

STEPS (Science Teacher Education Partnerships with Schools): Annotated Bibliography

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Disclaimer

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Science Teacher Education
Partnerships with Schools

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The STEPS (Science Teacher Education Partnerships with Schools) Project

The STEPS Project responds to international concern about primary teachers' lack of science knowledge and confidence to teach science, and recent questioning of the effectiveness of traditional approaches to teacher education. It will review and build on established, innovative and successful practices at five universities, to develop and promote a framework supporting school-based approaches to pre-service teacher education.

The models involve partnerships between universities and primary schools to engage pre-service primary teachers in classroom teaching and learning that effectively connects theory with practice.

Through critical appraisal of these and similar models, the project will identify key features of the approach and the critical success factors required to establish and maintain strong working relationships with schools and build student capacity. The following annotated bibliography was constructed following an internet search of journals, websites and books using the Deakin university Library search engine. To avoid repetition, unless an entry is clearly classifiable into two of the categories, most references here are cited once.

Some the key terms (or derivatives of these terms) used in this search were:

- partnerships,
- efficacy,
- science teaching,
- reflection,
- pre-service teaching,
- education,
- collaboration and,
- Australia.

The document is arranged into themes. These themes serve the purpose of the literature search, but also as categories for the analysis of data generated by the project. The themes are:

- Theory and Practice
- Partnerships
- Reflection
- Confidence and Identity
- Science teaching/Science education
- Placement
- Feedback on the model

Theory and practice

Some primary school teachers lack a theoretical background in science or choose not to focus directly upon science and instead they incorporate science into an integrated curriculum. The practice of integrating multiple learning domains such as science into units of work has led to science's lack of prominence in the curriculum. The school-based approach model to pre-service teacher science education provides the opportunity to employ intense, explicit work where they engage authentically with school students through hands on inquiry based activities. A pre-service teacher's prior knowledge is drawn upon to allow the school student to make sense of the world around them.

Cakmakci, G. (2012). Promoting pre-service teachers' ideas about nature of science through educational research apprenticeship, *Australian Journal of Teacher Education*, 37, 114-135.

This study examines an integrative context in which pre-service teachers take a research based approach as part of their training. This study is significant in that it carried out educational research with the incorporation of an explicit-reflective instructional model. Some possible implications for pre-service and in-service teacher education and further research are also discussed.

Campbell, C. (n.d.). Innovative science education assessment- linking theory with practice, COSMED.

This paper focusses on the assessment of learning outcomes of third year pre-service teachers who have undertaken a science unit. It highlights theoretical frameworks associated with assessment and how pre-service teachers link theory and practice. It uses an example of an assessment task and how it is embedded with principles of constructivism and conceptual models in science education.

Darby, L. (2005). Science students' perceptions of engaging pedagogy, *Research in Science Education*, 35, 425-445.

An exploration of teacher pedagogy from the perspective of the school student. Two forms of pedagogy are identified: instructional and relational. Instructional pedagogy is defined here as the process whereby the teacher draws the student into the process of learning and how they are enabled to learn and understand science. Relational pedagogy is described as how the student-teacher relationship is developed. The findings of this paper are used to consider future directions for the middle years and science education.

Darby, L. (2010). *Characterising secondary school teacher imperatives as subject (signature) pedagogies: A pedagogy of support in maths and a pedagogy of engagement in science*, Conference Paper presented as part of symposium "A multi-disciplinary exploration of signature pedagogies and the promotion of accomplished teaching" to AERA, Denver, Colorado, April 30-May 4, 2010.

This paper considers what is the efficacy of describing pedagogies that have become entrenched in secondary school subjects as signature pedagogies?; and in what ways can such

elaborations catalyse teacher and school change? Approached from a cultural perspective these questions are examined by comparing the subject cultures of junior school maths and science as experienced by, and represented in the classrooms of, a small number of teachers from two secondary schools in Victoria, Australia.

Etherington, M.B. (2011). Investigative primary science: A problem-based learning approach, *Australian Journal of Teacher Education*, 36, 36-57.

The pedagogical mode of learning open inquiry science, a problem-based learning approach, is the focus of this paper. It examines and reports on the replacement of the traditional content driven syllabus to the problem-based approach and then offers recommendations to facilitators of undergraduate science education as to how the problem-based learning approach can be incorporated into a science curriculum.

EunJin, B. (2013). Exploring impacts of the EED 420 science methods course on pre-service elementary teachers' views regarding the nature of science, *International Electronic Journal of Elementary Education*, 5, 219-232.

An examination of a semester-long science methods course and pre-service teachers views on the nature of science. The study indicates that a one semester course does not provides sufficient depth to improve a pre-service teacher's understanding of the nature of science.

Fieman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching, *Teachers College Record*, 103, 1013.

This paper draws upon a wide range of literature to propose a framework for thinking about a curriculum for teacher learning over time. It aims to generate debate about what a professional learning continuum from initial preparation through the early years of teaching could be like.

Hannafin, M.J., & Bryan, L.A. (2007). Technology-enhanced inquiry tools in science education: An emerging pedagogical framework for classroom practice, *Science Education*, 91, 1010-30.

The purpose of this paper is to examine the findings and implications of research on science inquiry tools on classroom teaching and learning practices. There is a summary of research on inquiry tools and the researchers provide a framework for teaching and learning in technology-enhanced, inquiry-based science classes. In the framework, three dimensions are discussed: the macrocontext (systemic reform and educational standards), the teachers' community (physical or virtual context, where teachers share expertise and mentor each other), and the microcontext (classroom context, where learning and teaching occur). From this pedagogical framework, the interactions among the standards, teachers' community, and classroom contexts are key to exploring the role of technologies.

Harris, J., Moran, W., Long, J., Ryan, S. (2007). *Improving pre-graduate teachers' professional knowledge, practice and commitment: Evaluating a school – university collaboration*, Paper presented at the Australian Association for Research in Education (AARE) International Educational Research Conference, Fremantle, November 2007.

Conference paper which examines the framework for accreditation of graduate teachers and provides an evaluation of student teacher and school staff perceptions of the learning

outcomes of a partnership initiative in which the pre-service teacher is immersed in a whole-of-school context for their professional experience. The research is based in New South Wales and found that the partnership approach enhanced learning outcomes for pre-service teachers' knowledge of children, how children learn and how to create environments to promote learning.

Heck, S.F. (1977). *An integrated pre-service/in-service school-based teacher education model*, Conference paper presented at the annual meeting, Association of Teacher Educators. Atlanta, Georgia, February 2-5, 1977.

A conference paper which provides an account of the integration of theory and practice to partner pre-service teachers with local school children throughout a four year teacher education. This paper considers multiple teaching disciplines and is not solely science focussed.

Hope, John A. & Aikenhead, G. S. (1974). *Theory into practice for elementary mathematics and science methods students*, *School Science & Mathematics*, 74, 280-292.

The authors have developed a teaching experience called "miniature teaching episodes" which has proven to be a useful lecture supplement. These teaching episodes were developed to give mathematics and science methods students a chance to integrate theoretical methodology with practical experience. Putting theory into practice is a common difficulty for education students. Various attempts to overcome this problem include: student teaching or internship, peer group teaching, micro-teaching, and now miniature teaching episodes.

Howitt, C. & Venville, G. (2009). *Dual vision: Capturing the learning journey of pre-service early childhood teachers of science*, *International Journal of Research & Method in Education*, 32, 209-230.

The issue of the construction of science methods courses which incorporate meaningful and relevant experiences for students is the focus here. The paper uses the experiences of a pre-service early childhood teacher and the interpretation of her learning journey on a pedagogical level in conjunction with a methodological consideration of a new qualitative research method titled 'dual vision.' Dual vision enables critical incidents to be constructed and interpreted through the combined lenses of the pre-service teacher and the researcher.

Hubber, P., Darby, L., & Tytler, R. (2010). *Student outcomes from engaging in open science investigations*, *Teaching Science: The Journal of the Australian Science Teachers Association*, 56, 8-12.

This paper reports an analysis focussed on the outcome for students of participation in open scientific investigations.

Jones, M. (2008). *Collaborative partnerships: A model for science teacher education and professional development*, *Australian Journal of Teacher Education*, 33, 61-77.

This paper proposes a collaborative partnership between practicing and pre-service teachers as a model for implementing science teacher education and professional development. This model provides a structure within which partnerships will work collaboratively to plan, implement and reflect on a series of Science lessons in cycles of action reflection adapted from Korthagen's (2001) ALACT model.

LeCornu, R., & Ewing, R. (2008). Reconceptualising professional experiences in pre-service teacher education...reconstructing the past to embrace the future, *Teaching & Teacher Education*, 24, 1799-1812.

This paper provides a conceptual framework for developing high-quality professional experiences for pre-service teachers. The paper begins with a discussion of how professional experiences are conceptualised, structured and supervised in each of three orientations, which we have termed traditional, reflective and learning communities. It also describes a number of professional experience initiatives at two Australian universities, which are being reconceptualised around the notion of learning communities.

Loughran, J., Mulhall, P., & Berry, A. (2008). Exploring pedagogical content knowledge in science teacher education, *International Journal of Science Education*, 30, 1301-1320.

While the development of pedagogical content knowledge (PCK) is considered to be a goal of teacher education, teaching about the concept itself is an unusual practice. In this case study, we explore the outcomes when a teacher educator explicitly introduces student-teachers to ideas about PCK through the use of a CoRes and PaP-eRs conceptualisation. The case study explores how, through this purposeful use of PCK in a pre-service science teacher programme, student-teachers' thinking about their teaching and about their development as science teachers is shaped.

Nilsson, P. & Loughran, J. (2012). Exploring the development of pre-service science elementary teachers' pedagogical content knowledge, *Journal of Science Teacher Education*, 23, 699-721.

An exploration of how a collection of pre-service science teachers came to understand their pedagogical content knowledge over the course of a semester's study in a science methods course.

Nixon, H. & Roberts, D. (1994). *Empowerment and inclusivity: A case study of mathematics and science curriculum in pre-service teacher education*, Conference paper presented at the Annual Meeting of the Australian Teacher Education Association (ATEA), July 3-6, 1994.

An investigation of pre-service teacher (student) diversity, student experiences of exclusion and inclusion, and teaching staff experiences in attempting to understand and counter exclusion. The paper considers what it might mean to plan and teach for inclusivity and empowerment within pre-service teacher education while paying attention to prior learning and assessment.

Phompun, C., Thongthew, S., & Zeichner, K. (2013). Pre-service teacher education in Thailand in the third space, *International Forum of Teaching & Studies*, 9, 11-20.

The teaching identities of student teachers were developed using the concept of third space. This paper exhibits an experiment in applying the third space concept to traditional five-year program for pre-service teacher education. Professors and cooperating teachers also participated in the training program on the third space concept. The findings here were that student teachers created their teaching identities and that the third space concept should be adapted to teacher education programs in Thailand.

Richards, M. (2001). *Collaboration uncovered: The forgotten, the assumed, and the unexamined in collaborative education*, Westport, U.S.A. Bergin & Garvey.

Researchers and teachers must work together to improve education by establishing strong collaborative connections so that theory and practice can inform one another. In addition to describing and discussing benefits and positive examples, the articles explore examples of negative collaborative relationships and raise a number of issues, such as the role of negotiation in collaborative projects that can serve to inform readers' subsequent experiences with collaborative initiatives.

Sim, C. (2010). *Sustaining productive collaboration between faculties and schools*, *Australian Journal of Teacher Education*, 35(5), 18-28.

Work integrated learning which is terminology now very familiar to all universities' faculty members, has always been integral to initial teacher education programs. As a result of the complexities involved in this field, building effective partnerships with schools continues to be a major focus of education faculties. These complexities around a partnership between two very different institutional contexts require negotiating a relationship that is of value to all involved. The concept of communities of practice can provide a framework to establish the collaboration needed.

Somekh, B. & Zeichner, K. (2009). *Action research for educational reform: Remodelling action research theories and practices in local contexts*, *Educational Action Research*, 17, 5-21.

