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ABSTRACT

The paper examines conceptual change in teacher education at Monash University (Australia) discussing approaches to promotion of conceptual change and conceptions of metacognition. At Monash University the student teacher is considered a learner who actively constructs views of teaching and learning based on personal experiences and who is shaped by previously constructed conceptions, perceptions, attributes, and skills. The discussion focuses on preservice teacher education, taking information from a 1-year, postdegree program for prospective secondary teachers. Examples are taken from a 10-month inservice program. The preservice program includes two foundation subjects, two methods subjects, and various technical service courses. Teaching practice is in three blocks with another week of visits to practice schools. An explicit constructivist perspective runs through the experiences. The three areas in which conceptual change is significant for student teachers are: beliefs about teaching and learning and roles appropriate for teachers and learners; beliefs about the discipline content and skills students will teach; and student teachers' beliefs about themselves. Examples of approaches in the first two of the three areas are provided and the consequences of the approaches are discussed. Seven principles fundamental to the promotion of conceptual change are contrasted with seven general issues which provide direction for actual preservice classroom practice. (SM)

CONCEPTUAL CHANGE IN TEACHER EDUCATION: THE CENTRALITY OF METACOGNITION

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INTRODUCTION

This paper is organised around the three issues central to the symposium: our conceptions of conceptual change; our approaches to promoting conceptual change; our data about the consequences of these approaches. As our paper title asserts, our conceptions of conceptual change are intertwined with our conceptions of metacognition. Hence metacognition is also explored in our discussions of conceptual change.

Our focus in the paper is largely on pre-service education, as that is the context of most of our practice and evidence. However our arguments apply broadly also to in-service education, provided that it is of a cohesive and extended form. In considering the second and third issues (approaches, data) we give examples from a 10 month, full-time inservice program with conceptual change concerns.

The pre-service context in which we teach, and from which our data comes, is a one-year, post-degree program for prospective high school teachers. Much of our work has been with a science-based group within this program.

We have previously elaborated the broad principles on which our program has rested for over a decade (e.g. Gunstone & Northfield, 1987; Gunstone et al., 1989). In brief point form these principles are:

(i) The prospective teacher has needs which must be considered in planning and implementing the program, and which shift through his/her preservice development;

(ii) The transition from learner to teacher is fundamental and difficult, and is greatly facilitated when intending teachers work closely with their colleagues; (one crucial aspect of the learner-to-teacher transition is to change from dependent to independent learner)

(iii) The student teacher is a learner who is actively constructing views of teaching and learning based on personal experiences, and strongly shaped by conceptions/perceptions/attributes/skills previously constructed and now brought to the course;

(iv) Since all teacher educators model teaching for their students, the program should model those approaches being advanced in the program;

(v) Student teachers should see the pre-service program as an educational experience of worth;

(vi) Pre-service training is, by definition, inadequate;

(vii) The notion of the reflective practitioner is a vital model for those teaching the pre-service program.

These principles all have relevance to the specific thrust of this paper, but (iii), with its explicit and wholehearted constructivist perspective, is central. Constructivist philosophies permeate much, but not all, of the program.

In its present form, the pre-service program comprises two "foundations" subjects and two methods subjects together with service courses on use of educational technology, computer literacy and using computers in classrooms, first aid, etc. The two foundations subjects, "Social Foundations of Schooling" and "Teaching and Learning" (TAL), each involve 4 contact hours per week, and students are with the same, cross-method seminar group for the two subjects. In the methods component for prospective science teachers, students undertake two formal methods subjects (each 2 hours per week) plus common experiences for all science methods students (varying between 2 and 6 hours per week). Teaching practice is in three blocks (in 1992 of 3, 3, 4 weeks) with another week of visits to practice schools. The sciences students also have further teaching experiences, e.g., at a residential camp, in elementary schools (as part of Australian Science in Schools Week), and direct to the public at a commercial exhibition (The Great Australian Science Show).

An explicit constructivist perspective runs through the TAL subject and through the methods experiences for sciences students. Our examples of approaches described below come from these components.

Two final points of context are given before we turn to the three issues around which the paper is structured. First, we use from this point "student teacher" to mean pre-service teacher education student, "teacher" to mean the teacher of these students, and "pupil" to mean school student. Second, we have before at AERA described something of our constructivist perspectives on pre-service (Gunstone & Northfield, 1986) and in-service (Gunstone & Northfield, 1988). Our construction of metacognition is more central in the current paper than in these previous statements. This, of course, reflects the developments in our thinking and practice.

