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ABSTRACT

Documented cases of quality science teaching have the potential to share the best of what has been taught with science teachers in all science classrooms. This paper reports on the use of case studies of practice as mechanisms for recognizing good ideas for teaching science, documenting them, and making them readily accessible to teachers. An objective of the Science Education Professional Development Project (SEPD), conducted at Monash University (Australia), was to develop a national strategy for enhancing the professional development of science teachers. The use of case studies is one component of the project's strategy. This paper presents uses for cases; an example of a teaching case that has been developed, and six methods for generating ideas for documenting practice referred to as the Science Classroom Science Project (CLASP). A 3-phase process for the production of cases is summarized. Two appendices include the first section of an activity on speed and acceleration graphs and experienced teachers' group meeting notes. (Contains 23 references.) (LL)

Developing and Using Cases of Pedagogical Content Knowledge in the Professional Development of Science Teachers

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Developing and Using Cases of Pedagogical Content Knowledge in the Professional Development of Science Teachers

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There are plenty of good ideas around for teaching science well. However, most of them remain 'locked away' in individual classrooms. Mechanisms for recognising these ideas, documenting them, and making them readily accessible among teachers are poorly developed in the profession. This is despite the fact that teachers rank other teachers' ideas very highly as a source of professional development.

One of the aims of the Science Education Professional Development (SEPD) Project was to trial some mechanisms for achieving these purposes. The brief for the SEPD Project was to develop a national strategy for enhancing the professional development of science teachers. We believed that there was much to be gained from encouraging the development of a tradition among science teachers for documenting 'case studies' of practice, as one component of such a strategy. The purpose of the case studies would be to open many more 'windows on practice'. We also believed that that it should be a tradition developed and run by the profession itself. The purpose of this paper is to provide a preliminary report on what we have learned after trialing several methods for locating and documenting the 'wisdom of practice'.

Shulman (1987) points to the 'wisdom of practice' as an important component in the knowledge base of teaching, but

> . . . one of the frustrations of teaching as an occupation is its extensive individual and collective amnesia, the consistency with which the best creations of its practitioners are lost to both contemporary and future peers. (pp. 11-12)

Because few effective mechanisms for documenting science teachers' practice are in place, there are few opportunities to give recognition and career rewards to teachers based on the contributions they have made to professional knowledge and practice. Without procedures for documenting and evaluating practice there is no reliable basis for such a tradition. And without such a tradition, controlled by the profession itself, claims for paying teachers on the basis of their knowledge and skills are thereby weakened. Unlike professions such as architecture and law, where previous practice is accessible through such means as blueprints and legal casebooks, teachers' work is more ephemeral, and, partly as a consequence perhaps, not so valued.

The lack of a tradition for documenting good practice in science teaching hit me again recently. I went to visit a young science graduate in the second week of her first teaching practice. She was giving a lesson on chemical bonding to a Year 11 class in a high school. She did it well, following mainly what was in the students' chemistry textbook, and using a few three dimensional models. The thing that struck me was how much we expected of her at this very early stage. She virtually had to plan how to teach chemical bonding to a full class from scratch. She had to 'invent' a way of teaching complex ideas such as ionic and covalent bonding herself. How do you do it? What are some of the more effective ways we have learned for making these ideas meaningful?

Although bonding has been a standard topic in any chemistry course for many years, there were few case studies or models she could turn to as guides for teaching this conceptually very difficult topic. There were few records of other teachers' work in this area. She could not look up cases, for example, that documented the strategies that three of Australia's most highly respected chemistry teachers had developed for teaching this topic. Although she was at the very beginning of her career, there was a sense in which she was already having to learn to cope alone, one of the central characteristics of teachers' work.

Background to the Science Education Professional Development Project

The Science Education Professional Development Project was commissioned by the Commonwealth Government of Australia as part of its Projects of National Significance Program. The Project came to place considerable importance on learning effective and efficient ways of developing case studies of science teaching. In order to understand why, it is necessary to provide a little detail about the direction we recommended such a strategy should take.

We developed a strategy with two broad and interlocking components

1. Strengthening the "Professional Community" of science teaching

Our preliminary research for the project led us to believe that we needed a strategy that had the capacity to strengthen the sense of professional community among science teachers at all levels; at the school science department level, across schools at the district level, and at wider levels such as state and national science teachers associations. One of the key indicators of a strengthening professional community is the growing involvement of its members in the production of knowledge and the establishment of standards about practice. We believed there were many signs that this was happening in the science teaching community.

The locus of authority about practice and its evaluation had been shifting away from employing authority bureaucracies for many years, with the demise of inspection and subject superintendencies. But it was not clear what it was shifting toward; whether the locus of authority was simply becoming diffused into some vague idea that every teacher was free to do their own thing with little accountability, or whether it was starting to precipitate around a growing belief among teachers that knowledge and standards concerning practice were matters they should claim as their own professional responsibility.

We also aspired to strengthen the sense of professional community by increasing teachers' accessibility to each others' ideas and best practices through the development of a tradition for documenting case studies of teaching. A longer term aim of this exercise was to lift the status of teachers' professional knowledge, and to demonstrate the sophisticated skills involved in good teaching. Much of this knowledge is the result of teachers' own research and evaluation of their practice, but there has been little incentive or support for teachers to disseminate the findings of their research.

2. Strengthening the relationship between teachers' professional development and their career development.

A new 'professional' career structure for teachers has been introduced recently in Australia. This industrial 'Award Restructuring' has led to the introduction of a new classification of teachers called the 'Advanced Skills Teacher' (AST). The AST position aims to provide a career path for teachers who wish to continue working mainly as practicing teachers, rather than to move out into administrative career paths. Its purpose was to keep more of the best teachers close to students and to reward them in salary and career terms for advances in their professional knowledge and skill. This industrial reform could not be effective without the development of new methods of teacher evaluation that were a valid reflection of professional development after the first ten years or so of teachers' careers.

The SEPD Project endorsed this proposal to create an alternative 'professional' career structure for practicing science teachers. It was hoped that it would give greater incentive and recognition to teachers for demonstrable improvement in the quality of their practice. For this to happen we needed to shift to a pay system more closely geared to paying for knowledge and skill. The concept of skills-based *career development* as a teacher needed to be institutionalised as an alternative to the traditional bureaucratic career ladder model based on payment for occupying a position, or for extra duties (Bacharach, Conley & Shedd, 1990; Lawler, 1990; Odden & Conley, 1991). A skill-based concept of career development was also seen as a 'professional alternative' to merit pay and career ladder pay systems, because it would require the profession to exercise more collective responsibility for the setting of standards and the evaluation of practice.