This paper explores how action research theories and practices are remodelled in local contexts and used to support educational reform. The paper also offers a framework to enable the analysis of how action research differs in local settings within and across national boundaries. The paper ends by suggesting that the emerging variations of action research in many countries during the period 2000–2008 can be construed as an example of Appadurai's 'globalization from below', in which teacher-action-researchers contribute knowledge and learning from multiple local sites about the process of effective educational reform.

Tisher, R.P. (1986). *Innovative techniques in the pre-service education of science teachers*, *Australian Science Teachers Journal*, 16, 125-134.

Describes instructional techniques used in a one year post-degree science teacher education program, emphasizing the role of microteaching, analysis of video-recordings of master teachers, and the detailed analysis of science curriculum developments in Australia, the United Kingdom and the United States of America.

Wang, J., & Odell, S. J. (2002). *Mentored learning to teach according to standards-based reform: A critical review*. *Review of Educational Research*, 72, 481–546.

This is a literature review of mentored learning practices.

Watson, L., Woolnough, J., Hay, I., Hellyer, L. & Stuckey, D. (2008). *Beyond the practicum: integrating content, pedagogy and practice in teacher education*, Peer Refereed Conference Paper delivered to the Australian Association for Research in Education (AARE) National Conference, 30 November – 4 December 2008, Brisbane.

Teacher education courses have three broad components – subject matter (content), learning theory (pedagogy), and professional experience (the practicum). Traditionally, these three components have been taught separately but teacher education faculties are increasingly expected to integrate all three and to provide more extensive school-based experiences for pre-service teachers. Nevertheless increasing the time pre-service teachers spend in schools does not automatically lead to improved learning outcomes for teacher education graduates. This paper describes the experiences of faculty staff at the University of Canberra in delivering content and pedagogy to pre-service teachers through Teaching Clinics in school classrooms. The benefits and challenges of integrating content, pedagogy and practice through school-based delivery are discussed.

Watson, L., Woolnough, J., Hay, I., Hellyer, L. & Stuckey, D. (2013). Challenging the theory/practice divide in higher education: The teaching clinics model of work-integrated in (eds.) Goodenough, K., Galway, G., Badenhorst, C. & Kelly, R. *Inspiration and innovation in teaching and teacher education*, Lexington Books, Plymouth U.K.

This chapter examines a form of work-integrated learning developed at the University of Canberra. The 'teaching clinic' model challenges the traditional model of professional experience by embedding university lecturers in workplaces with their students.

Partnerships

The school-based approach model is reliant on forming relationships. Contributions between school communities, school teachers, pre-service teachers, a university, and lecturers/tutors are critical. Partnerships lead to the sharing of learning and understandings of the requirements to make the partnership function effectively. For the model to succeed, partners need to maintain an awareness of lesson sequencing. The requisite knowledge of learners and educators, critical timeframes and ensuring topics fit into the school's curriculum also require consideration. In future, the applicability of the school-based approach model across other learning disciplines could be contemplated.

Adams, P., Legleiter, E., Davies, M., Seimars, M., Hrepic, Z., & Walizer, B. (2008). University partnership to deliver statewide professional development, *Science Scope*, 31, 20-24.

A professional development institute was jointly developed by Fort Hays State University and Emporia State University in Kansas. The three-year state-wide institute prepared middle school science teachers to implement a modelling pedagogical approach.

Adey, K. L., & Speedy, G. (1993). End-on innovation: A school-based approach to secondary teacher education, *Australian Journal of Teacher Education*, 18, 34-9.

This paper describes the development of a one year 'end-on' teacher education program used by graduates following the completion of a degree at University of South Australia. The concepts upon which the paper is based are implementation and evaluation of a program in 1992 and subsequent modifications to the program in 1993. The paper ends by discussing funding and issues relating to distributing the program for wider use.

Admiraal, W., Akkerman, S., & Graaff, R. (2012). How to foster collaborative learning in communities of teachers and student teachers: Introduction to a special issue, *Learning Environments Research*, 15, 273-278.

An introduction is presented in which the editor discusses various reports within the issue on topics including the collaboration of teachers with the students, the development of principles for development in school-university partnerships (SUPs), and the definition of teacher communities.

Allen, J. M., Howells, K., & Radford, R. (2013). A 'partnership in teaching excellence': Ways in which one school-university partnership has fostered teacher development, *Asia-Pacific Journal of Teacher Education*, 41, 99-110.

This paper reports on some of the factors that contribute to an effective partnership between an urban Australian university and a State Department of Education. The partnership, currently in its third year of implementation, entails as a key purpose the development of school Centres of Excellence which contribute to the preparation of pre-service teachers.

Ash, K. (2013)., STEM schools put high priority on digital skills; Programs build partnerships to provide the kinds of high-tech skills students need for college and careers, *Editorial Projects in Education, Inc.*, 32.

Educators in the Lake Washington school district in Washington state have partnered with a university to build a project-based, STEM-focused program that engages high schoolers with technology and college-level digital.

Baker, P.J. (2011). Three configurations of school-university partnerships: an exploratory study, *Planning & Changing*, 42, 41-62.

This paper presents an array of structural configurations that invite new consideration of the necessary conditions for developing systemic school reform; first by reviewing the current literature, and then by examining thirty-six existing partnerships as structural configurations, an exploratory typology for the analysis of successful school-university partnerships is developed. The paper concludes by noting the strengths and weaknesses of the three models, and suggests areas for inquiry, no matter the model chosen for a school-university partnership.

Bryan, C., & Sims, S. (2011). K-12 and university partnerships: Bridging the advocacy gap, *Strategies: A Journal for Physical and Sport Educators*, 25, 36-7

A paper that examines the benefits to the larger university community of a collaborative approach with K-12 schools to advocate better quality and daily physical education for children and adolescents.

Burton, S.L., & Greher G. R. (2007). School-university partnerships: What do we know and why do they matter? *Arts Education Policy Review*, 109, 13-24.

This paper, essentially an extensive review of literature discusses problems and possibilities of collaborations in both general education and music education contexts. They propose a research agenda focusing on (a) the developmental nature of the collaboration process, (b) the quality of the process, (c) the outcomes of the process, and (d) the perspectives of all parties involved to examine the role of school—university partnerships in music teacher education.

Butcher, J., Bezzina, M., & Moran, W. (2011). Transformational partnerships: A new agenda for higher education, *Innovative Higher Education*, 36, 29-40.

The notion of transformational partnerships are considered here and illustrated to demonstrate how such an understanding has enriched the relationship between a particular university and school system. Transformational partnerships are different in purpose, nature, and strategies from transactional partnerships. They are based upon genuine engagement and a focus on common goals and mutual benefits. In transactional partnerships each institution pursues its own goals with little consideration of mutual goals or shared purpose. The areas of community engagement, leadership, and transformational partnerships provided key concepts for analysing the case study showing how higher education institutions can think and work differently with other institutions, organizations, and groups to achieve mutual benefits.

Catapano, S., & Huisman, S. (2010). Preparing teachers for urban schools: Evaluation of a community-based model, *Perspectives on Urban Education*, 7, 80-90.

The article evaluates the use of community-based model in preparing teachers for urban schools. It mentions the importance for pre-service teachers to see firsthand and appreciate the community where a student lives in order to meet his or her needs. It affirms that school-

university partnership initiatives has helped providing school districts with a substantial number of teachers.

Castle, S., Fox, R. K., & Souder, K. (2006). Do professional development schools (PDSs) make a difference? A comparative study of PDS and non-PDS teacher candidates, *Journal of Teacher Education*, 57, 65-80.

This study assesses the impact of professional development schools (PDSs) on preservice teachers, comparing PDS and non-PDS candidates at the point of licensure. The case is made that PDS graduates may affect student learning sooner than traditionally trained beginning teachers.

Clifford, M., & Millar, S. B. (2008). *K–20 partnerships: Literature review and recommendations for research (WCER Working Paper No. 2008-3)*. Madison, WI: Wisconsin Center for Education Research.

This literature review provides researchers and evaluators information about what we know about the form, function, and achievements of K–20 partnerships, and how we know what we know. The review is based on an analysis of 36 rigorous and frequently cited K–20 partnership studies. We believe this review updates and extends previous literature reviews (Clark, 1988; Smedley, 2001; Kingsley & O’Neil, 2004) by focusing primarily, but not exclusively, on research/evaluation studies that define and describe K–20 partnerships.

Crocco, M., Faithfull, S. & Schwartz, S. (2003). Inquiring minds want to know. Action research at a New York City professional development school, *Journal of Teacher Education*, 54, 19-30.

This article describes a professional development school (PDS) relationship between Teachers College, Columbia University, and the Beacon School in New York City. The authors focus on the action research projects conducted by teaching interns at Beacon who are also master’s students in secondary education programs, chiefly social studies and English, at Teachers College. The authors analyze the impact of this collaboration on participants and institutions, while acknowledging the areas of strain in maintaining the professional development relationship over time.

Dalton, S. (1987). *Pre-service education for teachers of minorities: The Hawaii University/Schools Partnership Program*, Paper presented at the Annual Meeting of the American Educational Research Association (Washington, DC, April 20-24, 1987), University of Hawaii.

A conference paper that considered a partnership program in Hawaii focused upon preparing teachers for educating cultural minorities who have liberal educations and transdisciplinary knowledge bases. The paper additionally outlines curriculum, field experiences and the evaluation of a program that suggests the difficulties experienced in delivering this program.

de-Mora, J.C., & Wood, K. (2014). *Practical knowledge in teacher education: approaches to teacher internship programmes*, Oxford, Routledge.

A book that examines internship programmes across Europe and Asia with a specific focus on intensive, hands-on experience with innovative and creative teacher education programmes.

DuFour, R., Eaton, R., & DuFour, R. (Eds.). (2005). *On common ground: The power of professional learning communities*. Bloomington, IN: Solution Tree.

On Common Ground is the first book in the Leading Edge series. The Leading Edge is the undefined space where leaders venture to impact change it is the place where transformation begins. The Leading Edge series unites education authorities from around the globe and asks them to confront the important issues that affect teachers and administrators the issues that profoundly impact student success. The experts contributing to this anthology do not prescribe one method to transact change. They embrace the mission, trusting that teachers and administrators the true change leaders will venture to the Leading Edge to embrace the challenges and opportunities that will guarantee the success of their students. On Common Ground provides a valuable tool for educators who are doing the hard work of improving their schools. This resource offers teachers and administrators a coherent conceptual framework and specific, practical strategies for moving forward with their improvement efforts. Any listing of North America s leading authorities on school improvement would include the authors in this book. These authors agree on many of the best strategies for raising student achievement and support the premise that students would be better served if educators: Embrace learning rather than teaching as their school s mission Work collaboratively to help all students learn Use formative assessments and a focus on results to foster continuous improvement Assume individual responsibility to take steps to create such schools Although they stand on this common ground, clear differences emerge regarding their perspectives on the most effective strategy for making professional learning communities the norm in North America. The differences, however, focus on the means rather than the end. These educational leaders have found common ground in expressing their belief in both the desirability and the power of professional learning communities.

Eargle, J.C. (2013). "I'm not a bystander": Developing teacher leadership in a rural school-university collaboration, *Rural Educator*, 35, 23-33.

This case study is a program review that investigates how social studies teachers at a rural high school in the American southeast, are emerging as teacher leaders through a school-university partnership to improve their practice, mentor pre-service teachers, and generate reform. The findings indicate that the school-university partnership encouraged experimentation with new strategies, stimulated reflective practices and teacher growth, and created a more cohesive social studies department. However, while it was evident that teacher leadership did develop through the process, traditional school norms of egalitarianism and structural hierarchy prevented teachers from fully embracing their roles as teacher leaders.

Falloon, G. (2013). Forging school–scientist partnerships: A case of easier said than done?, *Journal of Science Education and Technology*, 22, 858-876.

This article uses two partnership programmes run by a New Zealand Science Research Institute, to illustrate the challenges faced by scientists and teachers as they attempted to forge meaningful and effective partnerships.

Fawns, R., Jacques, M. Redman, C., Sadler, J. & Rodrigues, S. (2001). *Partnerships in pedagogy and research in professional personal identity formation in early secondary teaching*, ATEA Melbourne.

