Enhancing pre-service primary teachers' learning in Science education using team-based project work

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This paper reports on the introduction of team-based project work in the Faculty of Education at the University of Southern Queensland (USQ), Australia. Many pre-service primary teachers at USQ lack the basic science content knowledge and self-confidence sufficient to teach science content effectively. This has prompted the Faculty of Education to investigate ways to improve student outcomes in both science content knowledge and science teaching self-efficacy in a compulsory science education course delivered in both face-to-face and virtual modes. A collaborative curriculum project designed to model the practice of effective teacher learning communities was chosen as a pedagogical strategy because team-based project work has been shown in the literature to increase long-term retention, critical thinking and teamwork skills. The team-based model chosen for implementation included advice about team management and a peer evaluation process. A survey consisting of validated measures of personal science teaching efficacy beliefs (PSTEB) and perceptions of learning was administered to 70 on-campus (ONC) and 42 online (WEB) students enrolled in a third year science curriculum and pedagogy course. Statistical analysis of the data revealed significant increases in personal science teaching self-efficacy for both ONC and WEB students as a result of the team-based learning experience. In addition, both ONC and WEB students rated their experiences of the team-based model more highly than their previous experiences of team work. Interestingly, there were no significant differences between ONC and WEB students' responses to the survey, validating the efficacy of the team-based learning in both face-to-face and virtual contexts.

Keywords: pre-service primary science education, science teaching self-efficacy, face-to-face and virtual teamwork

Background – context of the study

Pre-service science educators face several challenges in delivering science education courses in the current Australian climate. For the first time in Australia, the federal government has engaged in the preparation of a National School Curriculum from the early years (K) to year 12. The first stage is to be implemented in 2011, and includes Science as one of four compulsory subjects to be taught in all primary and lower secondary classes. This new initiative requires all pre-service primary and lower secondary teachers to be equipped to teach the mandated science competently and effectively.

Applicants for primary teaching degrees in many Australian universities do not require students to have completed Year 12 science or advanced mathematics subjects. This is a problem for primary science educators. At this university, a majority of the pre-service

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primary teachers have not completed any school science subject at year 12 standard. The minority that have studied a year 12 science subject have chosen Biological science or an Integrated science and only a small number have completed a Year 12 Physical Science subject such as Chemistry or Physics[1]. Consequently, many of our aspiring primary teachers appear to have no interest in or understanding of basic science concepts. Unfortunately, this is also reflected in many of our primary schools where science occupies a small percentage of the teaching program, and if it is taught, it is presented with a biological or environmental science perspective only (Masters, 2009). Many schools do not have a dedicated curriculum plan for teaching science and it is often left to the discretion of the teacher to include some aspect of science in their teaching program.

Thus primary science educators at this university face the challenging task of equipping pre-service primary teachers with an understanding of fundamental science concepts, enthusing them about science teaching and building their confidence in their capacity to teach science to primary aged children. With the introduction of a fully on-line mode for all education courses at USQ, science educators are exploring ways delivering the advantages of ONC delivery to students in a virtual environment. Existing science education courses involve individual study and assessment and WEB students work in virtual isolation with little opportunity to experience the benefits of synchronous interaction and collaboration with their peers and staff. Team-based learning, when supported with a range of synchronous and asynchronous communication has the potential to afford all students equal access to a collaborative learning environment. This study investigates the impact of team-based learning on pre-service teachers' science education outcomes and seeks to identify any differences between ONC and WEB students.

Enhancing pre-service primary teachers' science education outcomes

A prime indicator of success of a science education course is enhanced science teaching self-efficacy of pre-service teachers. Self-efficacy is defined as an individual's belief in their capability to successfully execute a course of action in a difficult or challenging situation (Bandura, 1977). Teachers displaying a high self-efficacy for teaching are learner-focused and believe they can help students; in contrast, teachers with a low teaching self-efficacy use authoritarian approach and spend less time on subjects they find difficult, such as science (Enochs & Riggs, 1990).

