
© Copyright 2008 please contact the authors
Transfer of learning across the globe: Pre-service teachers taking the initiative

Gillian Kidman1, Andrew Lanning1*, Peter Sercombe1*, Amy Brunner2, Stephen Fonash2

1 Queensland University of Technology, *Undergraduate pre-service teacher
2 Center for Nanotechnology Education and Utilization, The Pennsylvania State University, Pennsylvania, USA

Email: g.kidman@qut.edu.au

A continuing challenge for pre-service teacher education is the learning transfer between the university based components and the practical school based components of their training. It is not clear how easily pre-service teachers can transfer university learnings into ‘in school’ practice. Similarly, it is not clear how easily knowledge learned in the school context can be disembedded from this particular context and understood more generally by the pre-service teacher. This paper examines the effect of a community of practice formed specifically to explore learning transfer via collaboration and professional enquiry, in ‘real time’, across the globe. “Activity Theory” (Engestrom, 1999) provided the theoretical framework through which the cognitive, physical and social processes involved could be understood. For the study, three activity systems formed community of practice network. The first activity system involved pre-service teachers at a large university in Queensland, Australia. The second activity system was introduced by the pre-service teachers and involved Year 12 students and teachers at a private secondary school also in Queensland, Australia. The third activity system involved university staff engineers at a large university in Pennsylvania, USA. The common object among the three activity systems was to explore the principles and applications of nanotechnology. The participants in the two Queensland activity systems, controlled laboratory equipment (a high powered Atomic Force Microscope – CPIII) in Pennsylvania, USA, with the aim of investigating surface topography and the properties of nano particles. The pre-service teachers were to develop their remote ‘real time’ experience into school classroom tasks, implement these tasks, and later report their findings to other pre-service teachers in the university activity system. As an extension to the project, the pre-service teachers were invited to co-author papers relating to the project. Data were collected from (a) reflective journals; (b) participant field notes – a pre-service teacher initiative; (c) surveys – a pre-service teacher initiative; (d) lesson reflections and digital recordings – a pre-service teacher initiative; and (e) interviews with participants. The findings are reported in terms of the major themes: boundary-crossing, the philosophy of teaching, and professional relationships. The findings have implications for teacher education. The researchers feel that deliberate planning for networking between activity systems may well be a solution to the apparent theory/practice gap. Proximity of activity systems need not be a hindering issue.

Background Information

A continuing issue for tertiary educators, and pre-service teachers alike, is the articulation between university classes where the pre-service teacher is the user of knowledge, and the practical school setting where the pre-service teacher is the imparter of knowledge. It is not clear how easily pre-service teachers can transfer university learnings into ‘in school’ practice. Similarly, it is not clear how easily knowledge, both contextual content and pedagogical knowledge, learned in the school can be disembedded from this particular context and understood more generally by the pre-service teacher. This paper explores the problems of transfer between the university setting and school setting for pre-service secondary science teachers. It considers the framework of Activity Theory followed by its application in a school-university partnership. The paper explores how boundary crossing individuals construct knowledge and identities to ease transfer problems.

Boundary crossing

Tsui and Law (2007) claim “It is no longer sufficient for an individual to acquire expertise within the boundary of one’s own discipline or profession” (p, 1289). Tsui and Law further claim one must engage meaningfully with members of other communities of practice and move freely between multiple parallel contexts. This fluidity of expertise is known as “polycontextuality” and “boundary-crossing” (Tuomi-Gröhn, Engeström, & Young, 2003). Boundaries are the places where elements from the multiple contexts meet. They are multi-voiced, multi-scripted and characterized
by alternative or competing discourses. They are often considered to be sources of potential difficulties. As such, boundaries afford opportunities for the transformation of conflicts and tensions to become zones of learning. Through the study of boundary-crossing, contradictions in boundary zones become evident, and the resolution of the contradictions indicates learning.