Professional communities. There were three ways in which the SEPD Project suggested the professional community of science teachers could be strengthened. To enhance the sense of professional community at the science department level, the SEPD Project team developed a set of resources called *Where Do We Start?: Professional Development Resources for Science Departments?* These materials and ideas for in-service activities were aimed at science teachers who wanted to make their workplace and their science department meetings a time for sharing ideas and professional development activities, as well as routine administrative matters. These resources aimed to strengthen the leadership role of science department chairs in professional development.

We also recommended strengthening the corporate professional role of the Science Teachers Associations, in association with teacher unions. As one way of moving in this direction, the SEPD Project initiated a pilot project called *Professional Standards For the Teaching of Science: An Exploration of What Advanced Skills Science Teachers Need To Know and Be Able To Do*. This exercise was a first attempt to test the extent to which a knowledge base for the teaching of science could be articulated. Leading science educators were asked to write on various dimensions of what they expected an advanced skills science teachers to know and be able to do. The main purpose of the exercise was to provide an indication of how much work would be involved in a full scale exercise of developing standards and a professional evaluation system for science teaching. Case studies became important in this exercise as possible vehicles for representing or illustrating standards.

As a third means of developing a professional community, we trialled the development of a "case literature" (Shulman, 1987a) of quality science teaching and learning. This component of the SEPD Project is the focus of this paper. We wanted to test the idea of establishing a tradition of on-going documentation and validation of exemplary practice amongst science teachers as a vehicle for giving status and recognition to their professional knowledge. The paper is an evaluation of what we have learned about developing cases of pedagogical content knowledge (after Shulman, 1986) in the professional development of science teachers.

Career development. Award Restructuring required the profession to clarify what it expected teachers to get better at; what it expected teachers to develop towards. When we surveyed the field of science education we found that few attempts had been made to articulate such goals, goals that would help to give direction and purpose to science teachers' professional development over the long term, for example, the first ten years of their careers. Any strategy that aimed to enhance the quality of teaching and learning in science would benefit from the development of better methods for portraying images of what the profession considered to be 'advanced skill' or exemplary practice.

Award Restructuring offered the SEPD Project a golden opportunity to develop a professional development strategy with some 'bite'. We have talked for years about the need to give recognition to teachers for demonstrable advances in the quality of practice as a result of in-service education, but with little real progress. We have talked for years about 'professional development', but also with surprisingly little clarity about the major directions and dimensions for this 'development'.

Career restructuring meant that we had to learn how to set criteria or standards for what advanced skills teachers should know and be able to do. What was a 'standard'? What would it look like? How do we represent counts as 'quality' in learning and in teaching? Shulman (1986) refers to three ways in which knowledge in teaching may be represented: propositional knowledge; case knowledge; and strategic knowledge. Our work was an exploration of how to develop case knowledge that provided 'windows' into "the vast store of knowledge about teaching that resides in our best classrooms' (Clark, Lovitt & Stephens, 1990)

Further details about the SEPD Project can be found in the report *Integrating Teachers' Professional Development and Career Development* (Ingvarson, 1992)

Some uses for cases

The foregoing outline of the SEPD Project indicates that we became interested in the development of cases as a means of achieving a variety of possible purposes

- cases as vehicles for discussing and clarifying what 'counts' (and what does not count) as quality learning in science.
- cases as a means of documenting quality science teaching to make 'best practices' more accessible across the profession.
- cases as a means of representing pedagogical content knowledge about science teaching.
- cases as models which gave direction and purpose for a teachers' professional development.
- cases as a means of illustrating or representing professional standards for the teaching of science.
- cases as a vehicle for teachers to make a more general contribution to the 'knowledge base of the profession.
- cases as a means of giving recognition to teachers of quality.
- cases as vehicles for professional development through collaborative documentation in their preparation.
- cases as vehicles for professional development through trialling them in one's own classroom.
- cases as a means by which teachers might give evidence of their professional development when applying for promotion (e.g. a published case study in a professional journal; or in a teacher's portfolio)

Perspectives on the role of cases in education

Increasing attention is being given to the question of the knowledge base of teaching within the context of "professionalising" teaching (e.g. Shulman, L., 1987; Grossman, 1990; Sykes, 1991). Proponents of professionalism often argue that greater recognition and status should be given to the "practical knowledge" that teachers gain as a result of experience. A promising means of doing this could be through the development and use of 'case literature' of teaching. Bird (1990) outlines the potential value of 'portfolios' in teacher evaluation. Documented cases of a teacher's ideas, ideas which may have received the recognition of professional peers, could conceivably be a valid form of evidence to include in such portfolios. (It is interesting to note the extent to which case studies, or 'vignettes were relied upon to illustrate 'standards' in the recently published National Council for the Teaching of Mathematics report *Professional Standards for the Teaching of Mathematics* (NCTM, 1991).)

Interest in the use of cases in teacher education has also grown in recent years (e.g. Carter, 1988; Shulman, 1990; Barnett, 1991). Cases appear to be promising ways to represent knowledge about teaching in a form that makes it accessible for learning, action and reflection by others. Barnett has used case-based discussion of hard-to-teach topics in mathematics as a means 'to foster pedagogical thinking and reasoning skills that are broadly applicable in mathematics and teaching.' Cases provide alternative assumptions about expertise, about sources of knowledge in the teaching profession, and about how teachers learn, from those that underpin traditional modes of in-service education.

Broudy (1990) has argued that teacher education needs to develop cases as paradigms representing a consensus about the core problems in professional practice. Carter (1989) has examined the potential of the case tradition in law for teaching. Judy Shulman and others have worked on the idea of casebooks around themes such as the mentor teacher. Richardson (1991) has experimented with cases around issues such as motivation of students.

There is also a long tradition of using case studies in curriculum evaluation as a way of providing "vicarious experience", and a basis for wider audience discussion and understanding of educational programs (Eg Stake, 1975, MacDonald & Walker, 1975; Stenhouse, 1978; Walker, Borthwick and Ingvarson, 1982). Stake (1987) has argued more recently for the value of cases as a means of providing tacit knowledge and knowledge for action in staff development programs.

Developing cases

Schön's work has done much to make the the idea of "craft knowledge" respectable. Shulman uses the term 'wisdom of practice' for much the same idea, and has developed this into the concept of 'pedagogical content knowledge' (1987). Pedagogical content knowledge is an interesting concept, but a difficult one to pin down. It does seem to go to the heart of what teaching is about, and what good teachers have learned through experience. More recently, researchers have been trialing methods for revealing and documenting this knowledge.