Increases in teachers' science teaching efficacy have been achieved in courses that integrate both science content and teaching methodology and are delivered using a constructivist pedagogy involving a range of experiences such as co-operative and experiential learning, lesson planning and practical teaching (Bleicher & Lindgren, 2005; de Laat & Watters, 1995; Duran, Ballone-Duran, Haney, & Beltyukova, 2009; Richardson & Liang, 2008; Watters & Ginns, 1995). Science education courses at USQ follow this integrated science content and pedagogy model. In the past, ONC classes have involved interactive workshops in which students have the opportunity experience hands-on science learning activities engage in lesson planning and collaborate and share ideas with their peers.

An opportunity exists to enhance the science education integrated model by incorporating team-based project work as a learning and assessment tool. Collaborative learning environments have been shown to foster retention of material and higher order thinking skills,

[1] 35 % of the students participating in this study have completed Year 12 Biology and 12% have completed Year 12 Chemistry or Physics

and reflective practice (Brand & Moore; Fink, 2002; Hafner & Ellis, 2004; McInerney & Fink, 2009; Michaelsen, Knight, & Fink, 2002; L Michaelsen & M Sweet, 2008; Prince, 2004) and have widely applied in professional education in areas such business, engineering, medical sciences, social work and architecture (Fink, 2002; Livingstone & Lynch, 2002; Michaelsen, 2001; Parmelee; Peterson, 1996). Collaborative learning environments are highly relevant in teacher education courses (Albion, 2007; De Simone, 2008; Edwards & Hammer, 2004, 2007; Ford, Dack, & Prejean, 2006; Goodnough, 2005; Keppell, 2006; Kwan, 2008; Memory, Yoder, & Williams, 2003; O'Toole & Keppell, 2008). As most of our pre-service primary teachers have weak backgrounds in science, the experience of collaborative learning has the potential to increase students' grasp of science content and extend their thinking skills. This outcome is highly desirable as science teaching efficacy is linked to students' knowledge of science content (Riggs & Enochs, 1990).

Team-based projects also give students the opportunity to experience authentic collaborative work-based practices that are typically found in highly effective primary schools. In these learning communities, teachers work together to plan curriculum programs, teaching resources and teaching activities. A recent study of teachers engaged in designing and experimenting with new education practices showed a positive link between teacher learning outcomes and collaboration in interdependent teams (Meirink, Imants, Meijer, & Verloop, 2010). Using 'scenario-based' activities similar to those pre-service teachers are likely to encounter as teachers in schools, bridges the gap between theory and work-based practice and makes education courses relevant for students.

Education courses teach pedagogy. Collaborative learning is valued in primary and secondary education because of its impact on cognitive development and social growth. If this is so, it should be modelled in teacher education courses. In a recent professional development exercise with school teachers, Ruys (Ruys, Van Keer, & Aelterman, 2010) found that although the teachers agreed that collaborative learning was valuable, many were reluctant to use collaborative learning strategies possibly because of their lack of experience with it. Ruys advocates that teacher education courses should include collaborative learning to provide teachers with experience in collaborative learning.

Through use of existing communication technologies, WEB teams as well as ONC teams can experience the benefits of collaborative learning. At USQ, collaborative problem-based learning has been successfully implemented in a totally on-line first year engineering and surveying course (Brodie, 2009; Brodie & Porter, 2008). The effective use of a web–based learning management system in the engineering course has been shown to foster community, collaborative learning, and reflective thought. Student feedback indicates that teamwork, communication and problem-solving skills are developed. For our science education course, we have selected and adapted processes and strategies developed by Brodie and applied them to both ONC and WEB student teams.

Designing a team–based project in science education

The course chosen for this research was the third year compulsory science education course *Science Curriculum and Pedagogy*.

The major learning and assessment task required student teams to prepare a developmental sequence of science units addressing different primary school year levels. This activity was chosen because it is an authentic work-place task which models a learning communities approach to vertical curriculum planning. All students were provided with learning materials that addressed science content, science pedagogical content knowledge, science curriculum planning, team management strategies and project management. ONC teams were allocated to interactive workshop classes in which science content, science activities and team-work activities were discussed. On-line teams engaged with the same material individually or collaboratively using synchronous (e.g. Skype, Wimba Classroom, chat rooms) or asynchronous technologies (Wikis, forums, emails). Communication between WEB teams and their university lecturer occurred through forum postings and email.