Conference paper extracted from other literature (reference list) but unable to be sourced.

Ferrera, J. (2014). *Professional development schools: creative solutions for educators*, Lanham, Rowman & Littlefield Education.

This book is intended as a guide for practitioners interested in forming alliances within their community to support teacher and student success. Under the umbrella of a professional development school (PDS), school principals willing to engage in this type of partnership have access to a framework for school renewal.

Firestone, W. A., & Fisler, J. L. (2002). Politics, community, and leadership in a school-university partnership. *Educational Administration Quarterly*, 38, 449–493.

A review of 8 years of the history of one school-university partnership and detailed fieldwork for 3 years offers some new insights into this undertheorized organizational arrangement. The authors suggest that a micropolitical perspective be used to analyze such partnerships. They speculate that partnerships sharing elements of the professional community may promote more improvement but that only subunits within partnerships are likely to become professional communities. Finally, they suggest that although people in a number of positions may be able to offer leadership for such partnerships, those in boundary-spanning roles are especially well placed to do so.

Fisher, M., & Rogan, P.M. (2012). K–12 and university educators working together toward change: Initiating a conversation about practice, *The Teacher Educator*, 47, 123–143.

This case study of a joint school/university professional development opportunity explored how 12 practitioners came together to examine change in light of discrepancies between current practice in local schools and promising practices recommended in the literature for students identified as having significant disabilities. Findings are discussed in light of implications for researchers, teacher educators, and K–12 practitioners in their various roles as agents of social change.

Forbes, A. & McCloughan, G. (2010). Increasing student participation in science investigations in primary schools: The MyScience initiative. *Teaching Science*, 56(2), 24–30.

Outline of a primary science initiative that uses a team approach incorporating primary teachers, primary students and volunteer mentor scientists. PSTs from Grad Dip and B.Ed. programs are also involved in the program. The initiative is aimed towards supporting teacher professional learning, teaching and learning practices and school-community engagement.

Forbes, A. & Skamp, K. (2013). Knowing and learning about science in primary school 'communities of science practice': The views of participating scientists in the MyScience initiative. *Research in Science Education*. 43(2), 1005-1028. doi: 10.1007/s11165-012-9295-0.

This paper follows the 2010 Forbes paper detailing MyScience. It describes the roles in the program of 11 scientists who participated and acts as a vehicle for the scientists and teacher and student interactions to be analysed. Implications for science teaching and learning in primary school community of practice settings are discussed.

Forbes, A. & Skamp, K. (2014). "Because we weren't actually teaching them, we thought they weren't learning": Primary teacher perspectives from the MyScience initiative. *Research in Science Education*. doi: 10.1007/s11165-013-9367-9.

A paper that follows earlier work by Forbes which focusses on eight primary teachers from three primary schools who were active participants in the MyScience program. Analysis of mentor and student interactions are provided with consideration of notions of communities of practice and the nature of science.

Gajda, R. (2004). Utilizing collaboration theory to evaluate strategic alliances, *American Journal of Evaluation*, 25, 65–77.

Increasingly, collaboration between business, non-profit, health and educational agencies is being championed as a powerful strategy to achieve a vision otherwise not possible when independent entities work alone. But the definition of collaboration is elusive and it is often difficult for organizations to put collaboration into practice and assess it with certainty. The collaboration principles and corresponding assessment processes described in this article can be used by evaluators of large- or small-scale initiatives that seek to capitalize on the synergistic power of the “collaborative effort.”

Gardner, D.C. (2011). Science, technology, engineering, and math (STEM) school-university professional development partnerships: a special issue, *Planning & Changing*, 42, 3-8.

An introduction is presented in which the editor discusses various reports within the issue on topics including improving teacher quality state grants, the configurations of a school-university partnership, and evaluation capacity building in a school-university partnership grant program.

Gooden, M.A., Bell, C.M., Gonzales, R.M., & Lippa, A.P. (2011). Planning university-urban district partnerships: Implications for principal preparation programs, *Educational Planning*, 20(2), 1-13.

Universities are faced with increased accountability, requiring their leadership preparation programs to be more effective and proficient at monitoring and measuring the impact their graduates have on student achievement. Recent research supports creating university-district partnerships as part of a complex solution to address some of the demands by improving the effectiveness of principal preparation programs and thereby increasing the number of effective leaders prepared to work in urban schools. Findings from this work present some pitfalls to avoid and some recommendations for those interested in exploring university-district partnerships.

Goodlad, J. (1993). School-university partnerships and partner schools, *Educational Policy*, 7, 24-39.

This article is about school and uni personnel joining in renewing schools where a significant part of the PST education program is carried out jointly.

Gorodetsky, M., & Barak, J. (2008). The educational-cultural edge: A participative learning environment for co-emergence of personal and institutional growth, *Teaching and Teacher Education, 24, 1907-1918.*

The paper addresses the failure of the Professional Development Schools movement in bridging the cultural gap, existing between schools and academic institutions. A model, based on the 'ecological edge', is suggested. It is believed that this metaphor has a higher potential for constructing collaborative communities because of the unique nature of ecological edges as environments of growth and change. The paper describes an edge community that was constructed between a school and a teacher education program, the new grounded understandings and knowledge that emerged within this community and the diffusion of these to the core institutions. The concept of boundary objects is suggested as the medium through which new understandings are promoted.

Gorodetsky, M., Barak, J., & Hadari, H. (2007). A cultural-ecological edge: A model for a collaborative community of practice. In M. Zeller Mayer & E. Munthe (Eds.), *Teachers learning in communities: International perspectives* (pp. 99-112). Rotterdam: Sense Publishers.

'Teachers Learning in Communities is about teacher educators by those brave enough to make their professional learning public. The authors reveal the complexities of their participation in school/university partnerships and their relationships with teachers. Here practice informs theory, greatly expanding our knowledge and understanding of these important communities. Ann Lieberman, Senior Scholar at the Carnegie Foundation for the Advancement of Teaching. *Teachers Learning in Communities* is full of exciting success stories about rare and exotic teacher education episodes played out on the margins of the convention-bound large-scale teacher education enterprise. The chapter authors are earnest but sometimes ambivalent parolees from the frustrating drudgery of traditional labor-intensive, top-down teacher education programs. Their stories are implicitly critical of approaches to teacher preparation judged to be out of touch with the realities of contemporary public education, whether in Norway or Israel, England or the USA, Sweden or the Netherlands. From the Epilogue *Teachers in the Margins* by Christopher M. Clark, University of Delaware, USA.' *Taken directly from the Deakin University Library site*

Graden, J.L.&Bauer, A. M. (1992). Using collaborative approach to support students and teachers in inclusive classrooms, in S. Stainback &W. Stainback (Eds) *Curriculum Considerations in Inclusive classrooms: facilitating learning for all students*. Baltimore, MD: Paul H. Brookes.

This book discusses how the curriculum can be designed, adapted, and delivered in general education classrooms that are attempting to promote inclusive communities. Chapters include: "Toward Inclusive Classrooms" (Susan Stainback et al.); "Celebrating Diversity, Creating Community: Curriculum that Honors and Builds on Differences" (Mara Sapon-Shevin); "Inclusive Education: Making Sense of the Curriculum" (Alison Ford et al.); "Using Curriculum to Build Inclusive Classrooms" (William Stainback et al.) "Using a Collaborative Approach to Support Students and Teachers in Inclusive Classrooms" (Janet L. Graden, and Anne M. Bauer); "Integrating Support Personnel in the Inclusive Classroom" (Jennifer York et al.); "Student Collaboration: An Essential for Curriculum Delivery in the 21st Century" (Richard A. Villa and Jacqueline S. Thousand); "Support and Positive Teaching Strategies"

(Wade Hitzing); "It's Not a Matter of Method: Thinking About How to Implement Curricular Decisions" (Dianne L. Ferguson and Lysa A. Jeanchild); "Measuring and Reporting Student Progress" (Brian Cullen and Theresa Pratt); "Quality in Our Schools: A Parental Perspective" (Jeff Strully et al.); "Community-Referenced Learning in Inclusive Schools: Effective Curriculum for All Students" (Michael Peterson, et al.); "Extracurricular Activities" (Mary Falvey, et al.); and "Curriculum in Inclusion-Oriented Schools: Trends, Issues, Challenges, and Potential Solutions" (Michael F. Giangreco).

Haeffele, L., Hood, L., & Feldmann, B. (2011). Evaluation capacity building in a school-university partnership grant program, *Planning & Changing*, 42, 87-100.

This article describes the details involved in seven years' work with a sophisticated evaluation model assessing the value of grants designed to facilitate school-university partnerships.

Harris, J., Moran, W., Long, J., & Ryan, S. (2007). *Improving pre-graduate teachers' professional knowledge, practice and commitment: Evaluating a school – university collaboration*, Paper presented at the Australian Association for Research in Education (AARE) International Educational Research Conference, Fremantle, November 2007.

Conference paper which examines the framework for accreditation of graduate teachers and provides an evaluation of student teacher and school staff perceptions of the learning outcomes of a partnership initiative in which the pre-service teacher is immersed in a whole-of-school context for their professional experience. The research is based in New South Wales and found that the partnership approach enhanced learning outcomes for pre-service teachers' knowledge of children, how children learn and how to create environments to promote learning.

Hora, M.T., & Millar, S.B. (2007). *A preliminary case study of SCALE (System-wide Change for All Learners and Educators) activities at the University of Wisconsin-Madison: Factors influencing change initiatives in STEM undergraduate education, teacher training, and partnerships with K-12 districts*. Wisconsin Center for Educational Research Working Paper Series No. 2007-2.

A report on case studies which focus on structural and behavioural dynamics influencing the implementation of strategies employed by Institutions of Higher Education to build collaborative partnerships.

Hubber, P., & White, S. (2007). *A university-school partnership model for the delivery of a pre-service primary integrated science, mathematics and technology curriculum unit*, Conference paper: Australasian Science Education Research Association (ASERA), 38th Annual Conference Fremantle Western Australia, July 6 – 9, 2007.

This conference paper describes a school-based model for the delivery of an integrated Science, Mathematics and Technology primary pre-service curriculum unit. In this model a partnership arrangement is undertaken with a neighbouring primary school whereby the school provides a teaching space for the university students and their tutor to participate in a two and half-hour workshop.

Hudson, P. (2010). School-based experiences: Developing primary science preservice teachers' practices. *Journal of Science and Mathematics in Southeast Asia*, 33(2), 149-167.

Reviews into teacher education emphasise the need for preservice teachers to have more school-based experiences. In this study, a school-based experience was organised within a nine-week science curriculum university unit that allowed preservice teachers' repeated experiences in teaching primary science.

Hunter, L.R. (2011). School-university partnerships: A means for the inclusion of policy studies in music teacher education, *Part of a special issue: School-University Partnerships: Re-Envisioning Music Teacher Education*, 112, 137-143.

This article explores the inclusive use of policy studies in a music teacher education curriculum within a school-university partnership context.

Jantarakantee, E., Roadrangka, V., & Clarke, A. (2012). Pre-service science teachers' understandings of classroom research and the problems in conducting classroom research projects, *US-China Education Review*, 112-120.

This research paper explores pre-service science teachers' understandings of classroom research, problems in conducting classroom research and the supports that pre-service science teachers need from their cooperating teachers to help them conduct a classroom research project during the internship period. Pre-service science teachers would like recommendations from their cooperating teachers more frequently for promoting the pre-service science teachers' confidence and efficiency in their chosen classroom research projects.

Jelas, Z.M., Salleh, N.M., & Ali, M.M. (2010). Developing the foundations of inclusive education through university-school partnership, *International Journal of Learning*, 17, 145-156.

The purpose of the project reported here was to provide an opportunity for graduate students, school-based special educators and mainstream (general) educators to work together on developing activities designed to encourage students with special needs to learn together with typical peers supervised by on-site general and special education teachers. Reflections and informal discussions provide documented evidence on the benefits and challenges of collaboration in the effort to build an inclusive learning environment in the respective schools. The study also serves as a pilot for future integration of coursework and field experience in the context of university-school partnerships.

