The CRIMSPL - Context Rich Integrated Maths and Science Professional Learning Project

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The CRIMSPL - Context Rich Integrated Maths and Science Professional Learning Project aimed to improve resources and the quality of teaching in mathematics and science, and to increase the real-life context of education in these areas. It delivered teacher professional development (PD) workshops on creating and using open-ended investigations and problem-based activities. These sessions introduced teachers to innovative ways of teaching and stimulated reflection and discussion about modification of their own teaching practices. It established collaboration between six metropolitan and four rural schools, creating innovative real-world classroom resources written and trialled by practising teachers fully integrate mathematics and science. Workshops on the Statements of Learning and Professional Standards helped stimulate discussion of ways to make these connections. Teachers shared observations of student activities and samples of student work.

The professional development model enabled connections to be established between CRIMS project teachers, educational consultants, teacher professional associations, CSIRO CREST, Australian Science Innovations, and the Academy of Science personnel. The project was the stimulus for a new presentation of the TLF Learning Objects with a focus on integrating mathematics and science. Discussion with colleagues, examination of student work samples and reflection supported modification of teachers’ own teaching practice. The teachers were committed to quality teaching and the benefit of using open-ended tasks in the classroom. However, change requires time, to develop new resources, and to discuss and reflect on the path of change that is suitable for each teacher and in the context of their students. Teachers said that they appreciated the time that the project gave them to develop some CRIMS tasks. Teacher feedback served as a form of evaluation, indicating a continuing need for teachers to be provided with further professional development workshops on creating and using open-ended investigations and problem-based activities.

Teacher feedback has described ongoing change within schools. Teachers reported that pedagogical change was supported by the professional learning activities. Rural teachers in particular commented on the value of the collaboration with other teachers, and the benefits of the PD workshops on contextual open-ended investigations, problem-based learning, constructivism and student-centred learning. Teachers reflected on, and identified the factors that encouraged, inhibited and prevented the spread of innovative practices in their schools. Outcomes included improved resources and increasing the real-life contexts in mathematics and science. Activities developed for the project were disseminated internationally and nationally through conference presentations and the project website.
Introduction

This paper is a report of the outcomes of a professional development (PD) program designed to stimulate change in the classroom practices of teachers of science and mathematics. In order to accomplish this, the project focused on teacher professional learning. Research indicates a relationship between student achievement and the quality of teachers. This research indicates that the impacts of teachers on student achievement can be stronger than the influences of student background factors, such as poverty, language background, and minority status (Darling-Hammond, 2000).

The PD program was offered to primary and secondary teachers. The intention of the program was to support teachers in developing their pedagogical competence focused on making connections between science and mathematics. Further outcomes were for teachers to gain a better understanding of the teaching and learning of mathematics and science, to challenge teachers’ beliefs about teaching and learning, to encourage reflection on their practice and support them in their efforts to develop a student-centred approach in their teaching, using a range of instructional methods. This contributed to one of the important roles of PD which is to build capacity in teachers. The ultimate aim was to train key teachers who would inspire and assist colleagues in their schools to develop strategies to improve the quality of science and mathematics teaching in their schools.

One of the goals of the project was that networking between teachers and other professionals would support increased teacher retention, particularly for rural teachers who often feel professionally isolated. “Primary teachers outside Metropolitan Areas indicated a substantially greater unmet need for in-services in science and mathematics than did their metropolitan counterparts. Science teachers in Provincial and Remote Areas indicated a significantly higher unmet need for a broad range of professional development opportunities than did those in Provincial Cities or Metropolitan Areas.” (Lyons et al., 2006, p. vii)