As a general rule, all boundary-crossing activities require two-way actions. If only one provider attempts to cross a boundary but receives no response, the action is incomplete and cannot be categorized as boundary crossing. Such actions need to be distinguished by a mutual engagement and commitment between two providers to result in a change of practice or learning. In order to study the transfer of learning, and the personal development of pre-service secondary science teachers, this paper reports on a study of “boundary-crossing” which began as a university-university partnership, but at the initiative of the pre-service secondary science teachers, became a school-university-university partnership. In this study, the boundary-crossing actions required three-way inter-actions, a university in Queensland, Australia, a second university in Pennsylvania, USA, and a High School in Queensland, Australia.

**Activity Theory**

Prior to reporting the study, the basic tenets of Activity Theory are outlined. Activity Theory is a theoretical framework for describing the structure, development and social context of human activities. It is a descriptive framework useful for understanding and classifying the “cognitive, physical, and social processes involved in performing a specific task, and how those tasks can be related to a larger motivating activity” (Waite, 2005, p.1).

Figure 1 illustrates the systemic model proposed by Engeström (1987) that presents the relationships between the structuring elements of the activity.

![Figure 1. The structure of an Activity Systems (modified from Engeström, 1987, p.78)](image)

The elements are subject, object, and the mediating artefacts, the community, rules, and division of labour. According to Engeström (2001) and Rajkumar (n.d.), the framework, it is used to explain collective activities and cooperative work. An activity is undertaken by a human agent – the subject, who has a motivation towards the solution of a problem or a purpose – the object, which is mediated by tools – the artefacts, in collaboration with others – the community. The structure of the activity is shaped and constrained by the cultural factors in operation at the time – the rules, and the
social divisions – the divisions of labour. As in any system, the elements constantly change. Not only do people use tools, artefacts and instruments, they continuously adjust them for their own personal benefits. In a similar way, people are ‘obeyers’ as well as ‘breakers’ of rules, again for their own personal benefits. The division of labour is governed by its own set of rules, which are transformed by people for their own personal benefits. These transformations assist in the evolution of societies, and the interplay of the transformations inevitably leads to new outcomes.

In terms of the present study, it is helpful to conceptualise the difficulties of learning transfer for pre-service secondary science teachers from university settings to school settings, with the help of Activity Theory, seeing the school and the universities as separate activity systems. Thus, this study involves a theoretical conceptualisation of the school-university-university partnership represented in Figure 2.

Figure 2. The three activity systems involved in the school-university-university partnership

In the three activity systems, the objects, and therefore the professional success outcomes are both the same and different. In the Australian University Activity System, the pre-service secondary science teachers need to pass their university unit, in the Australian High School Activity System, the same pre-service secondary science teachers again need to ‘pass’ - - a self imposed hurdle in their attempts at passing their university unit. In the American University Activity System, the pre-service secondary science teachers needed to maintain their credibility within the Center for Nanotechnology Education and Utilization, or risk the withdrawal of the American commitment - - thus resulting in the possible failure of their Australian University unit.

The integration of Activity Theory and Boundary-Crossing can also be seen in Figure 2. Each Activity System has an object (Object 1) and therefore a professional success outcome. When multiple Activity Systems make an agreement to interact, allowing their subjects to participate in boundary-crossing, Object 1 of each Activity System is transformed to become Object 2. It is at the
border of the intersecting Object 2’s that boundary-crossing occurs. Where there is learning, and learning transfer, Object 2 is mutually altered to become a more advanced object (Object 3) which is the potential common ground or synergy between the activity systems. In the present study, the Object 1, Object 2 and Object 3 for each activity System is shown in Table 1.