In Part 1 of the project, each team was required to establish a team code of conduct and communication, assign roles and responsibilities to team members and submit a project timeline. Furthermore, each team had to construct a draft scope and sequence of science concepts and processes that would be used as the basis for their units of work. After four weeks, Part 1 was formally assessed and feedback was provided to each team about the project management plan and quality of the draft science scope and sequence.

In Part 2, the teams worked on constructing a sequence of linked science units. Each unit in the sequence was to be preceded by a rationale which justified how the chosen teaching strategies developed children's conceptual understanding and scientific processes skills. In addition, the team had to argue how the series of units formed a developmental science teaching program and evaluate the collective of units using Tytler's eight components of effective science teaching (Tytler, Symington, & Smith, 2009).

At the end of semester, a separate science content knowledge quiz was administered.

Making teamwork effective

Extensive research on team-based learning has revealed that four important factors are necessary to ensure the effectiveness of teamwork (LK Michaelsen & M Sweet, 2008). These are:

1. Teams must be formed properly and managed
2. Students must be held accountable for individual and team work
3. Teams must receive frequent and timely feedback
4. Team tasks must promote learning and team development

These four parameters were considered in the planning of the team-based project and how they were applied is described in the following sections.

Team formation and management

Forming and managing teams for the team-based project was complex. Two hundred and eighty-five students were enrolled in the course: 123 studied in a WEB based mode that included 95 students from all parts of Australia and 28 studying at the partner SEGi University College in Subang Jaya, Malyasia. The remaining 162 students attended ONC classes at three different sites in Queensland (Toowoomba, Springfield and Hervey Bay). These ONC students were allocated to teams based at their local campus and local tutors were assigned to these teams. The WEB SEGi teams were supported by a local Malaysian tutor whilst the remaining WEB student teams were managed centrally by one staff member.

The optimal size for a team is five to seven members because it is small enough to function efficiently and large enough to provide diversity (Michaelsen, 2001; L Michaelsen & M

Sweet, 2008). Following this advice, teams with five or six members were formed on a random basis to replicate a school scenario where teachers with different skills and interests are required to work together. Because *Science Curriculum and Pedagogy* is a compulsory course, it has students from all course specialities (Primary, Early Childhood and Special Education). Random selection is likely to provide sufficient diversity to cover all curriculum areas from early years to upper primary. It also avoids the formation of potentially disruptive sub-groups based on factors such as family relationship, friendship, race or culture (Michaelsen & Black, 1994).

Research on teams has shown that as teams work together, they progress through a sequence of four stages – forming, storming, norming and performing (Tuckman, 1965). Michaelsen (Michaelsen, 1999) has found that an entire semester is needed for student teams to reach the performing stage. As our science education project was scoped to occupy a whole semester (13 weeks) sufficient time existed for teams to achieve high level performance.

Successful student teams do not just happen. Student teams that are taught how to work in teams and to manage conflict within their teams have less conflict and social loafing and are more satisfied with their learning outcomes (Bolton, 1999; Scott-Ladd & Chan, 2008). This is also true for virtual teams (Kankanhalli, Tan, & Wei, 2007). Our team support materials contain strategic advice for both ONC and on-line teams on how to establish and manage a functioning team. Advice was provided to help teams to choose team roles and responsibilities, build team culture, deal with poor team behavior, manage conflict and communicate appropriately using synchronous and asynchronous communication technologies.

The team-base project specifications also incorporated team building and management strategies as part of the project requirements. At the commencement of the team project, all teams were required to

- identify individual members' skills and interests and assign and align these to team roles and responsibilities
- develop an agreed team code of conduct and communication, including consequences for non-adherence to team rules
- appoint a team leader as the major point of contact between the team and the university

A staff member, called a team facilitator, was allocated to manage a group of teams, with a brief to support teams with both academic and team issues.

In the next phase, students were required to scope the project and develop a project management schedule which included dates for regular meetings and developmental milestones. For ONC teams, some time was allocated during each workshop for teams members to meet face-to-face. Wimba Classroom was available for on-line synchronous communication. Both ONC and on-line teams were allocated web-based forums for team discussions and team wikis for viewing and editing project work. Each team was provided with the email addresses of their assigned team members.

During the project, records of team meetings and communications were to be logged, and team leaders were required to deliver regular interim progress reports on team functioning and task progress. Through these reports, poorly functioning teams were identified and support provided.