Background

Context

The original CRIMS project aimed to produce well-developed and tested context-based teaching resources to promote innovation and student interest. CRIMS are inquiry based and focus on student-centred learning and problem solving. They emphasise skill development, and thinking and reasoning. The central focus of a CRIMS task is open-ended investigation, scaffolded by the teacher. The interrelated disciplines of science and mathematics come together in the investigation process, developing students’ understanding of how science and mathematics are used to describe, represent and explain their world. Each investigation is accessible at a range of levels so each student can achieve some level of growth, hence there are different entry points and exit points. CRIMS use pedagogical tools that cater for differentiated instruction and contribute to a flexible and supportive classroom environment. Learning is social, and students may work in collaborative groups carrying out investigations.
CRIMS use rich contexts to create an environment whereby students can construct their own scientific and mathematical knowledge and develop understanding of scientific and mathematical processes. These resources support important aspects of teaching and learning in these disciplines, identified by researchers. “Mathematics and science education must be engaging and contemporary. Mathematics and science education must also be relevant to student’s lives, promote deep conceptual understanding and embrace investigative inquiry and problem solving” (Herbert, 2006, v). In order to achieve this, CRIMS tasks are characterised by:

interdisciplinary connections between mathematics and science
meaningful and worthwhile contexts e.g. a current event, a social issue relevant to students
an open-ended investigative approach, generating first hand data in cooperative groups
estimation, thinking, reasoning and communication
use of technology
  • multiple entry and exit points

Feedback from teachers who had been involved in a project to produce CRIMS tasks (and other resources that integrated science and mathematics) which provided one PD day, after which teachers developed and published the tasks; emphasised the value of the PD day and requested the project continue and expand with a program of further PD days that would build upon their professional learning. This supported findings that “to enhance student achievement, teachers need to be supported with sustained and classroom-oriented professional development”. (Goodrum, Hackling & Rennie, 2001, p. 174). This PD project was thus not imposed on teachers, but was developed in response to consultation with teachers and a statement of their perceived needs. Thus there was a sense of ownership.

Effective PD

Researchers into change in teachers’ classroom practices report that the implementation of pedagogical change is very complex. They emphasise that “the transformation of teaching is no easy task” (CERI 1998, p. 25), and state that “reforming teachers’ practice is not a simple matter” (Schorr & Koellner-Clark 2003, p. 192). Researchers looking at the effectiveness of the teacher doing PD, and how much that impacts change, suggest that PD that is ongoing and supported is more effective in eliciting change than one-off PD sessions. (Tytler, Smith, Grover & Brown, 1999)

Yates (2004) summarises the characteristics of effective professional development identified by CERI (1998) as:
  • “Sustained, intensive and ongoing
  • Experiential, engaging teachers in concrete tasks
  • Participant driven grounded in inquiry, reflection, experimentation
  • Collaborative, interactional, involve sharing knowledge inside and outside the setting
  • Supported by modelling, coaching, collective problem solving around specific problems of practice
  • Connected to and derived from teachers’ work with students” (p. 2)
CERI (1998) recommended that teacher professional development programs support teachers by modelling, coaching and collective problem solving based on specific issues of practice. Shorr and Koellner-Clark (2003) described a program that provided teachers with the opportunity to consider their approach to teaching, test predictions about classroom practice and reflect on the outcomes in a collegial setting. The benefits were that “teachers in the working group had a common context in which they could discuss content and pedagogy” (p. 209). Teachers are thereby provided with an opportunity to develop theoretical understandings.

Model for describing change

Senge (2006, p. 94) discusses how the “limits to growth” model may be used for identifying the patterns that control events. In this model, a reinforcing (amplifying) process is set in motion to produce a desired result. The process feeds on itself to produce a period of accelerating growth or expansion. It creates a spiral of success but also creates inadvertent secondary effects (manifested in a balancing process) that eventually slow down the success. The basic structure of the model is that in each case of limits to growth there is a reinforcing process of growth or improvement that operates on its own for a period of time. This growth phase is caused by a reinforcing feedback process (or by several reinforcing feedback processes). It runs up against a balancing (or stabilizing) process that operates to limit growth. When that happens, the rate of improvement slows down, or even comes to a standstill. When the growth begins to slow (often inexplicably to the participants in the system) it eventually comes to a halt, and may even reverse and begin an accelerating collapse. This happens because there is bound to be a limiting factor, typically an implicit goal, or norm, or a limiting resource. The slowing arises is due to a balancing process brought into play as a ‘limit’ is approached. This can be a resource constraint, or an external or internal response to growth. The accelerating collapse (when it occurs) arises from a reinforcing process operating in reverse, to generate more and more contraction.