Table 1. The nature of Objects 1, 2 and 3 in the school-university-university partnership

<table>
<thead>
<tr>
<th>Activity System</th>
<th>Object 1</th>
<th>Object 2</th>
<th>Object 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Australian University</strong></td>
<td>To obtain at least a passing grade in the unit.</td>
<td>To present a public lecture highlighting their successes and to write about their experiences.</td>
<td></td>
</tr>
<tr>
<td><strong>American University</strong></td>
<td>To determine if an “across the globe” outreach program was possible with pre-service teachers.</td>
<td>To remotely attend and participate in the public lecture highlighting their successes.</td>
<td>To reflect upon the experience of participating in a “World First” across the globe learning experience, involving nanotechnology education.</td>
</tr>
<tr>
<td><strong>Australian High School</strong></td>
<td>To expose their Year 12 physics students with a “real life” physics application.</td>
<td>To attend a public lecture highlighting their successes.</td>
<td></td>
</tr>
</tbody>
</table>

As the University Activity Systems collaborated to offer advice to the pre-service secondary science teachers, a boundary zone was created as the pre-service secondary science teachers crossed between Activity Systems. The remainder of this paper will show the contradictions generated by the interactions between the Activity Systems have provided affordances for pedagogical innovation and renewal.

**Research Focus**

Through the use of Activity Theory, the effect of a community of practice centred around pre-service secondary science teachers formed specifically to explore learning transfer via collaboration and professional enquiry, in ‘real time’, across the globe, is explored. The focus is specifically on mutual engagement where the pre-service secondary science teachers were provided with guidance to produce a seminar for their peers. The study explored how in the boundary zone created by the school-university-university partnership, the boundary object of ‘passing the unit by doing a seminar’ was assumed to be the mediating tool. This led to an initial research question: “How can “doing a seminar” act as a go-between ‘object’ for Activity Systems for enhancing pre-service secondary science teachers learning, and what contradictions are generated. A second research question evolved in that the study sought to determine: “How were the contradictions resolved and what kind of learning took place.

**Overview of the study**

A group of nine pre-service secondary science teachers were a subset of 95 pre-service secondary science teachers undertaking a 9 week curriculum unit at a large Australian university. The nine pre-service secondary science teachers all had intentions of becoming physics teachers. The
remaining 84 pre-service secondary science teachers in the curriculum unit were to be biology (78), chemistry (4), and earth science (2) teachers. The majority of the pre-service secondary science teachers had a further 18 months of study before graduating, whilst a small number would graduate at the end of that semester. One of the nine physics pre-service secondary science teachers was to graduate upon the completion of the curriculum unit.

The focus of the curriculum unit was laboratory based pedagogy skills. The main assessment item required the pre-service secondary science teachers to work in small groups to present a 1 hour seminar to their peers. The seminar topic was predetermined by the first Author and was to take the form of a professional development hands-on inquiry based session. The pre-service physics teachers were given the broad topic of ‘nanotechnology’ and the e-mail address of the fourth Author. The intention was for the pre-service physics teachers to contact the fourth Author to explore the variety of outreach programs offered to teachers based in Pennsylvania (USA) by the Center for Nanotechnology Education and Utilization. The pre-service physics teachers were then to use this information to develop a hands-on activity for their seminar.

As the study progressed, it became evident to the first and fourth Authors, that the pre-service physics teachers were intending to take their assessment task further than was initially intended. The first and fourth Authors responded to the initiatives of the pre-service physics teachers as they arose. For example, each pre-service physics teacher was supplied with a note pad in which to record reflective notes, ideas, and technical information for their seminar, and the group was also supplied with a Toshiba lap-top computer to enable them to test the remote operation of the Atomic Force Microscope.

At the conclusion of the 9 week unit, a collation of the activities revealed the pre-service physics teachers had shared the following experiences: (a) participation in remote lectures from the fourth Author covering topics such as an introduction to nanotechnology and the Atomic Force Microscope (AFM); (b) practice time using the AFM remotely; (c) participated in science faculty presentation involving a hands-on activity (Turner, et. al., 2006) relating to nanoscale measurement, and later presented a version of this activity to Year 12 physics students; (d) visited a local High School to present a lesson to Year 12 physics students in conjunction with staff from the Center for Nanotechnology Education and Utilization; (e) met regularly with their group and or the first Author in order to prepare their seminar; and finally (f) agreed to present their assessable seminar in the form of a public lecture to an audience of over 100 people (instead of the intended audience of 20 peers).

