peers and the teacher mentor in a process of integrated science teaching involves a mindful awareness of current experience, opportunities and problems, and the reflective element makes “conscious and explicit the dynamic interplay between thinking and action” (Leitch and Day 2000, 181.) The reflective processes of sharing understandings about the teaching of science, integrating multiple perspectives and raising doubts and uncertainties about possible solutions, are the base elements of collaborative teacher inquiry leading to increased teacher confidence and competence (Grangeat and Gray 2008, Yost, Sentner, and Forlenza-Bailey 2000.)

THE MSTIE PROGRAM

As part of our ongoing work in teacher education, we recognized that assessment in our science teacher preparation courses needed to aim at promoting higher-level thinking and developing greater independent learning. Indeed, we identified a range of needs, including building confidence and competence in science teaching and learning. In an attempt to achieve these multiple complex aims we modified the assessment by developing the MSTIE (Multi-disciplinary Science & Technology Integrated Experience) Project. These changes recognized that science education does not occur in isolation; it is best learned when integrated with other subject areas and in the context of the classroom.

Over the past eight years we have developed MSTIE into a unique capstone experience that has an emphasis on collaborative and problem-based learning. The MSTIE Program is a compulsory second semester experience for third year primary pre-service teachers of the Bachelor of Education degree at La Trobe University, Bendigo. Simultaneously, the pre-service teachers study and experience how Science can be integrated into school settings to provide real-world challenges and creative problem-solving with science. In addition, what the pre-service teachers learn in their core subjects is immediately applied in practice via their MSTIE unit.

In this program pre-service teachers work in teams of two to cooperatively plan, teach and reflect on an integrated unit of work as a part of their semester two core subjects (*Integrated Science Learning* and *Design and Technology*) and their three-week practicum in a primary school. MSTIE makes fundamental links between lectures, practicals/ tutorials and teaching science in primary schools. During the practicum component of the MSTIE Program, students have a chance to become further adjusted to the primary classroom, to practice teaching skills within the context of science and, in many cases, to design and teach their first integrated unit using a constructivist approach of teaching and learning. This program is aimed to provide pre-service teachers with confidence, competence and skills to plan, team teach, and reflect on an integrated science and technology unit.

In consultation with their mentor teacher, pre-service teachers are required to plan the integrated unit of work while incorporating multiple domains from strands of the Victorian Essential Learning Standards (VELS).

The MSTIE Project is built into the assessment of the two core subjects and counts for 70% of the assessment in *Integrated Science Learning* and 40% of the assessment in *Design and Technology.* This provides pre-service teachers with the experience of incorporating curriculum documents, integrating, and working as a team with a mentor to implement it in the classroom. For consistency in planning, the pre-service teachers are provided with a unit planning template that provides a clear format and structure for planning and preparing the unit documentation. The pre-service teachers are assessed as a team and their final MSTIE score is based on their MSTIE Unit Documentation including reflections (62.5%), Practicum Performance (12.5%) and a Forum Presentation (25%).

The Unit is planned using the 5E instructional model consistent with a constructivist approach (Bybee, 1997.) The core teaching and learning elements covered at each stage of the 5E instructional model are to engage, explore, explain, elaborate and evaluate. In order to clearly demonstrate this model, Table 1 is an example of a MSTIE project, outlined in relation to these stages. This example was generated by two pre-service teachers engaged in the authentic approach which includes four essential assessment elements: team planning and preparation of an integrated unit of work; assessment and reflection on children's learning, the unit and their teaching; effective classroom teaching and professional conduct; and a post-practicum forum presentation. This assessment enhances pre-service teachers' independent learning and through a real world context provides multiple levels of on-going feedback. This feedback includes the teacher mentor and university staff feedback during the writing of the unit and on practicum, participating primary student feedback during the practicum, feedback from peers during forum presentations, and feedback from the assessment of the MSTIE project documentation.

(See Table 01 on the following page.)