Gaea Leinhardt (1990), in a recent paper in the *Educational Researcher* called "Capturing Craft Knowledge in Teaching", describes craft knowledge as the wealth of teaching information that very skilled practitioners have about their own practice. "It includes deep, sensitive, location-specific knowledge of teaching, and it also includes fragmentary, superstitious, and often inaccurate opinions." (p. 18) Her paper addresses the vital issue of validity in craft knowledge - the need to ensure that our methods of documenting practice have quality controls that enable us to distinguish unverified opinion from probable truth, or, matters of taste and habit from expertise.

She describes approaches that she and others (e.g. Barnett, 1991) have used to tap the knowledge base of experienced teachers. One is simply based on shared discussion among practitioners about practice. For example, a group of primary teachers developed small case studies around the theme of "hard to teach topics" in maths. It is easy to imagine other themes that might be equally productive of cases.

Shulman and Colbert (1988, 1989) used other methods to develop cases. Their cases grow outwards from brief narratives, written, for example, by beginning teachers and mentor teachers, to include discussion and comments from others who read the narratives and identified issues and themes that they thought characterised the 'case'.

There seems to be no limit to the types of case studies we could develop in education, or the forms that they might take. Some years ago a group of us trialled the use of photographs in case studies of lessons (Walker, Borthwick and Ingvarson, 1982). These photographic case studies were designed as in-service education materials that would help to illustrate innovative methods for teaching history. They were intended to help teachers learn new teaching strategies. The photographs also helped to stimulate reflective comments from teachers and students and these were built into the case.

Windows on science teaching: case studies of practice

Pioneer work in the area of documenting quality teaching has been done in mathematics in Australia by Lovitt and Clark. (1990). Whereas Leinhardt talks about 'capturing' craft knowledge, and Shulman and Colbert use the analogy of the legal case book, Lovitt and Clark talk about 'windows on practice', or 'images of quality learning environments', and they talk about these images forming in the aggregate 'a gallery of the art of good mathematics teaching.' (p. 171). The purpose of Lovitt and Clark's documented classroom activities is primarily to help teachers who want to embark on the risky path of changing their teaching methods towards more 'active' forms of mathematics learning. A summary of their work can be found in Clark, Lovitt and Stephens (1990).

Our cases also attempt to document the pedagogical content knowledge of experienced science teachers in a form that makes it accessible for trial and reflection by other teachers. They are intended to be cases of quality teaching in science, as identified by the science teaching community.

Like Leinhardt and Barnett, our cases are situated in the teaching of particular topics in science; for example, speed and acceleration, chemical bonding, day and night, and so on. Unlike their cases, ours aim directly at providing teachers with information that will enable them to carry out for themselves the strategy or activity described in the case. Whereas many case studies are designed to foster discussion and deepen understanding about familiar classroom situations, such as classroom management or socio-cultural issues, our case studies aim to provide the essential information that will enable another teacher to use the case with as full an understanding of the pedagogical reasoning behind it as possible. This is not easy.

A case of a case

The best way to explain what we have been doing is to start with one of the cases we have developed. It is a case based on a idea for teaching about speed and acceleration graphs developed by Ian Mitchell, a high school science teacher. (The first section of the case can be found in Appendix 1.) It is important to bear in mind that Ian has been carrying out research on his own teaching with colleagues for several years and that this 'case' is but one example of how that research has shaped his understanding of what it means to teach and to learn science. (The early stages in this research are reported in Baird & Mitchell, 1986). This research has been guided by the value that Ian places on students being active agents in their learning.

The story of speed and acceleration graphs.

The ability to understand and interpret speed and acceleration graphs is an important skill. But many students encounter problems in making sense of them. The activity 'Speed graphs' introduces a fun and intellectually challenging way to 'read the story' of graphs. Students translate the graphs into the movement of a toy car. Later this translation process is turned around. Students are shown simple and more complex 'real life' examples of movement on a videotape, and asked to record the motion in terms of graphs that they create themselvesa.

> After explaining the overall point of the exercise. Ian shows his class a bench top that has a plus sign at one end and a minus sign at the other; he places a pen in the middle of the table. He explains that the pen represents the 'x - axis' of a speed graph with the pen representing the origin.

Ian then organises students into small groups and assigns each group a speed graph to interpret from a sheet containing many graphs of increasing complexity. He produces a toy car and tells the class that, after they have had a chance to look at their graph and talk about it, he is going to ask the groups to come out to the table and show their interpretation of their graph. They are to do this by moving the toy car across the table top in the direction and at the speed indicated by their graph.

The activity initially raises anxiety among some students and Ian talks about this and recognises their concerns. Ian places a lot of emphasis on building the kind of trust in his students that enables them to take risks in expressing their ideas in classroom situatons such as this.

Soon, one group is at the table showing their interpretation of their speed graph. Ian skillfully encourages questions and directs them from the class to the performers out the front. Much lively discussion usually ensues at this stage and it becomes clear that there is a wide variety of interpretations of the graph. It also becomes clear that the discussion is helping students to sort out their ideas. Assumptions about the task are surfacing and being revised. Assumptions about speed and acceleration, and what the graphs mean are also emerging and being quietly reviewed.

As each group in turn attempts their interpretation it becomes clear how much the later groups have learned from the earlier groups and the discussion that went before. The final groups demonstrate considerable aplomb at interpreting complex speed graphs accurately.

Ian has demonstrated this lesson many times to teachers in school classroom situations and at in-service settings. Teachers who observe the lesson readily agree that it has several characteristics that are representative of what they considered to be 'quality' learning and teaching in science. Isolating such characteristics is one of the key first steps in the process of documenting classroom activities. Teachers in one of our documentation groups analysed each part of the speed graphs lesson and came up withthe summary below for the first five parts of the lesson. These are examples of 'pedagogical understandings' that underpinned the lesson. They would need to be understood by any teacher who was intending to try the activity with their own class. (Another task of our research group was to find out and apply the criteria that teachers use making judgements about what counts as 'quality' in science learning and teaching.)

Part 1. Having students work in pairs results in more students being actively involved. Single sex pairs place girls in the position of having to handle equipment.

Part 2. Giving students time to look at graphs before role playing allows them time to interpret the graph and translate the information into physical movement. Their interpretations will provide Ian with rich opportunities to understand the sense they make of the graphs.

Part 3. Having one group model the exercise helps the rest of the class clarify initial questions about the task. Others are learning as they watch the first group making sense of the task. Being a learning exercise, it is expected that the first few groups will make errors and show misconceptions. Many of these will be resolved by the groups that follow.

Part 4. Other groups reflect on their planned role play in light of previous role plays. Giving groups more time for reflection allows students to incorporate ideas gained from the earlier role plays and remodel their own role role play.