Student accountability

Team-work is often perceived to be intrinsically unfair if all team members are awarded the same team grade without due regard to individual accountability. Academically capable students may feel that they are not rewarded adequately for their work and that unequal contributions from team members affect the team grades. 'Couch potatoes' are able to take advantage of the work of others (Livingstone & Lynch, 2002) .

We adopted Felder's process of peer assessment as a means of introducing individual accountability (Felder, Elhajj, Brent, & Oakley, 2004). Rather than requiring students to rate the relative contributions of team members to the final product, students were asked to rate each team member including themselves on "team citizenship" (participation, effort and fulfillment of team responsibilities and commitments). Teams were required to keep team meeting and communication logs and submit progress reports and these records could be used by the team facilitator to validate peer assessment ratings. On the basis of peer evaluations, the grades of team members were scaled down using a modified version of Felder's auto rating scheme (Felder, et al., 2004). As each team project was judged using a criterion-referenced rubric, we chose only to apply scaling factors of <1.

Feedback to teams

Ongoing feedback to virtual and ONC teams from facilitators was given face-to-face for ONC students, through web-based team discussion forums and email for web-based teams. Guidance for students on their progress was provided through the formal assessment of Part 1 of the team project.

Team tasks that promote teamwork and learning

A team-based project promotes team development and learning if the nature of the task requires the students to work together to achieve task outcomes. Field studies (De Dreu, 2007) of management and cross-functional teams found that tasks requiring outcome interdependence motivates team members to greater information sharing and increased learning outcomes, especially when the tasks require reflection as part of the task process. Teams with high levels of team member interdependence also have greater team performance, team member satisfaction, conflict resolution, collaboration and cooperation (Langfred, 2005; Van Der Vegt, Emans, & Van De Vliert, 1998). This also applies for virtual teams. A recent study of virtual teams (Kankanhalli, et al., 2007) has shown the importance of task interdependence in moderating the relationship between conflict and team performance.

Our team project explicitly demands team member interdependence. The project specifications and assessment rubrics require teams to demonstrate and justify that the science curriculum program is a unified and developmental sequence of units. This necessitates an iterative process which can only be achieved if team members work together.

The research questions

The purpose of this research is to evaluate the effectiveness of team-based learning in a pre-service primary science education course. Three questions underpin this research.

1. Does team-based learning increase the personal science teaching efficacy beliefs of pre-service primary teachers?

2. Does the course mode impact on the personal science teaching efficacy beliefs of pre-service primary teachers?
3. Is there a difference between the responses of virtual teams and face-to-face teams to team satisfaction and science education learning outcomes?

Research methodology

The research questions were investigated using a quantitative approach. A pre-test and post-test survey was administered to a group of pre-service primary teachers enrolled in the third year science education course *Science Curriculum and Pedagogy.* One hundred and twelve students completed both the pre-test and post-test. Of these, 42 were in WEB teams and 70 belonged to ONC teams situated at three different campuses. The participants were predominantly female (102/112).

Pre-test variables consisted of thirteen items of the Personal Science Teaching Efficacy Beliefs Scale (PSTEB) of the Science Teaching Self-efficacy Belief Instrument (Riggs & Enochs, 1990). The items were coded on a 5-point Likert-type scale from 1 = Strongly Disagree to 5 = Strongly agree. The thirteen items used in the survey are found in Table 1.

Table 1: PSTEB scale items

1. I will continually find better ways to teach science.
2. Even if I try very hard, I will not teach science as well as I will most subjects*
3. I know the necessary steps to teach Science concepts effectively.
4. I will not be very effective in monitoring Science experiments *
5. I will generally teach Science ineffectively*
6. I understand Science concepts well enough to be effective in teaching Science.
7. I will find it difficult to explain to students how Science experiments work*
8. I will typically be able to answer students' Science questions.
9. I wonder if I will have the necessary skills to teach Science*
10. Given a choice, I will not invite the principal to evaluate my Science teaching *
11. When a student has difficulty understanding a Science concept, I will usually be at a loss as to how to help the student understand it better *
12. When teaching Science, I will usually welcome student questions.
13. I do not know what to do to turn students on to Science*

* reverse coded

In the post-test survey, we added seven overall learning items (Williams, Duray, & Reddy, 2006), including one author constructed item and six team satisfaction items (Scott-Ladd & Chan, 2008). These items are shown Tables 2 and 3.