Table 1. Outline of an illustrative MSTIE unit of work (as a one-page unit at a glance)

5E stage	Lesson	At a glance
Engage: sets the context, raises questions and elicits students' existing beliefs.	1	Students will identify what they think they know about plant parts, plant growth and life cycles of flowering plants; as well as animals and the different types and their life cycle.
	2	Students will investigate the different eco-systems that both animals and plants live in. Elicit students' questions about plants and animals.
	3	Students create a plant trail to generate an understanding for the relationships between different plants.
Explore: investigation work where students gain first-hand (and, where possible, concrete) experience of the phenomenon of interest.	4	Provide hands-on shared experiences of the internal parts of a flower and their role in pollination.
	5	Provide students the opportunity to explore their understandings of the environment that plants need to grow.
Explain: draws on students' beliefs from the Engage phase, concepts introduced by the teacher or from text reading. These are used to construct explanations for the experiences of the Explore phase.	6	Students to represent and explain their understandings of the different sections of a flower. Introduce students to the 'Living Things' word wall (This will be ongoing for the remainder of the unit).
	7	Provide hands-on, shared experiences of the features, behaviors, habitats and life cycles of a range of animals. Students will explore local eco-system and work in small groups to create a food web.
	8	Introduce current scientific views and support students to represent and explain their understandings of seed germination, plant growth and plant life cycles.
	9	Introduce students to design briefs – students to design a hot house.
Elaborate: more experiences of the phenomenon, this time in a different context, so that the phase can involve students applying conceptions to new contexts.	10	Students use the design process to design, create and build their own 'hot house' to grow a mung bean. Students begin construction using recycled materials from their home.
Evaluate: an opportunity for students and the teacher to assess developed conceptions and compare them to their beliefs at the Engage phase.	11	Students to complete a number of assessment tasks, including presentation of hot house, design process, and research questions.
	12	Student comments on peer presentations, and final reflection discussion.

Table 1 demonstrates how the MSTIE program involves collaboration between university Science education and Design and Technology education subjects and has provided opportunities to link integrated teaching/learning in the core subjects with the practicum experience. MSTIE provides a validating and authentic teaching/learning experience for pre-service teachers, university lecturers, teacher mentors and primary school students involved in the program. Pre-service teachers, in their team of two, critically reflect on, and assess the success of their MSTIE teaching in school settings, and subsequently present these findings to their university peers. Through forum presentations the cohort discover what works, why it works, and what needs rethinking. The primary school students provide authentic feedback through the completion and record keeping/journaling of their own learning experiences, which demonstrate the connections between universities led theory-to-practice teaching, and real-world practical outcomes.

In summary, the Key Elements of the MSTIE program are:

1. The use of the 5E instructional model as a framework for planning and teaching
2. Pre-practicum visits (six half-days) to understand the school context in which they are planning and teaching their unit
3. Scaffolding the Unit planning process with appropriate documentation
4. Planning, teaching, and reflecting in teams of two
5. Linking the planning to the curriculum
6. Integrating Science with Design and Technology and other parts of the curriculum.

METHODOLOGY

We examined the influence of the MSTIE program on third year primary pre-service teachers' confidence and competence in teaching science at primary school. This mixed method study was composed of a survey involving 139 pre-service teachers who participated in the MSTIE project over two consecutive years (67 in 2012 and 72 in 2013.) The three major research questions being answered in this study were:

1. How do pre-service teachers rate the relative effectiveness of the various components of the MSTIE program?
2. What do pre-service teachers perceive to be the personal outcomes of participating in the MSTIE program?
3. How does the MSTIE program contribute to pre-service teacher's confidence and competence to teach science in primary schools?

This aimed to achieve a representative sample of MSTIE pre-service teachers (Teddlie & Yu, 2007) and followed the guidelines for mixed method sampling (Kemper et al., 2003.) The percentage response rates in the two years (2012 and 2013) of sampling were 75.3% and 84.7%, respectively. The survey involved a mixture of qualitative and quantitative questions to explore the research questions with both Likert scale and open-ended responses. These data were analysed using quantitative and qualitative methodologies. All attempts were made to legitimate the use of multiple approaches in answering research questions as research methods and instruments provided a roadmap to arrive at conclusions (Johnson & Onwuegbuzie, 2004.)