Part 5. All students can be engaged through direct discussion with the presenting group in trying to solve problems raised Students in the audience 'project' to the presenting group and mentally tackle the problems asked of the presenters. Asking the class 'if anyone would like to do the role play differently invites students individually to interpret the graph and match their interpretation to that of presenting group.

There are many more 'qualitites' that could be identified in the lesson.

This is a bare outline of Ian's lesson. The lesson looks like a fairly straight forward idea and many experienced physics teachers could probably latch on to it quicky and replicate the strategy successfully. It would therefore seem as if the task of documenting it would be a fairly straightforward one. However, it turns out to be not so easy at all, not if the case is to be a vehicle for teacher understanding and change rather that just a script to follow or imitate. It is one thing to sense that a teaching has quality and is worth sharing. It is entirely another to isolate and identify the main features of its 'quality'. And it turns out to be much more difficult than one expects to isolate the essential features of the activity and its stages in such a way that another teacher can replicate the activity.

Methods for generating ideas for documentation

This is only one case. There are thousands of cases that could be documented. We happened to know Ian Mitchell and we asked if he would mind demonstrating this lesson and allow us to try to document it. But we were interested in how could we set up a more broadly based system for doing this across the profession. In the brief nine months of the SEPD Project we tried several different methods for developing cases. No one knew how best to do this. So we looked on the task as one of sending out a flotilla of trial methods in the hope that some would return successfully. This part of the SEPD Project was called the Classroom Science Project (CLASP). Six methods were trialled. Three are described briefly below.

The first method was to establish a group of high school teachers from a cluster of local schools with an LEA consultant who set about documenting and trialling ideas. 'The Southern Metropolitan Cluster' consisted of science teachers in three schools, a curriculum consultant and the researcher. This group was a collection of experienced science teachers, geographically near each other and interested in sharing ideas about classroom practice. They were prepared to meet on a regular basis over a short time to share and document their work. A 'diary' of the work of this group is in Appendix 2.

We were also particularly interested in bringing science teachers into contact with practicing scientists to develop "cutting edge" teaching activities. This idea developed into the 'research science group.' A group of experienced science teachers responded to an invitation to participate in a project linking science, industry and teaching. Members of the project team had often mentioned the need for the practitioner to have access to recent developments in science, and to be able to use this experience in the classroom.The project was a cooperative venture between the science teachers, staff in the Faculty of Science at Monash University and Daratech, an independent research centre. The case that this group produced was entitled 'What do scientists do? Research into the slow release of a herbicide' (see SEPD Science Activity Folio, *Windows on Science Teaching*). This material was developed into a series of activities or a 'unit' of work. Currently there are 3 drafted activities with suggestions for further development.

Another tack was to offer payment to individual teachers to send drafts of teaching ideas to us. Our plan was that these ideas would be trialled and evaluated by other teachers, and developed further if they looked promising. This idea developed into the 'National Network Group'. An open invitation was sent to Australian science teachers via state science teacher associations and the Australian Science Teacher Association to participate in the CLASP project. Three methods of participation were offered. Participants could receive newsletter publications, they could trial and evaluate classroom materials and/or, articulate and document an exemplary activity. The response was pleasing and it was not long before we were communicating with 50 teachers, more than we could handle, and mail continues to arrive. Significantly more women have responded than men. A relatively high proportion of the respondents were from country areas, where teachers have less access to professional support.

Although the national group has been operating for only a short time, a number of teachers have indicated their willingness to work on the documentation of activities and to be involved in trialling CLASP material.

Some fifteen or so activities have been sent to us showing a range of stages of refinement of documentation and a range in the quality of the activities. Most are strongly activity based and feature group work, reporting techniques and construction exercises. Articulation of the underlying science understandings to be learned is generally not featured and many of the activities are written as worksheets or lesson outlines.

Most of the activities that have been sent to us require substantial development and refinement. Much vital information for a teacher who might want to replicate the activity is left implicit. As Gudmundsdottir observed of teachers explaining their work;

> 'They discovered their curriculum stories only when they had to explain their curriculum to someone who had limited experience . . . (with schools like theirs).'(Gudmundsdottir 1991)

Much more input and support will be needed for future projects to capitalise on the energies of these teachers. This support can come from various sources; the newsletter, telephone conversations, collaborative in-service work and guidance material for teachers who document activities.

These examples suggest that the presence of a support agent, a collaborative group of teachers from a cluster or a particular school, and a clear understanding of the task are important elements in the ability of teachers to articulate and document an activity. Trialling of CLASP materials has begun with this group of teachers using the activities developed so far. A simple profile sheet has been sent to teachers wishing to register as trial teachers. The information collected on the sheet gives a guide as to what materials might be most appropriate to send to these teachers

Documenting Practice

As can be seen from Ian's case in Appendix 1, the cases that we have been trying to develop are not simple vignettes of a single lesson. They are the outcome of several deliberate stages from identifying and articulating the initial idea, trialling, observation, documentation, retrialling by other teachers, discussion and evaluation, re-drafting, and retrialling. These stages attempt to extract the essence of the teaching idea. The cases attempt to build in and make explicit the pedagogical reasoning that lies behind the case. Reflective comments are included at each key stage in the activity to help achieve this. They are in no sense teacher-proof materials. In fact, they become teacher enriched during the processes of documenting and trialling. The experiences and suggestions of other teachers who use the activity have are added into the case. In a sense, these cases are never finished because there are always more insights and ideas that emerge as others use them.

A process for the production of cases.

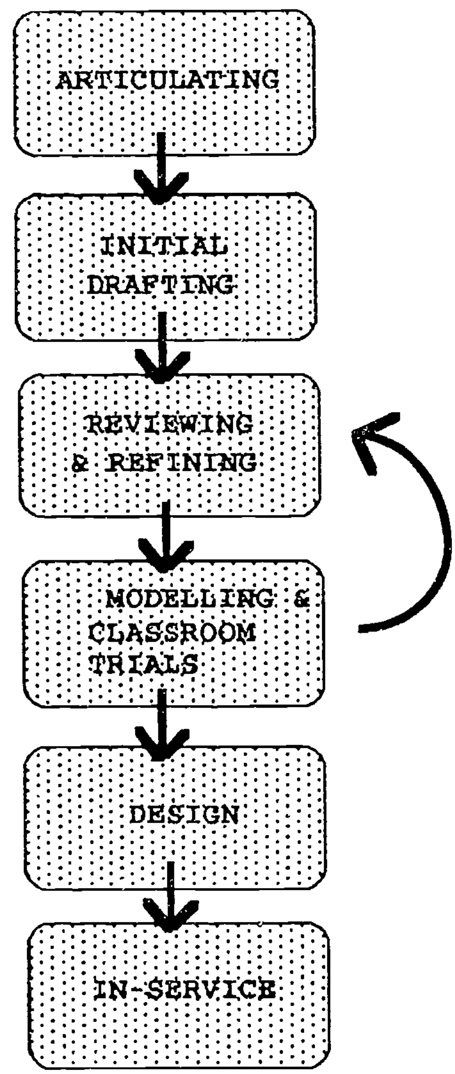
We distilled a process by which teachers might articulate, share and learn from the exemplary lessons of other practitioners. This process can be thought of as comprising three phases; each phase having one or more steps.