Jones, M. (2008). Collaborative partnerships: A model for science teacher education and professional development, *Australian Journal of Teacher Education*, 33, 61-77.

This paper proposes a collaborative partnership between practicing and pre-service teachers as a model for implementing science teacher education and professional development. This model provides a structure within which partnerships will work collaboratively to plan, implement and reflect on a series of Science lessons in cycles of action reflection adapted from Korthagen's (2001) ALACT model.

Kenny, J. (2009). Pre-service and in-service teachers working together to teach primary science, *Australian Journal of Teacher Education*, 34 (6), 1-22.

A partnership based approach for preparing pre-service primary teachers to teach science is explored here. The approach involved forming three-way or "triadic" partnerships, consisting of a final year pre-service primary teacher and an in-service colleague, to teach science in the colleague teacher's classroom, with the support of a teacher-educator. The pre-service teachers had to collaboratively plan, develop and deliver a sequence of science lessons and take major responsibility for teaching a 90 minute science lesson, at least once a week over a six week period.

Kenny, J. (2010). Preparing primary teachers to teach primary science: A partnership-based approach, *International Journal of Science Education*, 32(10), 1267-1288.

This paper reports on the effectiveness of a professional partnership approach to preparing pre-service primary teachers to teach science. The programme provided an authentic science teaching experience in which pre-service teachers were supported to plan and teach a sequence of work in a chosen science topic and reflect upon the experience. Many reported an initial lack of confidence in science and no experience with teaching it during their normal practice teaching.

Kenny, J., Hobbs, L., Jones, M., Chittleborough, G., Campbell, C., Gilbert, A., Redman, C., and Herbert, S. (2014). Science Teacher Partnerships with Schools (STEPS): Project-Partnerships in science teacher education. *Australian Journal of Teacher Education*, 39(12), 43-65.

This paper reports on the STEPS project which addressed international concerns about primary teachers' lack of confidence to teach science, and on-going questions about the effectiveness of teacher education. The five universities involved had each independently established a science education program incorporating school-based partnerships between the university and local schools to enable primary pre-service teachers (PSTs) to teach science. The diversity of the programs enabled an examination of the relevant literature underpinning the approaches and comparison of data from participants to identify key features and success factors for establishing and maintaining working relationships with schools. This preliminary analysis of learning from STEPS uses case studies and feedback from PSTs who participated. These findings indicate that authentic teaching experiences build the confidence of PSTs to teach science. Ultimately, the project will develop an Interpretive Framework which will articulate the characteristics of partnerships to be validated through feedback from other science educators from Australia and overseas.

King, J. (2013). The promise of cross-sectoral education partnerships in (eds.) Wierenga A. and Guevara, J.R., *Educating for global citizenship: a youth-led approach to learning and partnership*, Carlton, Melbourne University Publishing.

Konecki, L.R., Sturdivant, R.L., King, C.M., Melin, J.A., & Lancaster, P.E. (2012). Including multiple voices in collaboratively designing a teacher education program, *Action in Teacher Education*, 34, 526-540.

This narrative case study describes the collaborative processes employed by a mid-western university as it designed and implemented a clinically based, post-baccalaureate teacher preparation program for science, technology, engineering, and mathematics (STEM) graduates committed to teaching in high need secondary schools.

Kroll, L., Bowyer, J., Rutherford, M., & Hauben, M. (1997). *The effect of a school-university partnership on the student teacher experience, *Teacher Education Quarterly*, 24, 37-52.*

Descriptive paper of PSTs involved in a university-school partnership.

Kruger, T., Davies, A., Eckersley, B., Newell, F., & Cherednichenko, B. (2009). *Effective and sustainable university-school partnerships: Beyond determined efforts by inspired individuals*, Teaching Australia - Australian Institute for Teaching and School Leadership Limited.

This report was commissioned by Teaching Australia and examined university-school partnerships. It had two aims. Firstly, to identify examples of effective and sustainable university-school partnerships as part of pre-service teacher preparation programs, as well as research, induction and continuing professional learning for practicing teachers. Secondly, to analyse the programs to identify the characteristics of effectiveness and sustainability.

LeCornu, R. (2012). *School co-ordinators: Leaders of learning in professional experience, *Australia Journal of Teacher Education*, 37(3), 18-33.*

This article considers a gap in professional experience literature with a focus on a school-based co-ordinator role. It seeks to argue that school-university partnerships are necessary in providing high quality professional experiences.

Lee, L. (1999). *Partners in pedagogy: collaboration between university and secondary school foreign language teachers*, Washington DC, ERIC Clearinghouse on Languages and Linguistics.

One of the challenges facing many foreign language programs today is maintaining high quality instruction despite increased enrolments and teacher shortages. One strategy for meeting this challenge is collaborative teaching. Collaborative teaching can occur in various settings and for different purposes. Teaching with graduate students is only one way of teaching collaboratively. Other types of collaboration can be considered, depending on the particular needs of the program.

Lupu, M.M. & Pasca, E.M. (2010). *Innovations to school-university partnerships in Romanian programs for pre-service teacher education, *Journal of Educational Sciences / Revista de Stiintele Educatiei*, 12, 34-40.*

A possibly innovative approach to school-university partnership in setting up internships for pre-service teacher-students in the Romanian system of university based - initial teacher education is presented and explored in its relations to the current policy discourse and aspects of organizing and managing the learning activity.

McLaughlin, C. & Black-Hawkins, K. (2007). *School-university partnerships for educational research - distinctions, dilemmas and challenges, *Curriculum Journal*, 18, 327-341.*

This article examines partnerships between universities and schools that focus on the generation of educational knowledge through practitioner research and enquiry.

Martinez, K. & Coombs, G. (2001). *Unsung heroes: exploring the roles of school-based professional experience coordinators in Australian preservice teacher education, Asia Pacific Journal of Teacher Education, 29, 275-288.*

Feedback from the field suggested that the coordinator's role may in fact be crucial in ensuring that practicum is an occasion for quality learning. This paper reports on a study to explore ways in which a small selection of professional experience coordinators contribute to the establishment, support and appraisal of high quality practicum experience in a variety of settings. The research fills a gap in the existing literature on the practicum by providing some illumination of the varied ways the school-based coordinator role is filled. In addition, the paper raises questions about selection and support of coordinators, about ownership of the practicum, and argues for a reconceptualisation of the practicum as the site where all shareholders engage in the partnership, with continual opportunities for construction, reconstruction and renewal of the teaching profession.

Metz, D. (2005). *Field based learning in science: Animating a museum experience, Teaching Education, 16, 165-173.*

This paper examines the experience of pre-service teachers who were given the opportunity to work collaboratively with a museum to incorporate authentic science into school science. This authentic view of science becomes a contextual model which translates to a framework for authentic learning experiences.

Morgan, A.C., Parr, B., & Fuhrman, N. (2011). *Enhancing collaboration among maths and career and technical education teachers: Is technology the answer?, Journal of Career and Technical Education, 26, 77-89.*

This project represents an evaluation of the researchers' initial efforts toward providing in-service education for teachers focused on collaboration between math and CTE teachers. Research respondents valued technology but seemed a bit reserved about the likelihood of implementing and using technology. Results imply that teachers with positive attitudes and self-efficacy for adopting the model may struggle to implement collaboration due to a lack of time and access to technology.

Morgan, A-M. (2012). *"Me as a science teacher": Responding to a small network survey to assist teachers with subject-specific literacy demands in the middle years of schooling, Australian Journal of Teacher Education, 37 (6), 73-95.*

Middle years' teachers in primary schools are increasingly required to teach curriculum-specific subjects at a depth requiring considerable content and pedagogical knowledge, as well as a detailed understanding of the particular literacy requirements specific to each subject. Science teaching, in the latter years of primary schooling, is particularly demanding for non-specialist teachers. Many teachers struggle with feelings of (in)adequacy and (in)competence to be "science literate" and "good" science teachers, providing sufficient and valuable science learning opportunities for their learners. This paper describes one primary school's attention to teachers' feelings of wellbeing and competence in relation to themselves as science teachers.

Moyer-Packenham, P.S., Kitsantas, A., Bolyard, J. J., Huie, F., & Irby, N. (2009). *Participation by STEM faculty in mathematics and science partnership activities for teachers, Journal of STEM Education: Innovations and Research, 10(3-4), 17-36.*

This study examines archival data from a federally-funded mathematics and science program (NSF-MSP) where partnerships in the program provided pre-service and in-service education

for mathematics and science teachers. Of particular interest in the present study was the breadth of participation by IHE Science, Technology, Engineering, and Mathematics (STEM) faculty in the activities designed for teachers, and the relationship between the participation of IHE STEM faculty and the participation of all other providers of MSP teacher activities.

Moyer-Packenham, P.S., Parker, J.L., Kitsantas, A., Bolyard, J.J. & Huie, F. (2009). Increasing the diversity of teachers in mathematics and science partnerships, *Journal of Educational Research & Policy Studies*, 9, 43-72.

This study examines teacher diversity in a federally-funded mathematics and science partnership program. Each of the partnerships in the program provided pre-service and/or in-service education for teachers in mathematics, science, or both.

Mumba, F., Chabalengula, V. M., Moore, C. J., & Hunter, W. J. F. (2007). Mathematics and science teaching fellows' instructional planning for K-12 classrooms, *Science Educator*, 16, 38-43.

An exploration of instructional planning practices of university graduate students of traditional mathematics and science degree programs who provide content knowledge and instructional support to K-12 teachers in schools through university-school programs.

Mutemeri, J., Chetty, R. (2011). An examination of university-school partnerships in South Africa, *South African Journal of Education*, 31, 505-517.

A qualitative study of partnerships in the South African teacher education system. The research here revealed that the partnership model employed here was weak and a recommendation the creation of third spaces in teacher education which involve an "equal and more dialectical relationship between academic and practitioner knowledge" in support of student teachers' learning.

Myran, S., Crum, K.S., & Clayton, J. (2010). Four pillars of effective university-school district partnerships: Implications for educational planning, *Educational Planning*, 19, 46-60.

Continued calls for greater accountability in the PK-12 U.S. schools have placed increased demands and accountability upon universities to help schools meet state and federal student achievement requirements.

Nugent, P.N. (2013). Empowering innovations: Adding value to university-school partnerships, *College Student Journal*, 47, 567.

This article discusses results from a study on beginning teachers who developed university interns as a focus of their induction program at their schools.

Office of School Education. (2005). *Professional Learning in Effective Schools: The Seven principles of Highly Effective Professional Learning*, Abbotsford, Victoria, Victorian Department of Education and Training.

A state government document that is used to illustrate the requirements needed for the implementation of an effective professional learning program. The paper focusses upon areas such as learning, learning communities, learning teams, a performance and development culture.

Peters, J. (2011). Sustaining school colleagues' commitment to a long-term professional experience partnership, *Australian Journal of Teacher Education*, 36(5), 1-15.

The benefits, challenges and supportive factors associated with a long term school-university partnership are considered in this qualitative study and findings of the associated research derived from a successful partnership.

Pilo, M., Gavio, B., Grosso, D., & Mantero, A. (2012). Science education and teachers' training: Research in partnership, *US-China Education Review*, 2012, A1, 106-111.

Following concerns over the decrease in science disciplines across Europe as well as poor quality in science competences, this research is an investigation of ways to lift student motivation; to develop critical thinking and increase scientific literacy in the community. It concerns both pre- and in-service teachers' science training in areas such as increased awareness of concepts, sensitiveness to student involvement and reflection about the effectiveness of daily schoolwork awareness.

Ramsey, J., Guadarrama, I.N., & Nath, J.L. (2011). *Investigating university-school partnerships*, Research in Professional Development Schools, Charlotte, Information Age Publishers.

This is a collection of papers that represent the best and latest examples of practitioner thinking, research, and program design and evaluation in the field at the national level. The volume's contents of 26 chapters is divided into five areas: (1) PDS Evaluation (2) Teacher Research and Inquiry, (3) PDS Stakeholders' Studies, (4) Studies for Thought – Ideas for Development, and (5) Teaching Content Areas in PDSs. As a whole, the volume of papers maintains a consistency within a cohesive undercurrent that illustrates the spirited and visionary purpose of professional development schools to advance educational reform that leads to substantive change.