OUR CONSTRUCTION OF CONCEPTUAL CHANGE

We deliberately choose to not give a "definition". To define ("... to fix the meaning of...", Chambers Twentieth Century Dictionary, 1977) is to imply a static meaning, something we do not ever anticipate for this construct. So, we give our current understanding, our current construction for conceptual change.

We begin by describing our view of conceptual change for all learners (pupils, student teachers, etc.), then we address the central role of metacognition in this view, and then we describe the three areas in which conceptual change is of significance for student teachers in particular.

Conceptual change

School pupils, student teachers, post-graduate students. etc. all enter courses of study with existing conceptions, perceptions, beliefs and attitudes about both the content of the course of study (discipline, knowledge and stills) and the nature and purpose of learning, of teaching, and of roles appropriate for learners and teachers. Examples of content based ideas and beliefs held by pupils are now widely recognised, e.g. pupils entering physics courses with the view that a force is needed to maintain motion, students entering chemistry courses with a continuous model of matter (see Driver et al., 1985; Osborne & Freyberg, 1985 and many other sources). (Similar examples from science student teachers are given later in this paper.)

Pupil views about content of this nature have also led to the very common, and appropriate, assertion that these existing ideas and beliefs can be in conflict with what is to be learned. The same conflict often exists between pupils' views about learning/teaching/roles appropriate for learners and teachers and the learning/teaching approaches used to promote pupil learning,

although this area of conflict is far less widely recognised. Many examples are given in Baird and Mitchell (1986), e.g. "all this thinking is getting in the way of our work", and in other studies of pupil learning. (Again, relevant student teacher examples are given later in the paper.)

Conceptual change then may be appropriate in content and/or in views of learning/teaching/roles of learners and teachers. The central issue in our construction of this conceptual change is the recognition that any such change is in the hands of the pupil/student teacher. It is the pupil/student teacher who must first recognise his/her relevant ideas and beliefs, then evaluate these ideas and beliefs in terms of what is to be learned and how this learning is intended to occur, and then him/herself decide whether or not to reconstruct their ideas and beliefs. This formulation of recognise, evaluate, decide whether or not to reconstruct has obvious relationships with the Posner, Strike, Hewson and Gertzog (1982) formulation of dissatisfaction, then intelligible, plausible, fruitful. Dissatisfaction implies recognition, evaluation requires at least plausibility, and fruitfulness is an extremely helpful way to consider making the demanding task of reconstructing personally valuable to the learner. The Posner et al. (1982) formulation has been of major influence on our thinking and practice.

There is one further assertion to make before we address the centrality of metacognition to conceptual change. The assertion is obvious, but crucial. By

arguing that it is the pupil/student teacher who must themselves recognise, evaluate, decide whether or not to reconstruct we are not arguing a diminished role for the teacher. Quite the opposite. The consequence is different, much more demanding roles for teachers so as to allow and actively promote recognition/evaluation/reconstruction.

Metacognition

Crucial to our construction of conceptual change then is that learners (pupils, student teachers, others) make informed decisions about the reconstruction of personal conceptions, perceptions, attitudes, beliefs. By informed we mean to recognise and evaluate with an understanding of learning goals, of relevant uses of the knowledge/skills/strategies/structures to be learned, of links between these goals and personal ambitions relevant to the goals.

To make such an informed decision is, in our terms, to be appropriately metacognitive. That is, in brief, we use metacognition to mean learners having an informed and self-directed approach to recognising, evaluating, and deciding whether or not reconstruct. Hence metacognition and conceptual change are totally intertwined. (This argument is elaborated in Gunstone & Baird, 1988).

One consequence of this position is that to be informed requires having the skills and knowledge needed to be able to be metacognitive. This might be

taken as suggesting that learners be taught "study skills" or some such approach which treats necessary metacognitive skills and knowledge as separate from real learning tasks. Any such suggestion is the antithesis of our view of the intertwined nature of metacognition and conceptual change. We assert that the development of metacognitive skills and knowledge must be in the context of learning tasks perceived by learners to be appropriate and valuable. Such an assertion has strong support from classroom based research (e.g. Baird & Mitchell, 1986; Gunstone & Baird, 1988; White, 1988; White & Gunstone, 1989).

Conceptual change in teacher education.