Phase 1. Sourcing an idea. In this phase teachers and research workers locate a lesson (or part of a lesson) which they judge as exemplary. The lesson is articulated (Step 1.) orally, in written form, or through observation of a classroom lesson.

Phase 2. Documentation. Cases are made explicit to others by a process of drafting and review until the material carries the spirit of the lesson. (Steps 2, 3, 5 & 6 below)

Phase 3. Inservice use of cases. Cases are used at in service settings for the judgement and refinement of the cases prior to final production (Step 4.). Completed cases are then made available for use by all inservice providers and teachers.

A summary of the process



Below is a more detailed explanation of each step in a process for the production of cases.

Step 1. Articulating an activity

Articulating an activity is the process of identifying the main pedagogical components of the lesson, the pedagogical content knowledge. This exercise usually requires good interviewing skills to lead teachers to express their lesson and their understanding of it. Two situations commonly arise.

The first is the complete exemplary lesson. Here the activity exists in its exemplary form and is expressed as such in the classroom. The second situation occurs when a portion of an exemplary lesson resides in the practice of one or more teachers. In putting together an exemplary lesson of the second type the documenter must recognise the elements of the lesson and have the ability to synthesise the parts into a whole. In the experience of the MCTP developers, and in our own, this represents the most common situation.

Once a teacher recognises a potentially exemplary lesson or activity, (or part thereof) the teacher or a colleague can observe the activity and draft the ideas onto paper. Once again the skill of 'seeing' what the teacher is doing in the classroom, and of understanding what a colleague needs to 'hear' to be able to understand the lesson must be captured by the drafter.

Articulation of the case is like the unfolding of a story. We make similar observations to Gudmundsdottir about the the way teachers articulate the curriculum experience

> 'The stories teachers make and tell their students are not like traditional stories such as myths, legends, or fairy tales. Their content is the subject matter, and their structure is different from those traditional stories, yet including enough similarities to qualify as a story.(Gudmundsdottir 1991)

Step 2. Initial drafting of the activity

Drafting an activity encompasses a number of processes. During observation of the lesson the drafter needs to identify the significant moments and stages in a lesson. The particular words used by the teacher to introduce, explain and direct activities during significant moments needs to be captured, as does the classroom dynamics. Photos or sketches are also helpful in recording these moments in the activity.

During the lesson the teacher often reviews what has gone on, understands the significance of specific events, makes judgements about alternative approaches and projects into the future. This reflective ability is a critical component of the teaching exercise. The drafter must be able to describe the reflective component for the case reader. The MCTP documenters were attuned to this component and described the reflective component 'as a window into the mind of the teacher.'

Finally the initial drafter should collect or record any student material produced during the lesson that can aid understanding a lesson. To illustrate this we refer the reader to the first section of Physics in the playground, where a creative writing sample is included to give the teacher an example of the product which might come from writing about 'danger in the playground', and student dialogue in the following sections which indicate to the reader the thinking of students about the playground activities.

Step 3. Reviewing and refining the initial draft

Following the production of the initial draft, the material needs to be assessed for lesson quality prior to refining. The judgment of whether the lesson is exemplary rests on the opinion of the activity documentors and the activity users - the trial teachers and in-service providers. Activity users are asked to analysise and comment on the lesson after in-service and classroom modelling exercises. However, at the review and refine stage a decision has to be made whether to invest resources in preparing the case or not. Will teachers be prepared to try out this lesson? Will the lesson 'work' in the classroom? Can the lesson be modelled at in-service settings? Does the lesson demonstrate good pedagogy? Can teachers learn from this example? These are some key questions which have to be considered at this point.

Having made the decision to proceed, it is then incumbent on the project team to ensure that the documentation contains sufficient detail about the lesson for a teacher to be able to trial it, (ie carries the story in words, pictures, sketches). It must also;

- identify the science content and how it is used by the teacher,
- identify the teaching and learning approaches used by the teacher,
- identify the theories of learning which underwrite the particular actions taken by the teacher
- identify the organisational arrangements necessary for lessons to succeed,
- describe the role of the teacher in reflecting, learning and responding to the classroom practice,
- provide suggestions for integration and extension of the lesson and its ideas
- identify the significant moments of the lesson.

For the review and refining process we have used small editorial groups of experienced science teachers. These groups have provided valuable suggestions for the improvement of the case. A process of this nature was trialled by a group of experienced teachers using the <u>Ionic bonding</u> activity (see Science Activity Folio) which was a lesson suggested by one of the teachers . Initially the whole group worked on the <u>Ionic bonding</u> activity at a meeting. The source teacher took the ideas away and wrote up the activity. According to arrangement, the initial draft was posted through a chain of group members. The task of each member was to review and comment on the work and post it to the next person in the chain within forty-eight hours. By the next meeting, a fortnight later everyone had read and reviewed the activity, and one teacher had even managed to trial it in class.

We have also passed the activities on to tertiary science educators with expertise appropriate to the activity topic. This has also yielded valuable information for improving the quality of the case material.

Step 4. Modelling, classroom trial and feedback.

When the activity draft is complete it is ready for testing as a classroom lesson. The first step to classroom trialling is modelling of the activity at an inservice setting with the classroom teachers. If the lesson 'appears' workable by the teachers they are then invited to trial the lesson in their classroom. We ask trialling teachers to keep to the lesson script as closely as possible. An evaluation sheet, together with comments made directly onto the draft material, is made by the classroom trial teacher following the lesson and this is sent in to the Project Team in preparation for the next stage. Alternatively the trial teachers return with their evaluations of the lessons for a further inservice activity where they discuss their experiences. This is the preferred approach. The written feedback material brought by participants to the meeting becomes the core material for our project team to work through together with notes taken during the group feedback process.

We often have to employ economic approaches to the modelling and feedback steps. Many of our trial science teachers are at extraordinarily great distances from our centre. This is not an uncommon problem in our country. Consequently we used a postal model for teachers at remote schools. At this time are still evaluating the suitability of this approach for the trialling and evaluation of case material.