RESULTS

The results are presented under sub-headings related to the three research questions.

1. How do pre-service teachers rate the relative effectiveness of the various components of the MSTIE program?

The first survey question asked the pre-service teachers to indicate whether they agreed or disagreed with a set of ten statements regarding the general aspects of the MSTIE program using a five-point Likert scale ranging from *Strongly Disagree* to *Strongly Agree*. These ten statements were developed from the key aspects of the MSTIE program, vis-à-vis, the pre-practicum visits, teamwork, documentation, integration, the 5E model, and linking to curriculum. The average Likert responses and the percentage of Strongly Agree and Agree responses for the ten statements are presented in Table 2.

Table 2. Pre-service Teachers' average Likert responses to the General Components of MSTIE (1=SD, 2=D, 3=N, 4=A, 5=SA)

Rank	General Components of MSTIE	Av. Score	% SA & A
1	Pre-practicum visits gave me a good understanding of the school context	4.63	96.40
2	Pre-practicum visits improved my confidence in planning & teaching science	4.63	94.24
3	Working as a team improved my competence to teach science	4.42	88.49
4	The 5E model was an effective framework to think about teaching and learning	4.40	94.24
5	The 5E model was effective to identify student conceptual growth	4.40	93.53
6	Integrating with other disciplines provided authentic situations to learn science	4.36	93.53
7	Integrating with other disciplines made my science teaching more effective	4.35	93.53
8	The 5E model was an effective planning tool	4.34	91.37
9	Working as a team improved my confidence to teach science	4.34	86.33
10	The scaffolding documentation provided clarity about the MSTIE program	4.32	96.40

Overall, from Table 2, it is of interest to note the very high average responses to the effectiveness of all of the general components of the MSTIE program. These average Likert responses ranged from 4.32 to 4.63 with the lowest percentage of *Strongly Agree* and *Agree* responses being 86.33%. These very high positive responses indicate that all the components of the MSTIE program are very effective. Based on the average Likert scores, the component of pre-practicum visits was rated the highest and the documentation was rated the lowest. In Table 2, the ranking of the percentage of *Strongly Agree* and *Agree* responses varies from the rank order of the average Likert scores mainly due to the relative proportion of the *Strongly Agree* and *Agree* responses. The statistic of the percentage of *Strongly Agree* and *Agree* responses is a less reliable ranking value because of the varying proportions of *Strongly Agree* and *Agree* responses. For example, the highest ranked and lowest ranked components in Table 2 had the same percentage of *Strongly Agree* and *Agree* responses (at 96.40%), whereas their respective percentages of *Strongly Agree* were 69% and 37%. This highlights that the average Likert response provides a better ranking statistic as it weights all the possible responses from *Strongly Disagree* to *Strongly Agree*. This same issue occurs in Table 3 and Table 4, but will not be discussed in those sections.

The following quote from a 2013 pre-service teacher highlights the importance of the prior visits which is ranked first in Table 2:

> "I enjoyed MSTIE. I especially liked visiting the school prior to starting and being organised early. The fact that we got to integrate numerous domains / dimensions was fun and a great experience" (Q1.13)

The following quote comments on many general components of the MSTIE program and backs up the overall high rankings of all components:

> "Amazing experience! Lots of hard work and stressful times but well worth it for the experience and results. Whatever we had heard about MSTIE beforehand didn't do it justice! MSTIE is great for many reason: teamwork, experience, inquiry documentation … etc." (Q2.13)

This is consistent with the identified need to ensure coherence between university and school-based learning experiences (Billett 2009, Gallimore et al. 2009.) The usefulness of the 5E model, and its constructivist approach, were both noted by students as providing scaffolding and focus for the project (Putnam and Borko 2000.) The collaborative design of the experience was also perceived to contribute to its effectiveness (Korthagen 2010.)