Table 2: Overall learning items
Scale: 1 = Strongly Disagree, 5 = Strongly agree

Through participating I the team project:
1. I gained a good understanding of the basic concepts of the material
2. I developed an ability to communicate clearly about the subject
3. I learned to interrelate the important issues in the course materials
4. I learned a great deal of factual material
5. I learned to identify the central issues of the course
6. I improved my ability to integrate facts and develop generalizations from the course

material
7. I improved my understanding of basic science concepts*

* author developed

Table 3: Team satisfaction items
(Scale of 1 = Very negative, 5 = Very positive)

How satisfied were you with:
1. Experiences of teamwork in this course?
2. Experiences of teamwork overall (in other courses)?
3. The amount of time spent on team projects?
4. Your ability to coordinate times for teamwork?
5. The membership of your team?
6. Your learning in the team setting?

Data analysis

The Statistical package for the Social Sciences (SPSS), version 17.0 was used to analyse the data.

Results and discussion –personal science teaching self-efficacy beliefs

Reliability analyses carried out on PSTEB scale using pre-test and post-test data indicated that the PSTEB scale had high reliability with all items making an appreciable contribution to the scale's internal consistency (Cronbach's $\alpha = .841$ (pre-test) and $\alpha = .853$ (post-test)).

Paired sample T-tests were conducted on the data for the whole sample and the ONC and WEB sub-groups to determine the significance of any observed differences in the PSTEB scale. The results of these tests are shown in Table 4. On average, after completing the team-based project, the sample demonstrated a significantly greater PSTEB scores (M = 5.37, SE = .59) than those demonstrated at the beginning of the course (M = 46.53, SE = .66), $t\,(96) = 7.11$, $\rho<.001$, r = .59.

Table 4 : Paired sample T-test for whole sample, ONC and WEB sub-groups for the PSTEB Scale

Variable	Pre-test		Post-test						
	M	SD	M	SD	*t*	*df*	*ρ*	Mean diff	SD mean diff
Whole	46.53	6.46	50.37	5.83	7.114	96	.00**	3.85	5.32
ONC	45.58	6.54	49.68	5.62	5.53	61	.00**	4.10	5.83
WEB	48.20	6.05	51.60	6.06	4.65	34	.00**	3.40	4.33

** *ρ<.001*

Analysis of the data for ONC and WEB groups showed significant increases in PSTEB for both groups. The increase in PSTEB for the ONC group (pre-test (M = 45.58, SE = .83) and post-test (M = 49.68, SE = .71), $t(61) = 5.53$, $\rho<.001$, r = .58) was larger than the increase in PSTEB for the WEB group (pre-test (M = 48.20 SE = 1.02) and post-test (M = 51.60, SE = 1.03), $t(34) = 5.53$, $\rho<.001$, r = .62). In both cases, the size of the effect is medium: it accounts for 33% of the total variance for the ONC group and for 39% of the total variance in the WEB group.

From these analyses we can infer that pre-service primary teachers' personal science teaching efficacy increased as a result of their learning experiences in *Science Curriculum and Pedagogy*.

Further paired sample T-test were performed on the ONC and WEB group data for the thirteen items of the PSTEB scale and these results are shown in Table 5 and Table 6.

Table 5: Paired sample T-test for the ONC group for the PSTEB Scale

PSTEB Item Number	Pre-test		Post-test							
	M	SD	M	SD	*t*	*df*	*ρ*	Mean diff	SD mean diff	r
1	4.26	.63	4.44	.53	2.26	69	.03	.19	.69	0.26
2	3.38	1.04	3.49	.90	.93	68	.36	.12	1.04	0.11
3	3.04	.84	3.61	.69	6.19	69	.00*	.57	.77	0.60
4	3.74	.85	4.01	.63	2.57	69	.01	.27	.88	0.30
5	3.94	.78	4.04	.82	1.00	68	.32	.10	.84	0.12
6	3.16	.96	3.64	.79	4.12	68	.00**	.48	.96	0.45
7	3.42	.95	3.78	.76	2.97	68	.00*	.36	1.01	0.34
8	3.25	.85	3.68	.72	3.95	68	.00**	.44	.92	0.43
9	2.39	.86	2.94	1.03	4.09	68	.00**	.55	1.12	0.44
10	3.39	1.10	3.51	.93	.87	68	.39	.12	1.11	0.10
11	3.56	.79	3.90	.64	3.52	69	.00*	.34	.81	0.39
12	4.21	.80	4.46	.63	2.41	69	.02	.24	.84	0.28
13	3.26	.99	3.91	.72	5.14	68	.00**	.65	1.06	0.53