A further option worthy of testing is modelling the trial activity with in-service providers such as Ministry of Education science consultants who in turn take on some responsibility for modelling the lesson with their teacher groups, organising and supporting classroom trial exercises and collecting and returning the feedback to the project team. Fidelity to the lesson is to some degree assured through the use of the documentation and feedback sheets which ask for information about any changes made to the activity in the trial exercise. An activity feedback sheet has been developed for this purpose.

Step 5. Reviewing and refining the final draft

A final review of the material prior to the material design step is essential in enabling as good a draft as possible for the designer to work with. As a general rule we believe the material is ready for material production when the classroom trial teachers and the reviewers are satisfied with the quality of the case.

Step 6. Design of materials

The design features of documentation have received considerable attention from the project team. The readability of the material has to be such that teachers can refer to it during the lesson, and prior to and after the lesson use the document to aid the analysis of their work.

We wanted to give the reader a good overview of the activity from the commencement of their reading - this would act as an advanced planner. Included in the first section of the documentation of each activity therefore are; a list of features of the activity, a synopsis of the lesson, details of preparation of students and materials, and a short introduction.

The following sections of the cases are descriptions of each significant moment of the lesson. The descriptions include a synopsis of the teaching in that segment, photos, diagrams and illustrations indicating what is happening, selected dialogue between students and teacher, and anecdotal hints. The segment is further complemented by the reflections of teachers on the pedagogy of the lesson.

We have launched a few design prototypes embracing the features mentioned above. Although the current design is receiving good feedback there is no commitment to this format. Other approaches, for instance in the use of diary presentation and snapshots from lessons are in the pipeline for testing. A diary prototype is included in the Science Activity Folio.

Step 7. Training of users and providers of inservice education.

Inservice education providers have a wide range of options available to them with the way they use documented cases. The materials may be used to support the regular work of the provider, for example a science faculty head may demonstrate aspects of children's science to her staff drawing on case material to illustrate her point.

Collaborative clusters of teachers may select particular topics in science for exploration, model and trial case activities associated with that topic, and return as a group to share their learnings.

Other groups may both use the case material and generate more themselves, developing their curriculum approach whilst sharing their work with a larger audience.

Other teacher groups also have a wonderful opportunity to share the fruits of their work. They could run short sandwich in-service courses for teachers interested in sharing classroom science practice, increasing their science knowledge, teaching practice and pedagogy. The emergence of local cluster groups and the wider availability of cases through those groups can therefore provide in-service opportunities for teachers in the more remote areas.

Where to from here?

As the CLASP project developed, we saw a need to form stronger links with the science teachers' professional associations. Not only could they communicate ideas about this project to their members, but they could become wound into the fabric of development of quality classroom portrayals. They might become the agency for managing an on-going self-funding documentation program as part of their publishing and professional development functions.

Much has been learned from our pilot project in the production of cases for science teachers. Teachers have had too few opportunities to document and share their practice.

> Teaching ... has yet to evolve an appreciation of cases as a repository for knowledge about practice.(Carter 1989)

We are only in our infancy in discovering the value of cases for teaching, how they might be used and how to establish a comprehensive collection.

1. A collection of cases

Knowledge of quality science teaching resides in the minds and practice of science teachers. Documented 'cases' of this teaching have the potential to share the best of what we know to all science classrooms. Skilled interpreters need to develop skills enabling them to assist teachers to unlock and share their knowledge. As more teachers learn how to articulate good practice, and document their work, they too will contribute to a repository of the knowledge of science teachers.

The CLASP project has resulted in a small collection of cases over its short lifespan of nine months. In the long run, the process would have to be self funding. It will live or die depending on whether teachers think they are worth buying.

The size and diversity of cases is also a point for special consideration. Science teaching covers a very wide range of topics and concepts. (This situation became evident for developers of the National Science Strategy who in the first phase collected information from each state of what was taught in science classes.) It follows then that if science education is to maintain this diverse offering a comprehensive repository of cases will need to be offered to teachers.

2. Understand how to use cases

We must not see cases as materials for teachers to ape the 'expert' teacher but as material for interpretation by teachers. Carter identifies a similar argument in the initial teacher training context:

> 'If cases are taught not in order to prescribe answers but to reveal pedagogical puzzles, teacher educators must learn the research and theory on which to discern teaching dilemmas and present them authentically to students.' (Carter 1989)

The value of interpreting the work of others is that it equips teachers with ideas to reconstruct their regular classroom lessons. If classroom trialling of cases introduces teachers to new experiences and new ways of knowing which mix with a teacher,s own practices then the richer this amalgam.

3. Valuing collegiality

The preparation of CLASP cases demonstrates the richness of teacher development in collegial environments. In these situations teachers have an opportunity to share their collective wisdom in the areas of articulation, development and analysis of cases of good teaching. Many professional development situations can lead to this, from a team teaching environment, through faculty, whole school and external in-service programs. However collegiality can be enhanced with the support of advanced skill or expert teachers who can facilitate the group in informed analysis of content and pedagogy.

4. Recognition of advanced skill science teachers

Mechanisms for recognising and rewarding advances in professional practice are poorly developed in teaching. Having one's own ideas documented, evaluated by peers, and published would be convincing evidence in teacher evaluation, say, for "advanced skill science teacher".

Some Recommendations

1. Criteria which recognises science pedagogical skill should be built into the requirements for the AST (science) awards

Formal encouragement for science teachers to articulate what they do in the classroom, and why this leads to good science teaching, will have value directly to students in the classroom, and to colleagues developing their skills of science teaching. Evidence for this knowledge could come through the production of cases of science teaching by AST candidates and their assessment by colleagues. These cases could then contribute to a repository of cases published periodically for all teachers of science and inservice providers.

2. That a repository of cases of quality science teaching should be generated by the science teaching profession.

Science teachers associations might appoint officers with responsibility for collecting and documenting cases. Carter & Unklesbay (1989) describe such a mechanism for accumulating cases that lawyers use. This process would result in control by the profession.

The Maths Curriculum Teaching Project experience (Lovitt & Clarke, 1989), sponsored now by the Curriculum Corporation, has shown that costs can be recovered for enterprising projects of this nature.

The average age of science teachers is rising and many experienced teachers will leave the profession over the next ten years. The value of their work and their experience will be lost unless some effort is made to capture and pass on their knowledge. Documented cases can assist to preserve the 'situational knowledge' held by experienced and expert teachers. (Carter 1989)

3 That professional development workshops operate alongside the production and distribution of cases of teaching.

Professional development workshops, such as those run by MCTP, Initiative 5.4, EMIC, have proved useful in disseminating knowledge about teaching to mathematics and science teachers. Sales of MCTP material have risen sharply as a result. Many workshop participants, once they have worked through a modelling exercise with one activity, felt confident to try others using only the case material in the MCTP Activity Volumes. The adoption of a similar approach in science would reward teachers directly by making skills and knowledge available to all, offering models of teaching and collaboration for teachers to evaluate and providing case material to continue self development back at the school setting.