2. What do pre-service teachers perceive to be the personal outcomes from participating in the MSTIE program?

The second survey question asked the pre-service teachers to indicate whether they agreed or disagreed with a set of ten statements regarding their personal outcomes from the

MSTIE program using a five-point Likert scale ranging from *Strongly Disagree* to *Strongly Agree*. As per the first survey question, these ten statements were developed from the key aspects of the MSTIE program. The average Likert responses and the percentage of Strongly Agree and Agree responses for these ten statements are presented in Table 3.

Table 3. Pre-service Teachers' average Likert responses regarding Personal Outcomes from MSTIE (1=SD, 2=D, 3=N, 4=A, 5=SA)

Rank	Personal Outcomes from MSTIE: Following MSTIE I …	Av. Score	% SA & A
1	Can now provide rich learning in science with hands-on activities	4.61	98.56
2	Have improved my ability to work in a team	4.54	94.96
3	Have a high level of ownership over my MSTIE unit	4.53	94.20
4	Have improved my confidence in teaching science	4.52	94.96
5	Have improved my competence in teaching science	4.52	95.68
6	Can now plan an integrated science unit based on any curriculum	4.51	97.12
7	Can plan science lessons based on the learner's needs	4.44	95.68
8	Can now use an inquiry based framework for teaching science (5E model)	4.43	96.40
9	Can connect science to the daily life and context of students	4.40	96.40
10	Can plan science lessons based on school resources and curriculum needs	4.40	94.96

As discussed previously regarding the general components of MSTIE, it is also noteworthy that, in Table 3, there are very high average responses to the pre-service teachers' perceptions of all of the personal outcomes of the MSTIE program. These average Likert responses ranged from 4.40 to 4.61 with the lowest percentage of *Strongly Agree* and *Agree* responses being 94.20%. These very high positive responses indicate that almost all the pre-service teachers achieved all ten of these personal outcomes from the MSTIE program. Based on the average Likert scores, the outcome of *providing rich learning in science with hands-on activities* was rated the highest and the two that were rated the lowest of *connecting science to the daily life and context of students*, and *planning science lessons based on school resources and curriculum needs* (although still very high ratings) are outcomes that perhaps require experience more than other outcomes.

The following quotes from a 2012 and a 2013 pre-service teacher highlights the breadth of outcomes that are achieved through the MSTIE program:

> "Loved MSTIE! Taught me so much about planning units, assessment, working as a team and boosting my confidence in teaching and planning so much loved it all!" (Q1. 12)

"Opportunity to teach and work together was fantastic. Saw the value of 5E when we implemented [it] …" (Q3.13)

The broad outcomes achieved through the MSTIE program appear to emanate from the key aspects of the MSTIE program, vis-à-vis, the pre-practicum visits, teamwork, documentation, integration, the 5E model, and linking to curriculum.

The MSTIE project had a significant impact on student perceptions of their learning in Science education. This is consistent with the literature on effective tasks design in teacher education, emphasising the crossing of boundaries between university and school-based learning through a collaboration between peers and school mentors to apply a theoretically derived framework (Groundwater-Smith, Ewing, and Le Cornu 2007, Grudnoff 2011.) The main impact of MSTIE appears to be an increase in personal science teaching efficacy using inquiry approaches (Hechter 2010, Jung and Tonso 2006.)

3. How does the MSTIE program contribute to pre-service teacher's confidence and competence to teach science in primary schools?

The third and fourth survey questions asked the pre-service teachers to rate, on a five-point scale ranging from *Very Low* to *Very High*, each of the aspects of the MSTIE program in terms of how they contributed to their **confidence** and **competence** in teaching science. These key aspects of the MSTIE program are: the pre-practicum visits, teamwork, documentation, integration, the 5E model, and linking to curriculum. The average Likert responses and the percentage of *High* and *Very High* responses for the six aspects are presented in Table 4.