Rivera, M.A.J., Manning, M.M., & Krupp, D.A. (2013). A Unique Marine and Environmental Science Program for High School Teachers in Hawai'i: Professional Development, Teacher Confidence, and Lessons Learned, *International Journal of Environmental and Science Education*, 8, 217-239.

Here a description and evaluation of a unique professional development program for science teachers in Hawai'i that integrates the traditional approach of providing training to improve content knowledge, with the overarching theme of scientific inquiry and investigation through short duration research experiences is undertaken.

Rossner, P., & Commins, D. (2012). *Defining 'enduring partnerships': Can a well-worn path be an effective, sustainable and mutually beneficial relationship?*, Queensland College of Teachers, Retrieved July 28, 2014 from <https://www.qct.edu.au/PDF/DefiningEnduringPartnerships.pdf>.

This paper considers the notion of 'enduring partnerships' as applied to initial teacher education. It considers the variety of ways in which the terms 'enduring' and 'partnerships' are applied in relationships between teacher education providers and schools.

Ryan, J., Jones, M., & Walta, C. (2012). Creating a sustainable and supportive teaching practicum in rural and regional locations, *Australian & International Journal of Rural Education*, 22, 57-72.

The difficulties experienced by school and universities seeking to provide a high quality pre-service teacher experience for individuals in rural areas is considered here through a study undertaken jointly by lecturers from the regional campuses of two Australian universities.

Saleh, S.M., & Hamed, K. M. (2014). Service-learning through partnership with a community high school: Impact on minority health science students, *Journal on Excellence in College Teaching*, 25, 95-111.

Service-learning has been used to integrate an educational experience with community outreach, particularly among underserved populations. In this study, college students enrolled in a health science major were engaged in an educational outreach initiative with a group of students from a high school with a predominantly minority population. The college students participated in the development and delivery of a series of health science workshops to the high school students. Surveys were administered to both student groups before and after the initiative. The high school students improved in the self-efficacy dimension, while the college students also improved in empowerment, academic, civic responsibility, and career sectors.

Saxman, L.J., Gupta, P., & Steinberg, R.N. (2010). CLUSTER: University-science center partnership for science teacher preparation, *New Educator*, 6, 280-296.

A five year collaborative research project between an interactive science centre and a local college is described here along with the research results. The paper discusses the recruitment and training of fifty highly qualified science teachers in New York City as well as the development of a model for teacher preparation.

Sim, C. (2010). Sustaining productive collaboration between faculties and schools, *Australian Journal of Teacher Education*, 35(5), 18-28.

Work integrated learning which is terminology now very familiar to all universities' faculty members, has always been integral to initial teacher education programs. As a result of the complexities involved in this field, building effective partnerships with schools continues to be a major focus of education faculties. These complexities around a partnership between two very different institutional contexts require negotiating a relationship that is of value to all involved. The concept of communities of practice can provide a framework to establish the collaboration needed.

Stairs, A.J. (2010). Becoming a professional educator in an urban school-university partnership: A case study analysis of preservice teacher learning, *Part of a special issue: Moving Teacher Education into Urban Schools and Communities*, 37(3), 45-62.

The writer discusses pre-service teacher learning and how teacher candidates can become professional educators in urban school-university partnerships. She examines the concept of professionalism from multiple perspectives, including those of the scholars. She then presents a case study that illustrates the possibilities and challenges of becoming a professional educator in an urban school-university partnership.

Stevens, T., Harris, G., Aguirre-Munoz, Z., & Cobbs, L. (2009). A case study approach to increasing teachers' mathematics knowledge for teaching and strategies for building

students' maths self-efficacy, *International Journal of Mathematical Education in Science and Technology*, 40, 903-914.

A report that reports on an attempt to design and evaluate a professional development activity that focusses on mathematical knowledge for teaching and building self-efficacy building across a culturally and socially diverse middle school student population.

Tsui, A. (2011). *Learning in school-university partnership: Sociocultural perspectives*, London, Routledge.

This volume looks at school-university partnerships from sociocultural perspectives of learning that view participation in social practice as fundamental to the process of learning. Its two major themes -- school-university partnership and sociocultural and social theories of learning -- have both been treated extensively in the literature.

Trinidad, S., Sharplin, E., Lock, G., Ledger, S., Boyd, D., & Terry, E. (2011). *Developing strategies at the pre-service level to address critical teacher attraction and retention issues in Australian rural, regional and remote schools*, *Education in Rural Australia*, 21, 111-120.

A multi-university (W.A.) project to examine ways to improve the quality of preparation of pre-service teachers for rural, regional, remote appointments. Incorporates rural community and professional partnerships as well as government initiatives.

Tytler, R., Symington, D., & Smith, C. (2011). *A curriculum innovation framework for science, technology and mathematics education*, *Research in Science Education*, 41, 19-38.

This analysis provides an argument that innovation is a powerful idea for framing curriculum development in sciences at the local level that is generative for students and teachers. A response to falling levels of student engagement with science has led to the response of the Australian School Innovation in Science, Technology and Mathematics (ASISTM) initiative involving partnerships between schools and community and industry organisations in developing curriculum projects at the local level.

Tytler, R., Symington D., Kirkwood V., & Malcolm C. (2008). *Engaging students in authentic science through school--community links: learning from the rural experience*, *Teaching Science: The Journal of the Australian Science Teachers Association*, 54(3), 13-18.

A discussion paper on the rural school and community linked initiatives that better engage students with school science.

Vandyck, I., Graaff, R., Pilot, A., & Beishuizen, J. (2012). *Community building of (student) teachers and a teacher educator in a school-university partnership*, *Learning Environments Research*, 15, 299-318.

This study focused on the collaboration process of a team of modern language teachers who work and learn together in a teacher community. The aim of this study was to investigate how to design a learning environment that stimulates community development in these teams, applying the cooperative learning model of Johnson and Johnson in learning together and alone: cooperative, competitive, and individualistic learning.

Van Huet, S. (2007). Taking small group, teacher directed, student-focussed experiential learning into secondary schools, *LabTalk*, 51(4), 12-13.

A brief case study of pre-service primary science teacher interaction in the classroom.

Varma, T. & Hanuscin, D.L. (2008). Pre-Service Elementary Teachers' Field Experiences in Classrooms Led by Science Specialists, *Journal of Science Teacher Education*, 19(6), 593-614.

The purpose of this study was to examine the experiences of preservice elementary teachers in a content-specific field-based experience with elementary science specialists.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.

This book presents a theory of learning that starts with the assumption that engagement in social practice is the fundamental process by which we get to know what we know and by which we become who we are. The primary unit of analysis of this process is neither the individual nor social institutions, but the informal 'communities of practice' that people form as they pursue shared enterprises over time. To give a social account of learning, the theory explores in a systematic way the intersection of issues of community, social practice, meaning, and identity. The result is a broad framework for thinking about learning as a process of social participation. This ambitious but thoroughly accessible framework has relevance for the practitioner as well as the theoretician, presented with all the breadth, depth, and rigor necessary to address such a complex and yet profoundly human topic.

Yin, R.K. (2009). Student achievement data and findings, as reported in math and science partnerships' annual and evaluation reports, *Journal of Educational Research & Policy Studies*, 9, 141-163.

This article describes one of three complementary assessments of K-12 student achievement being conducted by the Math and Science Partnership Program Evaluation.

Zeichner, K. (2010). Rethinking the connections between campus courses and field experiences in college- and university-based teacher education, *Part of a special issue: Bold Ideas for Improving Teacher Education and Teaching*, 61(1/2), 89-99.

This article examines a variety of work currently going on across the country in newly created hybrid spaces to more closely connect campus courses and field experiences in university-based preservice teacher education. It is argued that the old paradigm of university-based teacher education where academic knowledge is viewed as the authoritative source of knowledge about teaching needs to change to one where there is a nonhierarchical interplay between academic, practitioner, and community expertise. It is argued that this new epistemology for teacher education will create expanded learning opportunities for prospective teachers that will better prepare them to be successful in enacting complex teaching practices.

Zimpher, N.L., & Howey, K.R. (2005). The politics of partnerships for teacher education redesign and school renewal, *Journal of Teacher Education*, 56, 266-271.

A paper from the United States on obstacles to achieving successful partnerships in the K-12 sector.

Reflection

Time to reflect and debrief both individually and collectively form a key element of the school-based approach. Reflection leads to deep learning, and a rethinking of one's attitude towards science, the teaching of science, and themselves as professional and reflective practitioners. All key stakeholders benefit from reflection on the partnership practices. Through course assessment and evaluation, the model's applicability to the primary school network and its success in delivering clear learning outcomes is an area of awareness for all partners.

Abell, S., Bryan, L.A., & Anderson, M.A. (1998). Investigating preservice elementary science teacher reflective thinking using integrated media, *Journal of Science Education*, 82, 491- 510.

This paper undertakes an investigation of the reflective thinking of preservice elementary teachers on teaching and learning science, with regards to integrated media-based instruction. The methods used in the research undertaken here incorporate the comparison of the process of developing thinking about teaching and learning to the process of conceptual change in learning science. As a result of the preservice teachers' responses to reflection tasks used in this research, a profile of images of preservice teachers as future teachers was developed. The findings from this paper led to reforms in how course instruction was delivered and had implications for preparing elementary science teachers and the ongoing education of science teachers.

Jones, M., & Ryan, J. (2014). Learning in the practicum: engaging pre-service teachers in reflective practice in the online space, *Asia-Pacific Journal of Teacher Education*, 42, 132-46.

This paper argues that online discussion is a useful tool for creating opportunities for learning in teacher education. The researchers here placed pre-service teachers undertaking practicum in rural areas in two different moderated online discussion forums. One, an unstructured personal blog space and the other, a structured threaded discussion forum where discussion topics guided them to reflect on their practicum experiences in relation to theoretical components of their studies. The findings here indicated a marked difference in the contributions made to each form of online discussion with significantly greater participation in the unstructured blog format. Using Kreber and Cranton's hierarchy of reflection, analyses of both forums found that PSTs rarely engaged in high-level reflection. In a vital component of teacher education, the study results ensured the researchers were left to consider ways in which the practicum experience can better promote reflective practice.

Kenny, J.D. (2012). University-school Partnerships: Pre-service and in-service teachers working together to teach primary science, *Australian Journal of Teacher Education*, 37, (3), Article 6. Available at: <http://ro.ecu.edu.au/ajte/vol37/iss3/6> .

This paper follows an earlier paper by Kenny and reports on a partnership approach preparing pre-service primary teachers to teach science. Partnerships involving pre-service teachers and volunteer in-service colleagues were formed to teach science in the classroom of the colleague, with support from the science education lecturer. Each pre-service teacher

collaboratively planned and delivered a sequence of at least six science lessons over six weeks.

LeCornu, R., & Ewing, R. (2008). Reconceptualising professional experiences in pre-service teacher education...reconstructing the past to embrace the future, *Teaching & Teacher Education*, 24, 1799-1812.

This paper provides a conceptual framework for developing high-quality professional experiences for pre-service teachers. The paper begins with a discussion of how professional experiences are conceptualised, structured and supervised in each of three orientations, which we have termed traditional, reflective and learning communities. It also describes a number of professional experience initiatives at two Australian universities, which are being reconceptualised around the notion of learning communities.

Perry, C.M., & Power, B.M. (2004). Finding the truths in teacher preparation field experiences, *Teacher Education Quarterly*, 31, 125-136.

Here, the writers discuss how and why they changed the field experience and student teaching element of their teacher preparation program to allow pre-service teachers, their mentors, and the teacher educators to engage in inquiry, develop practical knowledge, and grow as reflective teachers.

Pietsch, M., & Williamson, J. (2010). "Getting the pieces together": Negotiating the transition from pre-service to in-service teacher, *Asia-Pacific Journal of Teacher Education*, 38, 331-344.