To understand and use the structure, Senge suggests that the appropriate elements of the reinforcing and balancing loops be identified. First, the reinforcing process, by asking what is getting better and what the action or activity is which leads to improvement. The second step is to identify the limiting factor and the balancing process it creates. What ‘slowing action’ or resisting force starts to come into play to keep the condition from continually improving? Once the situation has been mapped, the management strategy is to search for leverage. This won’t involve pushing harder which will just make the resistance stronger. More likely it will require weakening or removing the limiting condition. The management principle thus becomes not to push growth or put more pressure on the reinforcing process, but remove the factors limiting growth, and remove or weaken the source of limitations.
The study

The program consisted of five days of PD organised for middle years teachers in ten rural and metropolitan schools over a period of a year. In addition, the project included sharing of activities by email, regular newsletters, and the project website. PD workshops included sessions on contextual open-ended investigations, problem-based learning, constructivism and student-centred learning. These sessions introduced teachers to innovative ways of teaching and stimulated reflection and discussion about modification of their own teaching practices. The professional development model enabled connections to be established between CRIMS project teachers, educational consultants, teacher professional associations, CRIRO CREST, Australian Science Innovations, and the Academy of Science personnel.

The study focused on the teachers’ reflections concerning the teaching and learning of science and mathematics and the factors that effect the implementation of change in the classroom. One of the main goals was that teachers share ideas about how students learn science and mathematics. The study included teachers’ reports of incorporating changes in the repertoire of their classroom practice, with the aim of ultimately enhancing student learning. Collaborative exploration of new activities with colleagues, examination of student work samples, followed by discussions with colleagues, and reflection supported the modification of teachers’ personal teaching practice. The teachers were committed to quality teaching and the benefit of using
open-ended tasks in the classroom. However, change requires time, to develop new resources, and to discuss and reflect on the path of change that is suitable for each teacher and in the context of their students.

The paper contributes to knowledge of effective professional development strategies that foster changes in teacher’s beliefs about teaching and learning science and mathematics, and assist teachers in acquiring new teaching practices.

Findings

Teacher reflections

Teacher feedback and evaluation indicated a continuing need for teachers to be provided with further professional development workshops on creating and using open-ended investigations and problem-based activities. This supported the findings by other researchers studying the effectiveness of teacher PD, and how much it impacts change, that PD that is ongoing and supported is more effective in bringing about change than one-off PD sessions (Tytler, Smith, Grover & Brown, 1999).

Teachers identified the following improvements, commensurate with current beliefs about high quality teaching, that were achieved through the PD program:

- A greater awareness of the integration of maths/science/ICT amongst staff as well as students.
- A greater willingness and openness amongst staff in developing programs for richer learning via integration.
- Students engaged and enthusiastic about Maths and Science.
- Students more confident when approaching Maths.

There was an emphasis on content-based knowledge and leading practice in pedagogy. PD days built teacher professional knowledge, and connected teacher attributes with professional standards.

Teacher feedback described ongoing change within schools. The teachers’ reflections stated that they have changed their practices. Teachers reported that pedagogical change was supported by the professional learning activities. The PD fulfilled some of the requirements of effective PD identified by Yates (2004) in that it was sustained and ongoing over the period of a year, and it was experiential, engaging teachers in concrete tasks. Each PD session introduced teachers to new resources and teaching methods, by means of a practical workshop, using a constructivist approach.

Teachers worked together on authentic relevant activities. Teachers had time to try these new activities and resources in a collaborative environment. Each PD day featured hands on activities, as teachers explored the resources. They were given assistance in finding new resources and skill support using the resources provided by the project. Thus, they were supported by modelling, coaching by the consultant, and collective problem solving with their peers around specific issues of practice.

Teachers reported the value of the time that the project gave them to develop some CRIMS tasks and to trial them in their classrooms.