* $\rho < 0.05$, ** $\rho < 0.001$

Table 6: Paired sample T-test for the WEB group for the PSTEB Scale

PSTEB Item Number	Pre-test		Post-test							
	M	SD	M	SD	*t*	*df*	*ρ*	Mean diff	SD mean diff	r
1	4.45	.55	4.48	.51	.26	41	.80	.02	.60	0.04
2	3.76	.97	3.73	1.10	-.21	40	.84	-.02	.76	0.03
3	3.07	.72	3.98	.47	7.22	40	.00**	.90	.80	0.75
4	3.98	.61	4.05	.81	.62	40	.54	.07	.76	0.10
5	4.03	.73	4.30	.65	1.98	39	.05	.26	.88	0.30
6	3.40	.86	3.90	.58	4.03	41	.00**	.50	.80	0.53
7	3.64	.73	3.76	.69	.93	41	.36	.12	.83	0.14
8	3.48	.67	3.76	.58	3.11	41	.00*	.29	.60	0.44
9	2.79	1.09	3.29	1.15	3.11	41	.00*	.50	1.04	0.44
10	3.54	.84	3.56	1.05	.17	40	.86	.02	.91	0.03
11	3.85	.65	3.86	.68	-.20	40	.84	-.02	.79	0.03
12	4.46	.55	4.41	.77	-.36	40	.72	-.05	.87	0.06
13	3.55	.86	4.12	.67	4.81	41	.00**	.57	.77	0.60

* $\rho < 0.05$, ** $\rho < 0.001$

Both ONC and WEB groups had significant increases from pre-test to post-test for those items (3, 6, 8, 9 and 13) related to science conceptual knowledge and the teaching of this knowledge. The effect on these items was medium to very large ($.43 \leq r \leq .75$) with the greater effect noted for the WEB group. From these results, we can conclude that students' experiences in this science education course contributed to developing their beliefs about their personal understanding of science concepts and ability to teach these concepts.

A significant gain and medium size effect (r = .30 and .34) was noted in ONC students' self-efficacy in a conducting and explaining science experiments (items 4 and 7). In contrast, there was no significant increase for WEB students. This result exposes a potential weakness in the WEB delivery mode. Although WEB students were encouraged to conduct simple everyday experiments at home, they did not have the opportunity to benefit from the supervised whole class science activities available to the ONC students.

For the items 1, 11 and 12, the ONC group registered significant increases whilst the WEB group did not. As these items referred to general confidence in teaching science, the gains for the ONC may derive from their opportunities to obtain face-to-face peer and teacher feedback in workshops. No significant changes were noted in either group for three items 2, 5 and 10.

Analysis of PSTEB values of the ONC and WEB groups in Table 4 shows that the WEB group has higher pre-test and post-test scores than the ONC group. Independent sample T-tests were performed to establish if these differences were significant and these results are found in Table 7.

Table 7 : Difference between the ONC and WEB sub-groups for the PSTEB Scale prior (Pre-test) to and after (Post-test) the team-based project

			ONC		WEB		*t*	*df*	*ρ*	Mean diff
Variable	F	*ρ*	M	SD	M	SD				
Pre-test	2.09	.15	45.54	6.49	48.28	5.90	2.16	102	.03*	2.74
Post-test	.78	.38	49.22	5.82	51.14	6.25	1.56	102	.12	1.91

* $\rho<.05$

At the commencement of the course, the WEB group (M = 48.29, SE = .94) had a higher PSTEB score than the ONC group (M = 45.54, SE = .80). This difference was significant, $t(102) = 2.16$, $\rho<.05$ and represented only small to medium effect (r = .21). After completing the team-based project, the WEB group (M = 51.60, SE = 1.03) retained a higher PSTE score than the ONC group (M = 49.22, SE = .71), however the difference was not significant, $t(102) = 1.56$, $\rho>.05$ and the effect small, r = .15. We can conclude that the initial difference between the two groups was ameliorated by the team-based project.