This paper explores the difference in knowledge growth between beginning teachers who commence teaching in fragmented teaching situations in the first two years of teaching, and their colleagues who have stable, secure and continuing employment during this time. This paper argues that the employment context in which beginning teachers take up their profession has a significant, but hitherto largely unacknowledged, effect on the capacity of teachers to develop the craft of teaching; on their continuing commitment to the profession; and on their self-confidence and self-image as teachers.

Watson, L., Woolnough, J., Hay, I., Hellyer, L. & Stuckey, D. (2013). Challenging the theory/practice divide in higher education: The teaching clinics model of work-integrated in (eds.) Goodenough, K., Galway, G., Badenhorst, C. & Kelly, R. *Inspiration and innovation in teaching and teacher education*, Lexington Books, Plymouth U.K.

This chapter examines a form of work-integrated learning developed at the University of Canberra. The 'teaching clinic' model challenges the traditional model of professional experience by embedding university lecturers in workplaces with their students.

van Driel, J. (2010). Teaching together and learning together - Primary science student teachers' and their mentors' joint teaching and learning in the primary classroom, *Teaching & Teacher Education*, 26, 1309-1318.

This paper focuses on what and how primary science student teachers and their mentors learn from planning and reflecting together on each other's science lessons for pupils aged 7-9. The student teachers had had training in scientific knowledge, but only brief experience of teaching. The mentors were well experienced in the pedagogy of teaching and mentoring, but did not feel confident about their science content knowledge and the teaching of science.

Throughout the process of teaching and reflecting together the student teachers and the mentors expressed several specific examples of their joint learning.

Zeichner, K. (1990). Changing directions in the practicum: Looking ahead, *Journal of Education for Teaching*, 16, 105.

Discusses several types of reported innovations in the practicum and examines these innovations in terms of how well they appear to offer promise of overcoming the obstacles to teacher learning. Obstacles to teacher learning; Teaching as an applied science; Teaching as a reflective practice; The school and community practicum; Establishing professional development/clinical/high activity school; Altering the structural context of the practicum.

Confidence and identity

The school-based approach model leads to improved pre-service teacher confidence. It facilitates real and authentic experiences of planning, implementing and evaluating quality lessons, whilst allowing pedagogy and learning theory, as well as science theory, to be employed in teaching. Another benefit is uplifting confidence in existing teachers who can draw upon new teaching ideas from University staff and pre-service teachers working in school. The school-based approach model challenges stereotypes attached to scientists who are often viewed as lab-coat wearing, wild-haired, bespectacled old men who experiment with, and explode, chemicals. Notions of self-efficacy and identity come under consideration here.

Akkus, H. (2013). Pre-service secondary science teachers' images about themselves as science teachers, *Journal of Baltic Science Education*, 12, 249-60.

This paper explores pre-service secondary science teachers' images of themselves as science teachers. The association between instructional style, and domains was explored. 130 secondary science teachers (biology, chemistry and physics) from 26 public universities participated in the data collection for this study. A 'Draw a Science Teacher Test Checklist' was used as a data collection instrument. The results of study showed that pre-service science teachers' images is 24.62% student-centred, 53.85% between student and teacher-centred, and 21.4% teacher-centred teaching style approaches. A significant association was found between domain and instructional style. Pre-service chemistry teachers were more willing to use student-centred teaching style rather than pre-service biology and pre-service physics teachers.

Dawson, V. (2007). Factors influencing pre-service teachers' decisions to become secondary science and mathematics teachers, *Teaching Science: The Journal of the Australian Science Teachers Association*, 53(4), 28-31.

Drawing upon numerous reports, this paper considers future shortages in science and mathematics teacher numbers. It aims, through contact with existing pre-service teacher cohorts, to identify ways in which retention of pre-service teachers can be achieved.

Di Lisi, G.A., McMillin, K.A., & Virostek, M.E. (2011). Project WISE: Building STEM-Focused youth-programs that serve the community, *Journal of STEM Education: Innovations and Research*, 12(5-6), 38-45.

The design and implementation of Project WISE, a multi-institutional partnership that assembles interdisciplinary teams of undergraduate and high school students charged with developing STEM-focused community youth-programs is the focus of this paper. Notions of self-efficacy are considered here.

Duran, E., & Duran, L.B. (2005). Project ASTER: A model staff development program and its impact on early childhood teachers' self-efficacy, *Journal of Elementary Science Education*, 17 (2), 1-12.

In this paper, the authors describe a model of professional development for early childhood science teachers based on their experiences over the past two years with Project ASTER:

Active Science Teaching Encourages Reform. The model described here emphasised enabling the teachers to become engaged with strategies that consist of ongoing processes rather than "one-shot" workshops. In addition, this study sought to explore the impact of the ASTER model of professional development on teacher self-efficacy and perceptions about science teaching.

Fittell, D. (2010). *Inquiry-based science in a primary classroom: professional development impacting practice*, Queensland University of Technology.

A Master's thesis examining teacher confidence to teach science and the introduction of Primary Connections material as a professional learning program which supports the delivery of effective science teaching .

Gilbert, A. (2009). Utilizing science philosophy statements to facilitate K-3 teacher candidate's development of inquiry-based science practice, *Early Childhood Education Journal*, 36(5), 431-438.

This study utilised pre-service teachers' philosophy statements to connect their beliefs for science teaching with inquiry-based constructivist classroom practice. This study addresses a method to engage prospective teachers in designing inquiry-based science pedagogy as well as developing their professional pedagogical confidence.

Gilbert, A. (2013). Using the notion of 'wonder' to develop positive conceptions of science with future primary teachers, *Science Education International*, 24, 6-32.

A common challenge for many primary pre-service teacher educators is to rekindle interest in science content with future teachers who often express a lifetime of negative associations with school science. This pilot study investigated if the notion of wonder could be utilized with preservice teachers as a vehicle to develop more positive conceptions of science. The results of utilizing a wonder framework with adult students offered promising results. This study further argues that we may need to conceptualize school science as not just a way to understand the world but also to clearly demonstrate that it is a field of inquiry that is sustained by mystery, beauty and wonder.

Gupta, P. (2009). *Identity Development in Pre-Service Teachers Who Are Explainers in a Science Center: Dialectically Developing Theory and Praxis*, PhD Thesis, The City University of New York.

This thesis examines how teaching in a hands-on science centre contributes to shaping one's teaching identity.

Hamel, F.L., & Ryken, A.E. (2010). Rehearsing professional roles in community: teacher identity development in a school-university partnership, *Teacher Development*, 14, 335-350.

Here, a description of a school-university relationship which aims to sustain dialogue between educators who are positioned differently in relation to pre-service teacher growth is provided. The authors distinguish an 'intentional partnership' model from other approaches to school-university collaboration, providing a rationale for their focus on identity development and dialogue.

Hobbs, L. (2012). Examining the aesthetic dimensions of teaching: Relationships between teacher knowledge, identity and passion, *Teaching & Teacher Education*, 28, 718-727.

Hobbs uses empirical data to explore the nature of a Deweyian inspired framework called 'Aesthetic Understanding to scrutinise relationships between teacher and knowledge identity and passion.

Hobbs, L. (2012). Teaching out-of-field: Factors shaping identities of secondary science and mathematics, *Teaching Science: The Journal of the Australian Science Teachers Association*, 58, 271-297.

The acceptance of teacher shortages in science and mathematics, leading to teachers teaching in fields which they are not qualified to teach is the focus of this paper. The author's research along with others is drawn upon here to consider the teacher's perspective of this issue and to identify implications of policy and practice around school governance, funding and teacher development.

Hobbs, L. (2014). Boundary crossings of out-of-field teachers: Locating learning possibilities amid disruption in (eds.) Langan-Fox, J. and Cooper, C.L., *Boundary-Spanning in Organisations*, (pp. 7-28), New York, Routledge.

Hobbs, following on from her 2012 paper, further explores the issues associated with teaching out-of-field and its implications for science teaching.

Hudson, P. (2003). Mentoring first-year pre-service teachers of primary science, *Action in Teacher Education*, 25, 91-99.

Through the use of a literature-based survey the perceptions of mentoring and primary science teaching were collected and analysed to gain an understanding of mentoring practices. Issues associated with mentoring form the key themes of this paper.

Jane, B., Fler, M., & Gipps, J. (2007). Changing children's views of science and scientists through school-based teaching, *Asia-Pacific Forum on Science Learning and Teaching*, 8, 1-21.

This study examined how children view scientists. Through the collection of a variety of data, it showed that when a child is viewed in a communal context and engages in relevant hands-on science activities, a child's view of what constitutes scientist is challenged with many developing the belief that they are a rudimentary scientist.

Jantarakantee, E., Roadrangka, V., & Clarke, A. (2012). Pre-service science teachers' understandings of classroom research and the problems in conducting classroom research projects, *US-China Education Review*, 112-120.

This research paper explores pre-service science teachers' understandings of classroom research, problems in conducting classroom research and the supports that pre-service science teachers need from their cooperating teachers to help them conduct a classroom research project during the internship period. Pre-service science teachers would like recommendations from their cooperating teachers more frequently for promoting the pre-service science teachers' confidence and efficiency in their chosen classroom research projects.

Lakshmanan, A., Heath, B.P., Perlmutter, A., & Elder, M. (2011). The impact of science content and professional learning communities on science teaching efficacy and standards-based instruction, *Journal of Research in Science Teaching*, 48, 534-551.

This study examines the impact of standards-based professional development on teacher efficacy and instructional practice of elementary and middle school science teachers. Professional development activities were conducted over a period of 3 years and included content courses as well as teacher involvement in professional learning communities.

Leavitt, D.R., Babst, R.D., Lampkin, J.L., Whitford, P.A., Palius, M.F., Donegan, R., & Smith, M. (2013). Teachers create a professional learning community to be a place of their own, *Mid-Atlantic Education Review*, 1, 3-16.

In 2012, seven New Jersey middle school mathematics teachers volunteered to lead an afterschool Professional Learning Community. The teachers set the meeting format, selected topics, and rotated facilitation of six 90-minute sessions. A university researcher, working within a National Science Foundation-sponsored Mathematics/Science Partnership, designed the project to investigate how, if at all, these activities would enhance teachers' leadership. The researcher videotaped the teachers' meetings, elicited written reflections, conducted interviews, and analysed these data. Emergent themes included cohesiveness, commitment, focus on practice, respectful participation in controversies, changes in confidence and leadership.

Logerwell, M.G. (2009). *The effects of a summer science camp teaching experience on preservice elementary teachers' science teaching efficacy, science content knowledge, and understanding of the nature of science*, Doctoral Thesis.

The purpose of this study was to investigate the impact of a summer science camp teaching experience on pre-service elementary teachers' science teaching efficacy, science content knowledge, and understanding of the nature of science.

Martini, M. & George, M. (2001). 'That's what scientists have to do': preservice elementary teachers' conceptions of the nature of science during a moon investigation, *International Journal of Science Education*, 23, 1095-1109.

An example of a science methods course for elementary education majors. Students were viewed separating the processes of observation from creating explanations in their learning without articulating the role of invention in science.

McKinnon, M., & Lamberts, R. (2014). Influencing science teaching self-efficacy beliefs of primary school teachers: A longitudinal case study, *International Journal of Science Education, Part B: Communication and Public Engagement*, 4, 172-194.

The purpose of this research was to determine if informal education institutions, such as science centres, could provide professional development that influences the science teaching self-efficacy beliefs of pre-service and in-service primary school teachers. The informal science education sector could be the key to achieving long lasting reform in science education where other, formal measures have failed.

Morgan, A-M. (2012). "Me as a science teacher": Responding to a small network survey to assist teachers with subject-specific literacy demands in the middle years of schooling, *Australian Journal of Teacher Education*, 37 (6), 73-95.

Middle years' teachers in primary schools are increasingly required to teach curriculum-specific subjects at a depth requiring considerable content and pedagogical knowledge, as

well as a detailed understanding of the particular literacy requirements specific to each subject. Science teaching, in the latter years of primary schooling, is particularly demanding for non-specialist teachers. Many teachers struggle with feelings of (in)adequacy and (in)competence to be "science literate" and "good" science teachers, providing sufficient and valuable science learning opportunities for their learners. This paper describes one primary school's attention to teachers' feelings of wellbeing and competence in relation to themselves as science teachers.