The cases are intended for use in a wide variety of pre- and in-service teacher education situations. We have developed methods for teaching with the cases.

Teachers can, of course, read and use them alone, but the major benefits come through situations where groups of teachers are using the cases and reflecting on them.

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Appendix 1

Draft Only

THE STORY OF SPEED AND ACCELERATION GRAPHS

SCIENCE EDUCATION PROFESSIONAL DEVELOPMENT PROJECT

"CLASP"

Speed and acce[illegible]tion graphs have proved to be useful but di[illegible]ult to interpret. This activity introduces a fun and intellectually challenging way to 'read the story' of these graphs.
The activity is in two parts and would probably be organised by the teacher as two linked lesson. Part one deals with the interpretation of graphs into the motion of a toy car. Part two inverts this process and deals with simple and more complex real life examples of movement and challenges the students to graphically record the motion.

Features:
- interpreting speed and acceleration graphs using concrete materials
- physical involvement
- uses video snippets to aid translation of movement to graphic representation
- cooperative group work
- encourages question asking and explanation
- groups refine their work in light of previous experiences
- useful in diagnosing student understanding of V and A graphs

What went on before this lesson

In previous lessons students had manipulated models and used graphs to inductively determine speed and acceleration relationships. Students were familiar with speed and acceleration graphs but experienced some dificulty in their interpretation.

PART ONE

1. Set the task

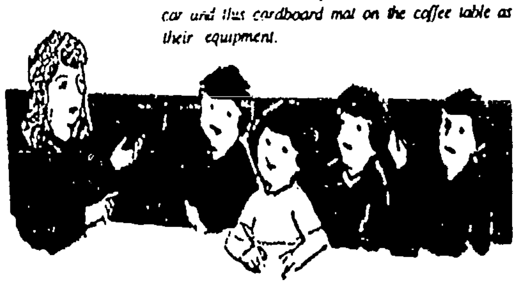
Explain the task explaining how to use the table set- up.
Hand out a copy of the graphs to each student
Arrange students in pairs and assign each pair a graph.
Pair the girls together.

SPEED AS DISTANCE/TIME IS USED FOR THIS ACTIVITY, HOWEVER TEACHERS MAY WISH TO USE VELOCITY IF STUDENTS HAVE TACKLED THE NOTION OF DIRECTIONAL SPEED. ACCELERATION IS DEFINED AS THE CHANGE IN SPEED OVER TIME

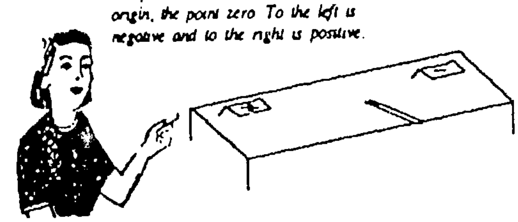
TRIAL TEACHERS SUGGEST THAT IT IS WISE TO CHOOSE A MORE ABLE, 'RISK TAKING' PAIR TO DO THE FIRST ROLE PLAY

In todays lesson I would like the class to play the stories of speed and acceleration

I would like you to work in pairs for this activity and I would like each pair in turn to use this toy car and this cardboard mat on the coffee table as their equipment.



The pen here on the table will be the origin, the point zero. To the left is negative and to the right is positive.



Having students work in pairs results in more students being actively involved. Single sex pairs place girls in the position of having to handle equipment.

2. Students are given time to prepare their role play of the graphs

Give students 4 or 5 minutes to interpret their graph
Sometimes you may want to do something with the car before you start.

I gave the first groups easier graphs to role play, but because they will be first to present to the class they have the more difficult task.

The rules of this role play are that you have to use the words 'start' and 'stop' 'Start' means that you are now role playing the information on the graph and stop means that you are no longer playing the information on the graph.

Talk amongst yourselves for a few minutes and decide what each person will do.

Giving students time to look at graphs before role playing allows them time to interpret the graph and translate the information into physical movement.

3. Have the first group role play a simple speed graph.

Have the first group come out and role play their graph.
Encourage questions and comments from the class.
Have the group repeat the role play after comments, making any changes.

STUDENTS OFTEN WANT TO DISCUSS THE USE OF THE TERM '+' AND '-' ON THE GRAPH AND 'LEFT' AND 'RIGHT' WHEN ACTING THE GRAPH OUT.

TRIAL TEACHERS SUGGEST THAT BY ALLOWING STUDENTS TO RESPOND TO QUESTIONS RATHER THAN THE TEACHER, GREATER CLASS PARTICIPATION RESULTS.

Having one group model the exercise helps the rest of the class clarify initial questions about the task. Others are learning as they watch the first group making sense of the task. Being a learning exercise it is expected that the first few groups will make errors and show misconceptions. Many of these will be resolved by the group that follows

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4. Allow an interval after the first role play

Give students a further few minutes to adjust their role play in light of the discussion and changes of the first group.
Check the readiness of the groups. If some groups are having trouble, skip their turn and bring them on later.

SOME GROUPS WILL FIND THE SUGGESTION OF A PRACTICE RUN AT ROLE PLAYING USEFUL

More time allows groups to check on their understandings and remodel their role play.
Other groups reflect on their planned role play in light of previous role plays. More time allows students to incorporate ideas gained from the earlier role plays.

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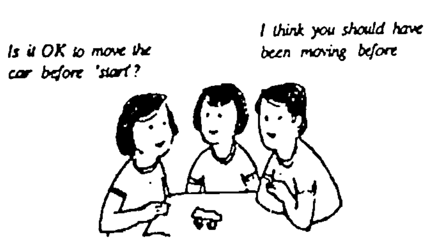
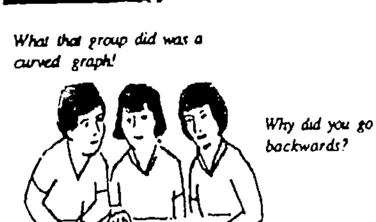
5. Students role play speed and acceleration graphs

Allow 2 or 3 minutes for each role play and discussion
After students have role played speed graphs allocate an acceleration graph to each group





OFTEN GROUP MEMBERS WILL CONFER PRIOR TO REPEATING THE ROLE PLAY. I HAVE FOUND IT USEFUL TO ASK THE TEAM 'WHAT THE PROBLEM IS' AND INVITE THE REST OF THE CLASS TO HELP IN RESOLVING PROBLEM. THIS HELPS THE TEAM CLARIFY AND SOLVE THE PROBLEM.