Above all, the project was participant driven, grounded in teacher inquiry and reflection, and encouraging experimentation. Teachers were not passive recipients of the PD – they drove the some of the innovations in the PD process and made
important contributions. At the suggestion of the participants, two of the PD days were held in schools, and focused around the observation of student activities followed by an informal forum where teachers reflected on their observations, gave feedback to the host teacher, and made connections to their own practice. This added another dimension to the project and enhanced its collaborative and interactional nature. The sharing of knowledge inside the school setting, which directly connected to and derived from teachers’ work with students, gave the teachers a different perspective, and linked to the findings by previous researchers that change is stimulated by teachers experiencing the benefits for students when they learn in different ways (Tytler, Smith, Grover & Brown, 1999). The common context which could be used as a foundation on which to build discussions of content and pedagogy was identified as an important feature of successful teacher PD by Shorr and Koellner-Clark (2003).

In feedback on the PD sessions teachers commented on the importance of networking, particularly in rural schools, in supporting them in their professional work. Rural teachers reported that they felt less professionally isolated. In particular, rural teachers commented on the value of the collaboration with other teachers, and the benefits of the PD workshops on contextual open-ended investigations, problem-based learning, constructivism and student-centred learning. In this way, the project provided emotional support – teachers valued having colleagues who supported them, celebrated their successes and understood their frustrations. Teacher feedback of the PD sessions particularly mentioned the value of the opportunity to network with teachers from other schools and other education professionals. Cooperative working led to a high level of teacher satisfaction and positive feedback about the PD days, units of work, tasks and courses that have been developed as part of the project.

The pedagogical underpinning and educational context of the project also explored issues of how to use their integrated activities to enhance learning. CRIMS school leaders examined innovative pedagogical practices, contexts that encouraged student engagement, interdisciplinary conceptual links, processes which made connections between the disciplines, scientific and mathematical literacy, student-centred pedagogy and employment contexts. PD days supported high quality teacher professional learning and upgraded their knowledge of contemporary practice. Teachers’ enhanced leadership capabilities were demonstrated by their mentoring of other teachers in their schools.

Factors that impacted on change

Teachers reflected on, and identified the factors that encouraged, inhibited and prevented the spread of innovative practices in their schools. Context is a factor that impacts on the implementation of change. This is evident from the reflections of a teacher from rural schools who reported the impact of professional isolation on their professional practice.

At the penultimate PD day the consultant presented a workshop to the teachers on the Senge model, and each teacher individually identified the factors that they felt had progressed and inhibited the project in their school. Responses of the factors were then pooled and were analysed by the group, as a workshop activity.
Factors which were identified as contributing to the reinforcing loop included some facets of school organisation, characteristics of the teachers who were involved in the project, student enthusiasm and achievement of learning outcomes and the support from the CRIMS project.

School organisational factors which helped drive change in the project were identified as timetabling organisation where “year 8 teachers were covering Maths and Science with the same classes”, and the physical arrangement of teachers who had a “shared staff room for Science and Maths teachers”. One of the most important factors identified was “support from the Principal, and the school”. “Student reactions” and “positive feedback” also encouraged teachers to persevere with the implementation of changes in their classroom practices. “Support from other teachers” was also identified as a driving factor and the “enthusiasm and participation of staff”, particularly of “insightful and enthusiastic teachers who are willing to take a challenge” were seen as important stimulators of change. “Teacher satisfaction” also contributed to the forward progress of the project in schools.

A wide range of contributions of the project were seen as drivers for changes at the school level. Fundamental to these was the “support of CRIMS peers”, particularly “informal discussion”, “observing others and working as a team to share ideas / concerns”, “interaction at Professional Learning meetings” and “seeing others do”. “Funding for resources and teacher release” and the provision of “professional learning which was continuous and on site” were identified. Information about “cross curriculum perspectives”, the “availability of materials, e.g. Maths 300, Learning Objects”, “ideas that motivate students e.g. excursions, displays”, “practical, relevant situations to motivate students” all supported teachers in implementing changes in their schools. The identification of milestones and learning outcomes and the “timeline from the project” were also important.

Factors that were identified as feeding into the balancing loop and thus slowing the impetus of the project were time, the crowded curriculum other teachers and school organisation, large classes and issues around the provision of appropriate technology. Teachers felt that some were external or internal responses to the changes, whereas others were identified as limiting factors that were intrinsic in their teaching situation.