Pinner, P.C. (2014). *Efficacy development in science: Investigating the effects of the teacher-to-teacher (T2T) professional development model in Hilo elementary schools*, PhD Thesis.

The purpose of this research was to describe the changes in efficacy elementary teachers experience as they participated in science professional development.

Powell-Moman, A.D., & Brown-Schild, V.B. (2011). *The influence of a two-year professional development institute on teacher self-efficacy and use of inquiry-based instruction*, *Science Educator*, 20, 47-53.

This paper investigates the impact of a two-year professional development program on teacher self-efficacy for inquiry based instruction. The program utilizes scientist-teacher partnerships to develop content knowledge, inquiry based instruction, and leadership skills for in service STEM teachers.

Shanahan, T., & Shea, L. (2012). *Incorporating English language teaching through science for K-2 teachers*, *Journal of Science Teacher Education*, 23, 407-428.

Teachers require higher quality and new forms of professional development to learn and meet the needs of their students. This study examines the impact of one professional development model that explicitly embedded language learning strategies into science inquiry lessons. It also demonstrates how teachers involved in the PD program improve their self-efficacy about language instruction embedded in content and how they interpret and implement the methodology.

Shell, D.F., Snow, G.R., & Claes, D.R. (2011). *The cosmic ray observatory project: Results of a summer high-school student, teacher, university scientist partnership using a capstone research experience*, *Journal of Science Education and Technology*, 20, 161-177.

This paper reports results from evaluation of the Cosmic Ray Observatory Project (CROP), a student, teacher, scientist partnership to engage high-school students and teachers in school based cosmic ray research.

Taylor, N., & Corrigan, G. (2005). *Empowerment and confidence: Pre-service teachers learning to teach science through a program of self-regulated learning*, *Canadian Journal of Science, Mathematics & Technology Education*, 5, 41-60.

This paper follows on from an earlier study exploring the implementation of a program of self-regulated learning with a small group of pre-service teachers in an elementary science course. A first year cohort of nineteen pre-service teachers was exposed to a thirteen week program of self-regulated learning in science education in two stages. The program offered

students substantial flexibility and freedom in what they investigated and the methodology they adopted coupled with ongoing support as required. By the end of the program, the majority of students involved in the study reported a more positive attitude to science and significantly enhanced confidence in their ability to teach elementary science. Although difficult to measure, students believed that they were more competent to teach primary science. Furthermore, they were able to identify aspects of the SRL environment that had contributed to this change in attitude.

Wingfield, M., Nath, J.L., Freeman, L., & Cohen, M. (2000). *The effect of site-based preservice experiences on elementary social studies, language arts, and mathematics teaching self-efficacy beliefs*, Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 24-28, 2000).

This study examined the effectiveness of a Professional Development School (PDS) student teaching program within one university's teacher education program. The program is field-based during students' entire senior year, which is divided into a PDS semester and student teaching.

Science teaching/science education

Making science teaching 'real' for pre-service teachers is inherent in the school-based approach model. It takes tertiary level science teaching out of the lecture theatre and into the school classroom. This is complimented by school students who bring knowledge to the classroom, which is then supported with new concepts involving deep thinking and cross curriculum integration. The mention of 'science' to school students is generally met with reactions of excitement particularly as science involves hands-on learning. Science becomes valued and rewarding to all involved in the lesson. There is immediate value to the classroom teacher as their personal development is supported by providing ideas for teaching science.

Abell, S.K. (2008). The design, enactment, and experience of inquiry-based instruction in undergraduate science education: A case study, *Science Education*, 92, 591-607.

This paper details a study seeking to understand undergraduate inquiry-based instruction through the words and actions of students and instructors. The paper is a demonstration of the achievability of inquiry-based instruction in undergraduate science education and it draws upon field notes from the work of student groups, and instructors whilst also using laboratory manuals, lecture handouts and a course syllabus.

Atwood-Blaine, D., & Bowman, R. (2010). *Improving K-12 climate science education through collaborations with scientists*, Conference paper: Proceedings 2010 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2010), Piscataway, NJ, USA; Honolulu, HI, USA. Country of Publication: USA.

The Center for Remote Sensing of Ice Sheets (CReSIS) is a National Science Foundation Science and Technology Center based at the University of Kansas that concentrates its research on understanding the role of the polar ice sheets in sea level rise as a response to global climate change. Two primary objectives of the Center's Education Program are to excite K-12 students about science and to enhance K-12 foundational skills necessary to pursue further education in STEM fields.

Bolyard, J.J., & Moyer-Packenham, P.S. (2008). A review of the literature on mathematics and science teacher quality, *Part of the special issue on the Math and Science Partnership Program*, 83, 509-535.

This review specifically examines teacher quality as it relates to mathematics and science teaching and learning. The review highlights key policy and practitioner perspectives, provides a focused synthesis on current research findings on mathematics and science teacher quality, and suggests areas of research that are limited in the literature.

Brown, P., Abell, S.K., Demir, A., & Schmidt, F.J. (2006). College science teachers' views of classroom inquiry, *Science Education*, 90, 784-802.

The aim of this paper was twofold. Firstly, to gain an understanding of the views of inquiry held by faculty members involved in undergraduate science teaching and secondly, to describe the challenges, constraints, and opportunities that they perceived in designing and teaching inquiry-based laboratories. The notion that inquiry is more appropriate for higher level of science majors is accounted for here.

Bryan, L., & Bodner, G.M. (2013). Secondary science teachers' development of pedagogical content knowledge as result of integrating nanoscience content in their curriculum, *Cosmos*, 8, 187-209.

In a rapidly developing field of science and research combining engineering, chemistry, biology and IT, the need for K-12 teachers to understand this field is discussed in this paper. The theme here is that it is becoming incumbent upon K-12 teachers and undergraduate educators to learn to teach nano-scale science. This paper poses numerous questions including how science teachers learn to this in this field.

Carr, M., & Symington, D. (1991). The treatment of science discipline knowledge in primary teacher education, *Research in Science Education*, 21, 39-46.

This paper takes the science concepts of floating and sinking and asks science teachers what knowledge they should have to enable them to effectively handle this topic in a primary classroom in a way consistent with constructivist ideas. It also addresses the issue of how the knowledge that is taught to school students could be assessed.

Cooper, G, Kenny, J., Fraser, S. (2012). Influencing intended teaching practice: exploring pre-service teachers' perceptions of science teaching resources, *International Journal of Science Education*, 34, 1883-1908.

A discussion on the poor science background and low confidence that students bring to delivering science education to primary students. This paper discusses the merits of the Primary Connections material, a series of learning resources developed by the Australian Academy of Science. It concludes by investigating the effectiveness of these teaching materials and how quality teaching resources can be embedded within a program of teacher education designed to encourage and support pre-service teachers to embrace science teaching.

Darby, L. (2007). Experiencing relevant mathematics and science through story, *Teaching Science: The Journal of the Australian Science Teachers Association*, 53(3), n.p.

This paper shows how mathematics and science can be made more meaningful and appropriate to students' lives through exploring the need for a teacher to understand the relevance of the lesson to the student. It compares maths and science and 'relevance' of each is thought of across disciplines as is the problems associated with moving between mathematics and science.

Darby, L. (2009). Translating a "relevance imperative" into junior secondary mathematics and science pedagogy, *Eurasia Journal of Mathematics, Science & Technology Education*, 5, 277-88.

The notion of 'relevance imperative' is considered here through interview data and classroom excerpts in the context of junior secondary teaching. The incorporation of the notion of 'relevance imperative' into contemporary rhetoric surrounding quality education is apparent here. Teaching out-of-field is discussed and how teachers at secondary level are considered subject specialists.

Darby-Hobbs, L. (2011). Responding to a relevance imperative in school science and mathematics: Humanising the curriculum through story, *Research in Science Education*, 43, 77-97.

A further paper to Darby's 2009 paper on the 'relevance imperative' in which Darby-Hobbs considers how this imperative is translated into mathematics and science teaching in the junior secondary years. Making mathematics and science relevant to the school student is key here and through the discussion of relevance, as well as mathematics and science literature becoming more 'humanistic', the author argues for the notion of relevance to be expanded.

Elmore, R. F. (1979). Field-based teacher education: How far do we go? *Education*, 99, 378-380.

This article describes some of the problems which may arise in the development and implementation of the implementation of the field based component of teacher education. It includes poor supervising teacher role models, inferior school programs, schools who utilise the PST as a clerical aide, college interference in and domination of local school curriculum and additional expense and management problems for colleges and schools.

Feldman, P. & Kent, M. (2006). A collaborative effort: Bridging theory and practice in pre-service preparation, *The New Educator*, 2, 277-288.

This article presents: (1) teacher educators with a field-based clinical model for preparing pre-service teacher education candidates; (2) classroom teachers with effective mentoring strategies; and, (3) public school and university administrators strategies for working with a more authentic model of teacher preparation that requires deep and rich clinical field experiences to help novice teachers become more effective in today's schools.

Fittell, D. (2010). *Inquiry-based science in a primary classroom: professional development impacting practice*, Queensland University of Technology.

A Masters thesis examining teacher confidence to teach science and the introduction of Primary Connections material as a professional learning program which supports the delivery of effective science teaching

Freeman, B. (2010). *Science, mathematics, engineering and technology (STEM) in Australia: Practice, policy and programs*, Centre for the Study of Higher Education.

A report into the programs at federal and state level designed to support school-level science.

Gunstone, R.F. (1989). *Learning about learning To teach: A case study of pre-service teacher education*, A conference paper presented at the Annual general meeting of the American Educational Research Association.

This conference paper reflects upon a 3-year longitudinal study which has two strands, both of which are concerned with understanding better the complexities of teaching and learning science, knowing more of the processes by which individuals change, and understanding more of the research methodologies appropriate for these purposes. One strand involves a collaboration between researchers and secondary school teachers. The second strand involved a group of science graduates who undertook a one year pre-service education course during which an intensive case study of the development of the members of the group was undertaken.

Hardy, T., & Kirkwood, V. (1994). Towards creating effective learning environments for science teachers: the role of a science educator in the tertiary setting, *International Journal of Science Education*, 16, 231-51.

This paper considers the role of the science education tutor and is based on the experiences of the authors' work across pre- and in-service courses for primary and secondary teachers' courses.

Hudson, P. (2006). Exploring a four-step science teaching and learning sequence for sustainable living. *Teaching Science*, 52(1), 39-41.

Science education for sustainable living is a new area of education that requires exploring teaching and learning models. A four-step sequence for understanding sustainable living issues was used with 14 pre-service teachers and two classes of middle school students. The Year 6 and 7 students were required to identify an issue, explore its associated concepts, record and articulate their understandings, and finally, brainstorm realistic solutions and/or future projects. Two issues are reported here: sustaining frog habitats and the effects of chemicals on water. The pre-service teachers reflected on their practices and provided suggestions for improving pedagogy.

Jones, M.M., & McLean. K.J. (2012). Personalising learning in teacher education through the use of technology, *Australian Journal of Teacher Education*, 37, 75-92.

A consideration of the impact that ICT has upon enabling personalised learning. The findings of this research support the notion that meaningful student learning experiences can be achieved through a personalised approach which also supports the emerging tenets of effective, pedagogical use of ICT for learning.

Kennedy-Clark, S. (2011). Pre-service teachers' perspectives on using scenario-based virtual worlds in science education, *Computers and Education*, 57, 2224-2235.

This study examined the use of virtual environments in science education and the willingness of pre-service teachers to use virtual worlds to support teaching. It also highlights the advantages and disadvantages of the use of virtual worlds in the classroom setting.

Kenny, J., & Colvill, M. (2008). Primary science: Professional learning and curriculum development in Northern Tasmania, *Teaching Science*, 54, 35-8.

This paper reports on the results of a survey of primary teachers who attended a series of three 14 day workshops that focused on primary science activities concerned with two key outcome areas from the Tasmanian Essential Learnings curriculum: Investigating the Natural and Constructed World and Inquiry.

Kidman, G. (2012). Australia at the crossroads: A review of school science practical work, *EURASIA Journal of Mathematics, Science & Technology Education*, 8, 35-47.