IDENTIFYING ANY PARADOXICAL ARGUMENTS AND PAIRING THEM PLACES STUDENTS IN THE POSITION OF HAVING TO DECIDE WHICH APPEARS MOST LIKELY.

QUESTIONING CHANGES BETWEEN THE FIRST AND SECOND ROLE PLAY INVITES THE STUDENTS TO EXPLAIN THEIR FRESH REASONING.

All students can be engaged through direct discussion with the presenting group in trying to solve problems raised. Students in the audience 'project' to the presenting group and mentally tackle the problems asked of the presenters. Asking the class 'If anyone would like the role play differently invites students to interpret the graph themselves and match their interpretation to that of presenting group.

Appendix 2

CLASP 1. The Southern Metropolitan Cluster. (Vic.)

The cluster consisted of science teachers in three schools, a curriculum consultant and the researcher. This group was a collection of experienced science teachers, geographically near each other and interested in sharing ideas about classroom practice. They were prepared to meet on a regular basis over a short time to share and document their work.

We kept a diary of events as a record of the meetings and reflections on the progress of this group. The group met about once a month for six months

Over the few months of their operation the group's achievements were:

1. Articulation of the commentaries and reflections for The story of speed and acceleration activity;
2. Articulation and documentation of an Ionic Bonding lesson;
3. Articulation of Atomic structure role play activity;
4. Video of using a jigsaw technique in physics

Beginnings: Looking back at the diary I note my fears about conscripting science teachers to examine how they teach. Speaking with Derek, the science consultant in that region we decided on a plan to engage schools near our home base. We knew of a cluster of schools that we had had contact with during our earlier '5.4' Project in-service activities on activity documentation and unit writing, and decided to invite them to initiate the first CLASP group.

I knew Andrew, a science teacher at one of our contact schools. After discussing the plan with Andrew we decided to introduce the teachers to the project objectives gently by examining some of my lessons. This would reduce the personal risk participating teachers might feel in placing their own work on the line for critical analysis and would introduce everyone to some ideas about pedagogy, reflection and documentation.

I decided to start with the activity speed graphs. The activity was in the initial stages of being documented and still very much in the form of Ian's (the developer of the activity) lesson.

Diary entrees.

Meeting 1.

'I showed the video of Ian doing his speed graphs lesson. The idea caught their interest. We paired off and had a go at using the toy car to role play the graphs. By this time everyone was really in to the activity. We finished off by discussing the lesson and adding further ideas to build it into an exemplary lesson. Someone suggested the idea of showing a video of a car accident, kids on skateboards, a driver, a gymnast and asking the kids to graph it.'

Meeting 2

In this meeting we were in a position to analyse the activity

(I) asked the group as a whole to examine each (significant moment) of teaching in Ian's Speed Graph activity and comment about it. Comments were to focus on the major teaching and learning approaches being used by Ian and how these lead to articulating good learning - its rationale. The group responded very well to this and after a slow beginning really launched into commenting about the work. Their understanding and ability to identify the good (features of) teaching and learning approaches was, from my initial analysis very good. I can add the commentaries into the document now . . . As we worked through this a number of misconceptions surfaced about the physics arose.

At this stage I was feeling confident that experienced teachers could produce good analyses of activities, and help with their refinement. The next test was of critical importance to the project - could teachers articulate their own own good classroom activities?

Meeting 3

... we started by canvassing any (lesson) ideas members of the group would like to work on. Michelle launched the session with four quite different lesson suggestions. Out of the four suggestions we decided to begin with the lesson about 'ionic bonding' using a role play strategy.

Now that the CLASP 1 teachers knew what was involved in articulating a classroom activity from their work on 'speed graphs', they decided to focus their attention on examining just one lesson. The nine activities offered by participants at this session was an indication that experienced teachers do think that they have activities worthy of sharing.

As Michelle articulated her ionic bonding activity to the interest of the others, I became convinced that experienced teachers had a store of quality lessons or briefer activities and that these ideas were not widely shared.

Work on 'ionic bonding' went at a fast pace. Teachers analysed what Michelle did, asked questions of her about her reason for using particular approaches, and made many suggestions to strengthen the activity. I found that my role was to ask Michelle questions to elicit what happened at significant moments during the activity; questions such as; 'What questions did you ask your students?', 'What did your students say about...?' Did you give any instructions at this point?', 'What do you mean when you say that the students worked cooperatively, how did they interact?'

As the activity developed I grabbed some chalk and began recording everyones' ideas on the blackboard. Soon we had a written outline of two activities; atomic structure and ionic bonding.

As the session moved towards an end, Michelle took the ionic bonding notes with her to document into a lesson, and Noel took the atomic structure notes. We decided that when the drafts were finished Michelle and Noel would post a copy to another person in the group who would comment and passs the notes on. In order for us to get the draft to everyone we all agreed on a 48 hour turn around.

This review exercise proved to be an exciting development. Michelle's draft made it around the team and got to me before the next meeting, complete with comments from everyone. A trial of the activity even eventuated.

Andrew commented;

'What a gem of a lesson. 15 mins after I first set eyes on this I trialled it with my VCE chemistry class (year 11). It worked beautifully after an initial period of student unrest. The students were unsettled because they felt a little threatened and insecure about the task. They and I soon identified the gaps in their learning as they were confronted with the need to present the bonding process accurately/correctly - not that I was insisting on correctness, they seemed to adopt that goal themselves.'

In the following meetings we usually returned to Ionic bonding for brief editing sessions. Michelle worked particularly hard during these times making sure that the material properly represented how her lesson appears in the classroom. This strong commitment I would expect to see from all colleagues as their work comes up for review.

A first draft of atomic structure arrived. Noel has called the activity, 'Using role play to develop ideas of the atom.'

CLASP 1. continues to operate. Ahead of us we have the atomic structure activity to refine and we are preparing for a workshop at the CONASTA (Australian Science Teachers Association) conference in Adelaide at which CLASP teachers will put on a half day workshop.

An unexpected outcome is worthy here of mention. Derek in his regular duties works with science teachers in schools in his district. One of the schools Derek works with has decided to adopt the articulation and documentation of lessons idea - a sound 'P.O.E. lesson on magnetism has arrived at CLASP.

Conasta conference (Adelaide)

Noel attended the Conasta conference in Adelaide and presented a part of the CLASP session in which he described the experiences of the teachers in developing the case on Ionic Bonding.