Time was identified as a factor which impacted on the rate of change. Teachers identified “lack of time” and “time constraints” as factors which slowed the potential growth of the project. Specific instances given were the lack of “time to respond to communication, e.g. emails” and the additional “time required to construct a cross-discipline unit”.

A significant number of teachers identified issues to do with the curriculum as factors which came into play, slowing the change process. These included: “curriculum constraints”, “crowded curriculum”, “covering the curriculum content”, “system numeracy testing” and the “content driven syllabus”. Teachers perceived these as factors which impacted on their ability to maintain the impetus of their projects in the schools.

A number of issues that arose concerned teachers. Some of these related to school management and organisation, including “large classes”, the impacts of “changeover
of staff”, an “unstable workforce”, and the appointment of “senior teachers [who] usually cover Maths or Science, so [it is] harder to integrate.” Another focus of teacher-related comments was based on teacher attributes, and included “teacher qualifications” and issues of “getting teachers on board” which stopped teachers becoming involved, including “teacher resistance”, “staff who are reluctant to be involved” and “staff who think they are already doing a ‘good’ job” and so are resistant to change.

The final group of factors which teachers found could not sustain the growth of the project involved the provision of appropriate “ICT Technology”, including comments on the “lack of technology” and “no access to technology”. “Financial constraints” also became more acute as the project progressed.

In trying to identify the limiting factors which needed to be addressed, teachers identified implicit norms, or resource constraints which fed into the balancing process and which they felt had acted as to limiting their project outcomes.

The first of these was the way science and mathematics are perceived in the community, and teacher perceptions about teaching and learning in science and mathematics, so that what they were attempting was very much “seen as a change from the norm”. The teachers perceived the students and parents as having “tunnel vision”, and found that the “students’ preference for Maths or Science can set up barriers to integration”. Teachers’ professional knowledge also contributed to this as they perceived a paucity in the ”knowledge of other discipline’s syllabus” and in the “knowledge of [the] core content of [the] discipline”, leading to a “lack of teacher confidence in integrating subjects”. This was compounded by the impact of a “changing workforce” and “changes in school personnel” caused by promotions. They found that some teachers were particularly resistant, especially those that taught years 9 and 10. In addition, teachers in rural schools found a “lack of extra-curricular opportunities for reinforcing of Maths and Science learning”.

Teachers perceived time as a major limiting factor on the project, limiting their opportunities to develop a more extensive repertoire of professional practices. They perceived time as having a substantial impact on their ability to keep advancing the project. Issues they identified included:

- “Lack of time in a content driven syllabus
- Programming restrictions
- Lost time – excursions, sports events
- Time to prepare units
- Exam times; excursions
- Time – making sure all is covered
- Other in-school commitments
- Timetabling – lack of common Science – Maths times”

The management of change in the model that Senge described focuses on removing the limiting factors, rather than attempting to continue to keep pushing the factors that have previously contributed to the growth of the project. The manipulation of the factors that teachers identified, in order to make more time available for the project, was seen as an ongoing challenge.
Discussion

Appropriate PD can support teachers in making changes to their classroom practice. The project incorporated several of the characteristics of effective PD. The program took place over an extended period of time, it gave teachers opportunities to try new ideas and reflect on the impact of changing methodologies. Teachers had time to assimilate new information, and try out, reflect on and refine new practices. Collaboration with and support by colleagues, were important factors. Consultants provided guidance and modelled good practice. The PD was participant-driven and allowed flexibility to change in response to teachers’ requests. Teachers’ reflections were focused on their work and related directly to their teaching. Teachers’ work was legitimised by conference presentations, project reports and publication on the project website.

The identification of the factors which enhanced the project, and those that acted as limits of growth for teachers undertaking professional development in order to bring about change in their own practices and extend these changes to a whole-school level, was an important outcome of the project.

Conclusion

A reasonable conclusion is that teachers would benefit from more time spent in professional development courses that model practical experiences and provide the support of colleagues who are sharing the experience. Information about factors that impinged on the ability of the teachers to maintain the change process in their schools can be taken into account in the planning of future projects, and ways to minimise their impact can be incorporated into the planning.

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References