Results and discussion – students' perception about overall learning

Student responses (Table 8) to measures of overall learning show overwhelming support for the proposition that the science education course contributed significantly to overall student learning. Over 91% of all students agreed or strongly agreed that participating in the team project improved their understanding of basic science concepts (item 7), whilst over 80% of students agreed or strongly agreed that participating in the team project increased their understanding of course materials. Although some differences exist between ONC and WEB sub-groups in terms of item ratings, independent sample T-tests revealed that these differences are not significant. These results strongly suggest that the course was equally successful in engaging both ONC and WEB pre-service primary teachers in learning science and course content.

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Table 8: Group means and percentage ratings for overall learning items

Item Through participating in the team project:	Group	M	Rating Percentages (1 = Strongly disagree, 2 = Disagree 3 = Neutral, 4 = Agree, 5 = Strongly agree) 1	2	3	4	5
I improved my understanding of basic science concepts*	All	4.05	0	6.3	5.4	65.8	22.5
	ONC	4.06	0	5.7	2.9	71.4	20
	WEB	4.02	0	7.3	9.8	56.1	26.8
I gained a good understanding of the basic concepts of the material	All	3.96	0	4.5	6.3	77.5	11.7
	ONC	3.97	0	4.3	4.3	81.4	1.0
	WEB	3.95	0	4.9	9.8	7.7	14.6
I developed an ability to communicate clearly about the subject	All	3.92	0	3.6	1.8	75.7	9.9
	ONC	3.95	0	1.4	10	81.4	7.1
	WEB	3.88	0	7.3	12.2	65.9	14.6
I learned to interrelate the important issues in the course materials	All	3.91	0	2.7	14.5	71.8	1.9
	ONC	3.91	0	2.9	11.6	76.8	8.7
	WEB	3.90	0	2.4	19.5	63.4	14.6
I learned a great deal of factual material	All	3.91	.9	4.5	12.6	66.7	15.3
	ONC	3.91	1.4	2.9	14.3	65.7	15.7
	WEB	3.90	0	7.3	9.8	68.3	14.6
I learned to identify the central issues of the course	All	3.85	.9	5.4	12.6	7.3	1.8
	ONC	3.87	1.4	4.3	8.6	77.1	8.6
	WEB	3.80	0	7.3	19.5	58.5	14.6
I improved my ability to integrate facts and develop generalisations from the course material	All	3.80	.9	5.4	12.6	7.3	1.8
	ONC	3.77	1.4	4.3	20	64.3	1.0
	WEB	3.85	0	4.9	17.1	65.9	12.2

*Author developed item

Results and discussion – students' satisfaction with team-based learning

Paired sample T-tests (Table 10) were conducted on student data for the following two team satisfaction items:

1. How satisfied were you with your experiences of teamwork in this course?
2. How satisfied were you with experiences of teamwork in other courses?

Table 10: Paired sample T-test for Whole sample, ONC and WEB sub-groups for satisfaction with team-based learning

	In this course		In other courses						
	M	SD	M	SD	*t*	*df*	*ρ*	Mean diff	SD mean diff
Whole	3.72	1.01	3.15	.98	4.74	109	.00**	.57	1.27

sample								
ONC	3.84	.93	3.30	.94	3.64	69	.00*	.54	1.25
WEB	3.51	1.13	2.88	1.02	3.01	39	.00*	.63	1.31

* ρ<.05, ** ρ<.001

On average, all participants were significantly more satisfied with their experience of teamwork experience in this course (M = 3.72, SE = .10) than their experience of teamwork in other courses (M = 3.15, SE = .09), $t(109) = 4.74$, ρ <.001, r = .41. Similar results were achieved for the ONC and WEB sub-groups: the ONC group reported higher average teamwork satisfaction levels for this course (M = 3.84, SE = .11) than other courses (M = 3.30, SE = .11) which represents a significant difference, $t(69) = 3.64$, ρ<.05, r = .40 . The WEB group also reported an average satisfaction with teamwork in this course (M = 3.51, SE = .18) that was significantly greater than their average satisfaction with teamwork in other courses (M = 2.88, SE = .16), $t(39) = 3.01$, r = .43. In all instances, the size of the effect was medium to large.