Data were collected from (a) reflective notes; (b) observation field notes from the Year 12 physics students class - - a pre-service physics teacher initiative; (c) surveys from the Year 12 physics students - - a pre-service physics teacher initiative; (d) lesson reflections and digital recordings from the Year 12 physics class - - a pre-service physics teacher initiative; and (e) interviews with the pre-service physics teachers. As an extension to the project, the pre-service physics teachers were invited to co-author papers relating to the project.

**Findings**

The findings are reported in terms of the major themes: boundary-crossing, the philosophy of teaching, and professional relationships.

**“Boundary-crossing”** between the three Activity Systems outlined earlier was enjoyed by six of the nine pre-service physics teachers. Within the first fortnight of the semester, three pre-service physics teachers withdrew from the nanotechnology topic. The first pre-service physics teacher to withdraw (Mitchell) negotiated (with the first Author) a new seminar topic of ‘catapults’. Two other pre-service physics teachers (Charles and Simon) quickly followed. When interviewed some time
later, Mitchell claimed to be a ‘control freak’. He needed to be in control of his learning, so working with the others would have been very difficult for him. “Too many cooks spoil the broth; too many students stuff the assignment”, was his reasoning. He also stated that the topic was not exciting, and he needed to be passionate about the topic to do well. “I need a top grade for this unit, and was not going to get it from nanotechnology” said Mitchell. Catapults and their creation had been a childhood toy of both Mitchell and Charles, and so it was perceived to be an easier more exciting topic for a seminar. Charles and Simon said they withdrew from the nanotechnology topic as catapults appeared to be a more exciting topic “especially the way Mitchell described his vision. He was going to create a big wooden catapult in a park, and video it and put the video on ‘U-Tube’. It sounded cool so I wanted to do that” (Simon). Mitchell, Charles and Simon did succeed in their catapult topic. They worked collectively, well within their comfort zones, and relied totally upon themselves and their own resources. As such, they did not participate in boundary-crossing.

The remaining six pre-service physics teachers embraced the nanotechnology topic. The individual skills of the six complemented each other. One of the group had well advanced computer skills and was able to understand the download and installation of software necessary for the remote operation and boundary-crossing between their Australian University Activity System, and the American University Activity System. Another pre-service physics teacher had the initiative to take their project into the Australian High School Activity System. Yet another pre-service physics teacher had the skills to undertake a learning activity, adopt and modify the activity and present it equally well in both the Australian University Activity System and the Australian High School Activity System. The final two pre-service physics teachers held the group together ensuring no individual deviated from the task. These two also conducted the background research. Thus, the Activity Theory element of Division of Labour within the group evolved quite naturally, enabling the pre-service physics teachers to boundary-cross as individuals as well as as a collective.

“The journey has been very exciting and working with 5 other students was great, everyone got along well and enjoyed the experience. Very different to past presentations – research what has been done before and replicate. This was a first time, so was hard, was different and we didn’t really know where it was going to take us. If I was just myself doing this, I never would have got through it! Especially the technology side of it. Everyone brought different strengths to the group to make it happen” (Jane).

The initial contact with the fourth Author proved daunting for the group. One of the pre-service physics teachers reflected in her journal that she felt “out of her league”. She did not know how they would be received by the Americans, and was concerned that she would be seen as dumb, because she “didn’t know what nano was”. However, as a collective, the group was strong enough to persevere and overcame their fears. Another of the pre-service physics teachers reflected that: “had we not had Pete [third Author], I would have quit. We really needed him to sort out the technology side of things. I am no good with computers. I am scared I will deprogram them or something. But having seen Pete hack, (well not ‘real’ hacking), into the computer to get us working, I saw a whole new side of him, and of computers. I still cannot do much with them, but they are not as scary” (Jane).