Table 4. Pre-service Teachers' Ratings of the Contribution of each Aspect of the MSTIE Program to their Confidence and Competence to Teach Science (1=VL, 2=L, 3=M, 4=H, 5=VH)

Aspects of the MSTIE program	Contribution to Confidence (Av. Score)	% VH & H	Contribution to Competence (Av. Score)	% VH & H
Pre-practicum visits	4.54	92.81	4.49	92.81
Teamwork	4.47	91.37	4.46	91.37
Documentation	4.31	92.09	4.37	92.09
Integration	4.27	90.65	4.40	94.96
5E Model	4.20	89.21	4.29	89.93
Linking to curriculum	4.17	86.33	4.26	90.65

Table 4 covers the questions regarding confidence and competence together because the responses were so similar in rank order, the aspects have been sorted on average Likert responses to the confidence score and it is of interest to note that the order is identical except in the ranking of competence values for documentation and integration.

These average Likert responses ranged from 4.17 to 4.54 for confidence and from 4.26 to 4.49 for competence with the lowest percentage of *Very High* and *High* responses being 86.33% for confidence and 89.93% for competence. These very high positive responses indicate again that all the aspects of the MSTIE program are very effective for building confidence and competence for pre-service teachers to teach science. Based on the average Likert scores, the highest two rated components for both confidence and competence were pre-practicum visits and teamwork and this finding triangulates the same finding from Table 2. The particular finding that pre-practicum visits was the most highly rated aspect, both as a component (Table 2) and in building pre-service teacher confidence and competence in teaching science (Table 4), was a surprising finding among the university lecturers and practicum administrators and highlights the benefits of the proactive nature of pre-practicum visits to create a ready-to-deliver unit prior to commencement of practicum. Pre-practicum visits appear to provide a win-win situation for the school, mentor teachers, and for the pre-service teachers.

The following three quotes from 2012 pre-service teachers provide an insight into the confidence and competence that is developed through the MSTIE program:

> "Fantastic experience. Related highly to my future teaching and having the documentation when applying for jobs" (Q2.12)
>
> "I loved this program. It is really set me up for success in my future teaching in science and beyond" (Q3.12)
>
> "MSTIE was excellent; it provided great experience in planning and implementing a science unit. We now have a solid unit of work in which we can use as evidence of our planning" (Q4.12)

The confidence and competence expressed in the above quotes highlight that through the MSTIE experience the pre-service teachers are now ready to face the real world of teaching science in the primary classroom. This goes directly to the main concerns expressed at the commencement of this chapter regarding the need for revisions and innovations in the preparation of primary science teachers. The complementary aspects of confidence and competence have been positively impacted by the MSTIE program.

CONCLUSIONS

The MSTIE program is a complex and challenging task, designed on the principles of inquiry, collaboration, reflection and authentic classroom contextual enactment. A program such as this requires an investment from university and school-based educators, and also from pre-service teachers. A capstone experience such as MSTIE provides a positive and influential learning experience for science education, although the design principles are universal in application.

This chapter has presented a study that has examined the influence of the MSTIE program on third year primary pre-service teachers' confidence and competence in teaching science at primary school.

This study has found that the pre-service teachers reported an increase in confidence and competence to teach science following participation in the MSTIE program, and that this could be attributed to:

- the proactive nature of the pre-planning process;
- effective team-teaching supporting an authentic classroom environment; and
- the provision of scaffolding and modelling in the university subjects that link to MSTIE.

It is recommended that the key aspects used in the MSTIE program (pre-practicum visits, teamwork, documentation, integration, the 5E model, and linking to curriculum) are valuable components for university science education programs to consider for building confident and competent future science teachers. The essence of the efficacy and success of the MSTIE program lies in linking practicum-based and university-based science teaching experiences in an integrated way using an effective instructional model in a team-based environment.

Five explicit implications for the design of effective science education in teacher preparation have emerged in this chapter; these include:

1. Pre-practicum visits to ensure pre-service teachers commence practicum with a fully planned unit appropriate for their students and school.
2. Team-based experiences that go beyond simple co-teaching to include making meaning and building knowledge through a team-based construction of knowledge.
3. Provision of scaffolding using documentation that is structured using sound pedagogical principles such as the 5E instructional model.
4. Applying a complex model of integration covering: science with other disciplines; university and school-based learning; and connecting science to the real world.
5. Requiring students to link their project to relevant curriculum requirements.

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