Student satisfaction with other aspects of teamwork (items 3-6) is shown in Table 11. Although the ONC students' levels of satisfaction were higher than those of the WEB students, independent sample T–tests showed that the differences were not significant, except for item 3. This item referred to the amount of time spent on teamwork and WEB students reported much lower levels of satisfaction than their ONC counterparts on the time that was involved in teamwork.

Comparing students' views on previous experiences of teamwork shows that, on average, WEB students had negative views about their previous experiences of teamwork (M = 2.88). On the other hand, the ONC students view of other teamwork experiences was slightly positive (M = 3.30), $t(108) = 2.22$, r = .21. It is gratifying to note that for both groups, the satisfaction levels with teamwork increased significantly as a result of the teamwork experience in this course.

Table 11 : Difference between the ONC and WEB sub-groups for team satisfaction items

			ONC		WEB					Mean
Item	F	ρ	M	SD	M	SD	t	df	ρ	diff
1	7.46	.00*	3.84	.93	3.51	1.12	1.60	72	.12	.33
2	.03	.86	3.30	.94	2.88	1.02	2.22	108	.03	.43
3	3.34	.07	3.74	1.00	3.29	1.15	2.17	109	.03	.45
4	1.21	.28	3.96	.82	3.76	.92	1.21	1.210 9	.24	.20
5	.45	.51	3.83	.98	3.80	.98	.13	109	.90	.02
6	3.40	.07	3.97	.74	3.83	.83	.93	109	.35	.14

*ρ<.05

Conclusion

The purpose of this study was to investigate the change in pre-service teachers' personal science teaching efficacy after participating in a team-based project in a science education course. The study also sought to identify whether pre-service primary teachers were satisfied with teamwork and believed that teamwork contributed to their learning. The impact on mode of delivery (ONC or WEB) on students' views about teamwork and changes in science teaching self-efficacy was also evaluated.

The results of this research confirmed that a significant increase in pre-service primary teachers' efficacy beliefs occurred after their participation in a team-based project in the third year science education course *Science Curriculum and Pedagogy*. Without a control, it is not possible to state categorically whether this increase is due to the experience of team-based learning or if in fact a similar change would have occurred using another pedagogical approach. However, there are a number of indicators that suggest our team-base approach contributed positively to these students' outcomes. Firstly, all students, whether ONC or WEB, rated that the team-based approach highly and significantly better than their experiences of teamwork in other courses. Secondly, over 90% of the students agreed that "though participating in the team project, I improved my understanding of basic science concepts '. The literature supports the notion that teachers with a weak science background have a low self-efficacy and are reluctant to teach science (Riggs & Enochs, 1990). The fact that our students believe they have gained an understanding of basic science concepts though teamwork and report an increase in personal science teaching efficacy beliefs validates the collaborative learning approach used in this study.

Our analysis of post-test PSTEB data and measures of team satisfaction and overall learning, revealed no statistical difference between face-to-face teams and virtual teams. There were two notable exceptions. WEB students were significantly less satisfied than ONC students with the time they spent on teamwork. The reason for this is unknown but may be related to factors such as demographics (age, family responsibilities or work commitments), the use communication technologies (asynchronous or synchronous communication) or teamwork dynamics (information sharing, conflict, cohesion, trust). An important aspect of science teaching involves hand-on science activities and practical investigations. Whilst this study demonstrated that teamwork enhanced ONC students' self-efficacy in monitoring and explaining science experimental work, no corresponding increase was noted for the WEB students. This may be a consequence of the lack of opportunity WEB students have to engage in face-to-face science practical activities in a classroom environment. Finding solutions to the issues associated with WEB delivery requires further investigation.

Finally, from the team progress reports, we identified approximately 15 % of students who did not meet team obligations regarding participation and agreed timelines. These students had their team grades scaled lower. Currently, we are exploring available student data (demographic, the use of communication technologies and teamwork dynamics) to identify those factors contributing to student disengagement with the team processes.

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