Jane was describing the difficulties the group had with the technology required for the remote operation activities. The mediating tools of computer software were already established in the American University Activity System, but not in the Australian University Activity System or the Australian High School Activity System. Activity System contradictions were created as a result of the third Author having to establish these mediating tools so that the group of pre-service physics teachers could participate in all three Activity Systems.

The philosophy of teaching of individuals became evident as the discussed aspects of the project. Keiran was the pre-service physics teacher due to graduate upon the completion of the unit. He had
an undergraduate degree in physics, and was undertaking a Graduate Diploma in Education – 1 year course for graduate students to become teachers. In his reflections and interview, Keiran showed depth and insight to his views on education. When queried by the first Author if he thought his views were due to him being Canadian and mature aged, he said “No, I have always been more interested in the big picture and seeing where things fit into life”. This was quite evident in a reflection on the final Public Lecture where Keiran wrote:

“I think the biggest issue for our group was determining the main focus of our project; nanotechnology or using technology to bring experts and sophisticated/expensive equipment into the classroom. I fought with the majority of the group to make the focus of the presentation and the project the latter. I feel this could be revolutionary for science education and nanotechnology was just a topic we were using to demonstrate how technology could be used to bring an expert in from anywhere on the planet to introduce or further the understanding of the topic” (Keiran).

Keiran wanted the Year 12 boys in the physics class, and his peers to get more real life information out of the project. Keiran feels science and education in general, could be revolutionised by bringing experts into the classroom to show the bigger picture. This view was also held by Natalie who made the comments she was now interested in, and had the confidence to try new things in the classroom. She saw that teaching could bring things to life, and that she didn’t have to base her instructional philosophy on her own learning experiences. Natalie was also mindful of the pitfalls teachers could find themselves in:

“What we weren’t prepared for was the feedback from students [the peers in the Australian University Activity System] complaining they couldn’t see where our topic related to their teaching area or any teaching area for that fact! I think I became quite protective of our ‘little nano’ topic and didn’t like anyone criticising it. This opened my eyes to in schools teachers can become blinkered to only what they teach and start to be unable to connect to other topics the students may be able to relate to with more ease” (Natalie).

These experiences both indicate that Keiran and Natalie did not just focus on the ‘how-to’ concerns of the classroom. Routine procedures like time management and lesson planning were present, however the group learnt to reflect, which enabled them to build praxis for teaching that acted as an individual as well as theoretical knowledge base.

**Professional relationships** as teacher and academics were explored and enjoyed by the group. There is no doubt the pre-service physics teachers enjoyed the move from being considered students, to being considered as “knowledgeable beings, with something to say that someone actually wants to listen to” (Natalie). Julie noted that she was uneasy entering the Australian High School Activity System at first. She had limited experience teaching physics in a school, and didn’t know if the “whole thing would work or not”. However, once the group had overcome the contradictions with firewalls and the live link-up with the fourth Author, Julie found herself at ease especially over morning tea with the science staff of the school. The pre-service physics teachers provided a morning tea for the science teachers and this gave all involved the opportunity to discuss the project further. Julie and Natalie initially felt uncomfortable mingling with the teachers, but the food, and the fact that they had knowledge the teachers didn’t have - but were curious about and wanted, enabled to break down barriers and the boundary-crossing to occur. Julie experienced life as a professional teacher (all be it for a few minutes over morning tea), and liked it.

Other pre-service physics teachers mentioned a change in identity and a feeling of professionalism. The second and third Authors were shy about a new level of professionalism offered to them as an extension activity to the project. The first Author obtained funding so that the second and third Authors could further explore their roles as researchers, and to learn to write academic papers. These two pre-service physics teachers were given office space and computers to conduct literature
reviews, and explore their thinking. This is an ongoing process, but the following statement from the second Author sums up the impact of the experience:

“I normally just read journal articles to get a bit of information for an assignment. You know, beef up the literature review a bit. Now I am not using the articles, I am creating them. I find this scary to think that someone is interested in what we did, what we learned. Yea, it was a world first, so I guess it is interesting. But me? Doing something and writing about it? Scary. But good. I like the importance feeling” (Lanning)

Lanning and Sercombe will graduate in November of the current year. Before then, they will continue (we hope) to boundary-cross into university academic life. It is hoped they will continue to reflect upon their experiences in all forms of teaching and learning, and tell their stories. Each of them has something to say, as do all pre-service teachers. They just needed help to gain the confidence to acknowledge the contribution to teaching and learning that they themselves have made. These other group members were given this same opportunity, but declined it for whatever personal reasons. They were not ready to boundary-cross into yet another system it seems.