This paper is an historical account of the development of curriculum to the implementation of the first truly Australian National Curriculum. It also identifies seven forms of practical work used in Australian schools and the purposes aligned with each form.

Kirbulut, Z.D., Boz, Y., & Kutucu, E.S. (2012). Pre-service chemistry teachers' expectations and experiences in the school experience course, *Australian Journal of Teacher Education*, 37(2), 41-57.

Prospective chemistry teachers' expectations and experiences of teaching practice are considered here. The outcome of this study was that school experience courses are crucial for pre-service teachers in deciding whether to continue in the teaching profession. It was also concluded that the harmony between pre-service teachers' expectations of and experiences in

the school experience course had an influence on their opinions related to the teaching profession.

Mansfield, C.F., & Volet, S.E. (2014). Impact of structured group activities on pre-service teachers' beliefs about classroom motivation: an exploratory study, *Journal of Education for Teaching, 40*, 155-172.

This study was designed to provide pre-service teachers with the chance to develop their existing beliefs about classroom motivation in peer interaction. The findings indicate that pre-service teacher' initial beliefs about classroom motivation can be consolidated and expanded through engagement in semi-structured collaborative learning activities that induce in-depth reflection and examination of beliefs, and in authentic problem-solving situations that connect with theory.

McCrea, E. J., & deBettencourt, K. (2000). *Environmental studies in the K-12 classroom: A teacher's view*, Maryland University, College Park Survey Research Center.

This report considers how environmental education occurs in the K-12 classroom and seeks to understand how teachers incorporate education about the environment into the classroom. It also asks how environmental subjects are taught and if they form part of an integrated curriculum.

Mulholland, J., & Wallace, J. (2003). Crossing borders: learning and teaching primary science in the pre-service to in-service transition, *International Journal of Science Education, 25*, 879-898.

A case study of the transition from pre-service to in-service teaching of two Australian primary science teachers over a four-year longitudinal study is considered here. Using Aikenhead's (2006) framework, the teachers' change and professional growth is reflected upon as are the hazards encountered by the teachers when they cross sub-cultural borders as part of their experience.

Mursky, C.V. (2008). *Science fair mentors: The relationship between pre-service teacher mentors and elementary school students*, PhD thesis, ProQuest Information & Learning.

A study of mentorships between pre-service teachers and student who are experiencing a high level of poverty.

Nyberg, L. (2014). Seeding science in elementary schools, *Science & Children, 51*(7), 84-88.

The article examines how science education can be promoted among young students early in their academic careers. Particular attention is given to the educational benefits of developing collaborative relationships between school districts and universities as well as exposing students to scientific concepts beginning in preschool. The author goes on to discuss the use of school gardens and professional learning communities.

Odgers, B.M. (2007). Elementary pre-service teachers' motivation towards science learning at an Australian university, *International Journal of Learning, 14*, 201-206.

The results of a questionnaire and subsequent research undertaken to understand pre-service teachers' motivation to learn science.

Orion, N., & Thompson, D. (1999). Changes in perceptions and attitudes of pre-service postgraduate secondary science teachers: a comparative study of programmes in Israel, England and Wales, *Research in Science & Technological Education*, 17, 165-192.

A comparative research programme involving Israeli and English-Welsh pre-service teacher cohorts. Pre-service secondary science teachers were studied immediately before and after their initial teacher education courses. Data was collected using questionnaires and interviews to develop numerous findings to identify similarities and differences across two cohorts.

Öztürk-Akar, E., & Doğan, D. (2013). Turkish pre-service teachers' views of science technology –society: influence of a history of science course, *Journal of Baltic Science Education*, 12, 793-802.

This research is conducted to explore the pre-service teachers' views of science-technology-society (STS) issues and to investigate the influence of a History of Science (HOS) course on these views. The influence of teaching STS issues through different instructional approaches on the pre-service teachers' views was also examined. Findings revealed that the HOS course and the instructional approach did not have significant influences on the pre-service teachers' STS views.

Pepper, C. (2013). Pre-service teacher perceptions of using problem based learning in science investigations, *Teaching Science*, 59, 23-27.

An article that considers the introduction of problem based learning to a cohort of science education pre-service teachers. The focus here is the enabling of pre-service teachers to engage in a widely used learning and teaching strategy and the strategy's use in aligning university work to professional work.

Preston, C., Gray, A., Fullerton, C., & Riley, J. (2006). Teaching primary science constructively: Experiences of pre-service teachers at Macquarie University, *Teaching Science, The Journal of the Australian Science Teachers Association*, 52(4), 12-15 AND

Preston, C., Mules M., Baker D., & Frost K. (2007). Teaching primary science constructively: Experiences of pre-service teachers at Macquarie University -- Part 2, *Teaching Science: The Journal of the Australian Science Teachers Association*, 53(2), 29-32.

A two part article outlining the approach that encouraged pre-service primary teachers to support the construction of conceptual understanding during the science and technology component of their professional experience practicum.

Redman, C., & O'Mara, L. (2008). *Primary teachers' practices in a demonstration school: The pedagogical uses of websites*, Conference paper delivered at Australian Association for Research in Education (AARE) International Educational Research Conference 2008, Fremantle, W.A.

Rennie, L.J., Goodrum, D. and Hackling, M. (2001). Science Teaching and Learning in Australian Schools: Results of a National Study, *Research in Science Education*, 31(4), 455-498.

This is a report on a large scale study examining the quality of teaching and learning science in Australian schools.

Stohlmann, M., Moore, T.J., & Roehrig, G.H. (2012). Considerations for teaching integrated STEM education, *Journal of Pre-College Engineering Education*, 2, 28-34.

Quality Science, Technology, Engineering, and Mathematics (STEM) education is vital for the future success of students. Integrated STEM education is one way to make learning more connected and relevant for students. There is a need for further research and discussion on the knowledge, experiences, and background that teachers need to effectively teach integrated STEM education.

Symington, D. (1982). Lack of background in science: Is it likely to always adversely affect the classroom performance of primary teachers in science lessons?, *Research in Science Education*, 12, 64-70.

A presentation of data supporting the view that, because there are abilities possessed by some teachers which can, in certain situations, compensate for any lack of scientific knowledge, one cannot make simple conclusions about teacher background.

Symington, D., & Mackay, L. (1991). Science discipline knowledge in primary teacher education: Responses to the discipline review of teacher education in mathematics and science, *Research in Science Education*, 21, 306-312.

This paper describes a study of primary teacher educator reaction to those aspects of the Discipline Review of Teacher Education in Mathematics and Science dealing with early childhood and primary pre-service teacher education. Interviews with two of the authors of the Review are also reported.

Symington, D., & Osborne, R. (1983). *Toward professional development in science education for the primary school teacher. Learning in science project (primary)*, Working Paper No. 119, Waikato Univ, Hamilton Science Education Research Unit.

Based upon a New Zealand Learning in Science project, issues relating to teacher demands and concerns which restrict their development as teachers of science are considered. The movement of concerns about science learning from the concerns of the self to concerns about learners is discussed in detail.

Symington, D., & Tytler, R. (2011). Schools and teachers supporting student open investigations, *Teaching Science: The Journal of the Australian Science Teachers Association*, 57, 8-12.

The role of open investigation in schools is the focus of this paper and how schools can build a culture of investigation.

Taylor, N., & Corrigan, G. (2005). Empowerment and confidence: Pre-service teachers learning to teach science through a program of self-regulated learning, *Canadian Journal of Science, Mathematics & Technology Education*, 5, 41-60.

This paper follows on from an earlier study exploring the implementation of a program of self-regulated learning with a small group of pre-service teachers in an elementary science course. A first year cohort of nineteen pre-service teachers was exposed to a thirteen week program of self-regulated learning in science education in two stages. The program offered students substantial flexibility and freedom in what they investigated and the methodology

they adopted coupled with ongoing support as required. By the end of the program, the majority of students involved in the study reported a more positive attitude to science and significantly enhanced confidence in their ability to teach elementary science. Although difficult to measure, students believed that they were more competent to teach primary science. Furthermore, they were able to identify aspects of the SRL environment that had contributed to this change in attitude.

Teacher Education Ministerial Advisory Group. (2014). *Teacher education ministerial advisory group issues paper*. http://studentsfirst.gov.au/files/temag_issues_paper_-_april_2014_4.pdf.

A paper which identifies issues in teacher education in Australia on a state by state basis. Includes discussion on what is currently occurring with teacher education and a discussion section on what needs to happen.

Tytler, R. (2007). *Re-imagining science education: engaging students in science for Australia's future: Australian Education Review 51*, Australian Council for Educational Research.

A report that examined and challenged current conventions in science education and proposes new directions for science teaching and learning.

Tytler, R., Symington, D., Darby, L., Malcolm, C., & Kirkwood, V. (2011). *Discourse communities: A framework from which to consider professional development for rural teachers of science and mathematics*, *Teaching & Teacher Education*, 27, 871-879.

This paper explores aspects of professional development for teachers of science and mathematics in schools in rural Australia. The study identified a range of issues including tensions between government, school and individual professional learning priorities and their respective responsibilities; the shaping of professional development by rurality; and issues of generic versus subject-specific professional learning. The paper will focus on the needs of teachers, particularly secondary teachers, for subject-specific professional development and the capacity of different professional development approaches for satisfying these needs. The notion of discourse communities is proposed as a framework for considering this issue.

Tytler, R., & Hobbs, L. (2011). *The Australian science curriculum, Primary & Middle Years Educator*, 9(2), 3-10.

The article offers information on the context and quality of science learning and teaching in Australia. It presents analysis on the generative methods of enacting and viewing the science subject. Moreover, it features the widespread concerns related to the quality of teaching of the science curriculum.

Zellermayer, M. (1997). *When we talk about collaborative curriculum-making, what are we talking about?*, *Curriculum Inquiry*, 27, 187-214.

The purpose of this study is to unpack the often taken-for-granted notion of collaborative curriculum-making within the context of writing instruction. The study focuses on a group of writing teachers, participants in a staff development program, who have transformed their view of writing instruction and have come to understand it as an activity of collaborative



curriculum-making. From their stories, we gain a better understanding of the possible dimensions of this complex idea.

Placement

This school-based approach model is part of course/program units not normally linked to the traditional 'placement'. Having pre-service teachers teaching science as a specific unit/course within their teacher education course/program provides a school based experience that cannot be gained in the University environment. The intense focus on a teaching domain and groups of school students ensures relationships and rapport are built with school students. This is supported by tutors and teachers who observe and support the pre-service teacher to deliver the unit of work. Obstacles can impede the success of the model relating to timetabling both in a school and in the University environment. However, this time in schools, which is in most cases additional to the traditional 'placement', provides pre-service teachers with excellent preparation to move into teaching.

Laidlaw, K.-R., Taylor, N., Fletcher, P. (2009). Teaching primary science in rural and regional Australia: Some challenges facing practicing and pre-service teachers, *Journal of Science and Mathematics Education in Southeast Asia*, 32, 105-130.

The issues associated with teaching in rural and regional Australia are considered in this paper. Issues relating to confidence in science teaching associated with pedagogical knowledge, insufficient resources, time constraints and limited Professional Development opportunities are all seen as determinants of why pre-service and in-service primary teachers face difficulties in teaching science.

Feedback about the model

To develop the school-based approach model, feedback from all partners is essential. There are high levels of positive feedback for the model and an appreciation by school teachers of the planning, preparation and flexibility demonstrated by pre-service teachers. Contact between school teacher and pre-service teacher prior to the placement needs consideration as well as formalising debriefing opportunities. Attention also needs to be given to establishing appropriate levels of classroom teacher involvement for when pre-service teachers are in the school classroom.

Campbell, C., Chittleborough, G., Hubber, P., Tytler, R., Jobling, W., Cripps-Clark, J., Barraza, L., & Herbert, S. (2012). *Primary science specialist learning program – report of delivery*, Melbourne, Department of Education and Early Childhood Development Victoria.

Report for government.

Smith, D. (2008). *Review of the professional experience in teacher education programs in the School of Education at Deakin University*.

Report.



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