Keiran spoke of professionalism within the group he was working with, as well as between himself and students in general:

“The 5E teaching model tells us we must first engage the student by capturing the interests of students. How can we expect to get our students interested in something we cannot find fun in ourselves? This is why I thought it was important to include some humour, and I am glad my group supported and encouraged me to do so. I was happy when Steve mentioned he believed it was important to be your self and to give the students part of yourself. I can be professional with my students as well as be myself” (Kerian)

Discussion and Conclusion
The pre-service physics teachers had to find ways to ‘work around’ contradictions by adapting their practices. Natalie reflected upon the contradictions in general

“Most of the obstacles we came across we could learn from. All the things that made our presentation harder were also things that could come up when planning any lesson on something completely new. The fact that we were doing something that had never been done before, exploring something none of us had ever heard of in a way that included computers made this a very daunting task!! However the fact that I came out alive and with new knowledge has probably given me the confidence to try new things and take challenging opportunities when I get into schools” (Natalie).

What was initially a small topic for nine students, very quickly became a “world first” topic for six pre-service physics teachers. Although it proved to be a difficult task, Jane does not regret it: “Glad for the experience and hope everyone gets a chance to do something like this”. The six pre-service physics teachers all experienced large levels of personal and academic growth.

“It was part of our progression from having almost no knowledge, to having enough knowledge and confidence to present in a school and then critiquing our performance in the classroom and making changes before our final presentation. We all learnt a lot …. Importantly because of going into the school with almost no guidelines and having to present something credible we learnt extensively about teaching and co teaching” (Julie)

They were boundary-crossing three Activity Systems simultaneously – one in North Eastern America, and two in Queensland Australia. The pre-service physics teachers developed strategies to allow them to resolve contradictions and allow movement between the Activity Systems. They gained new confidences in their teaching and planning abilities; they were able to resolve transfer issues between Activity Systems as they could draw on each other and a supporting group of
university personnel on opposite sides of the globe; and finally some took up the continuing challenge to be assisted in developing an identity as a researcher of their own teaching and learning. This paper told aspects of their story – one which is continuing.

The findings have implications for teacher education. The researchers feel that deliberate planning for networking between Activity Systems may well be a solution to the apparent theory/practice gap. Proximity of activity systems need not be a hindering issue. By undertaking this study, we have discovered that, through the process of boundary-crossing, it is perhaps more important for the pre-service teacher to develop the ability to engage in ill-defined problems than to be concerned with how much they know or whether they have acquired skills. Learning transfer may then cease to be an issue.

“Our group came so far, and overcame so many obstacles that if I end up being placed in a similar situation in a school (being told to teach something I know nothing about), I will not resign, I will know where to start looking for help. What is more, I think we changed the minds of many of our classmates. Their changed views were best summed up by a statement on one feedback sheet: “Whoever knew physics could be so much fun … maybe I should give Biology away for Physics!” (Julie).

Acknowledgements
The Australian based Authors are thankful for the most generous support from the American based Authors. Without their after hours support (due to time zone differences) this study would not have been possible. The kind support Professor Kar-Tin Lee in making available the lap-top computer for the duration of the study is also acknowledged. The first Author would also like to acknowledge the pre-service physics teachers for their stoic endurance throughout the semester and beyond. Without your individual perseverance, the collective could not have succeeded. Finally, the Authors would like to acknowledge the CLI Cluster Grant for funding to allow the second and third Authors to “tell their story”.

References