Conceptual change in teacher education then occurs when student teachers, in an informed and self-directed way, recognise, evaluate and decide whether or not to reconstruct existing ideas and beliefs. Conceptual change is necessary, variously for individual student teachers, in three areas:

(i) ideas and beliefs about teaching and learning and roles appropriate for teachers and learners (this includes both the context of their own learning in the pre-service program and the context of their teaching of pupils in schools) (see, for example, Gunstone et al., 1989);

(ii) ideas and beliefs about the discipline content and skills students will teach, science in this case (see, for example, Ameh & Gunstone, 1986), and epistemological issues surrounding this content such as the nature and purpose of observation in science and science learning (see, for example, Gunstone, 1990);

(iii) ideas and beliefs about themselves (see, for example, Northfield, et al., 1992).

Of these three, (iii) is not pursued in this paper as it is much more difficult to be specifically instructionally intrusive in this area. However it is a crucial aspect of conceptual change and is a focus for activities in our program.

APPROACHES APPROPRIATE FOR PROMOTING CONCEPTUAL CHANGE

In this section we give some specific examples of our approaches. These examples all have links to some aspects of the principles given in the introduction. Our conceptualising of issues related to these principles h:. changed during the many years of evolution of this program. We give our current thinking about these issues in the conclusion.

Some specific examples from our program.

We now describe a selection of examples from our practice. Some are particular single episodes, others are forms of pedagogical practice which run across various experiences. For each example we attempt to also briefly describe our purposes in terms of the list above of general issues. Our description and discussion of the first example is more extensive as we try to use this to give a greater sense of the context in which examples occur.

Example 1: (The bad lecture) The first formal lecture to the sciences group is one made deliberately very poor (monotone, rapid voice; no eye contact; no non-verbal behaviour; lecturer "hides", motionless, behind large lectern; etc.) It lasts about 15 minutes, and then students move into seminar groups where they begin in the traditional way (discuss content of lecture) but are moved by the teacher to then consider why the lecture was bad. Later on the same day the person who gave the lecture meets the group for a second time and runs a lecture-discussion to review the purposes of the experience and introduce a set of questions which student teachers are encouraged to use throughout the program as one way of appropriately analysing their experiences. These questions are reproduced in Figure 1. This second session also allows the "bad lecturer" to recover some pedagogic credibility with the student teachers.

- Figure 1 about here -

Our purposes for this experience are, with one exception, made explicit to the student teachers in the whole group review session. Figure 2 contains the purposes shown to and discussed with the student teachers in this session.

- Figure 2 about here -

The review also raises, but does not attempt to resolve, the question of whether or not, in terms of these purposes, the "bad lecture" is good teaching. At this point of their development we want to have student teachers recognise the validity of the question and the importance of considering the question in terms of purposes.

Of the purposes listed in Figure 2, (i) comes from our knowledge that many student teachers enter our program with the belief that content organisation is all that matters in teaching, and the remaining 5 all reflect in various ways our concerns with student teachers recognising and analysing their own views, reflecting on and analysing experiences, seeing alternative approaches, and recognising collegiality. In addition there is a further purpose, one which we did not see when we first used this experience but which was pointed to by a number of students later in the program. That is to demonstrate that the teachers in the program are prepared to take risks when these are pedagogically appropriate, an important aspect of our general issue (iv) above (supporting intellectual risk talking). Many of the pedagogies we later argue

student teachers should use are pedagogies which can appear to relinquish control in the classroom. Hence student teachers see these as risky. It is fundamental for teachers to recognise this. Demonstrating so explicitly that the teachers also will take real risks, such as making oneself look very bad on the first occasion of working with a group, sends a powerful message to some student teachers.

Example 2: (Learning about learning) This also occurs early in the program, either in the first or second week. It is in the hands of the "bad lecturer" from example 1, thus giving that person another chance to show that the bad lecture was contrived behaviour. In this example, the sciences students, in seminar groups, experience an interpretive discussion approach (Barnes, 1976) to the learning of a concept most do not understand (normal reaction in mechanics). At the end of this learning student teachers then write answers to the following questions: What have I learned about physics? What have I learned about my own learning? What have I learned about the learning of others? What links are there between my learning or lack of learning and the teaching approach? Any other comments? Responses to these questions are, with the exception of the physics learning question, anonymously collated and copies returned to the student teachers. Only those responses from the physics learning question which have relevance to learning/teaching issues are included. A very brief selection of responses from the 1992 program are given

in Figure 3. The full list returned to students contained 61 statements, plus a selection of 44 from previous years.

- figure 3 about here -

Our purposes in this example are, first, to reveal something to student teachers of views, theirs and their colleagues, of teaching/learning/roles for teachers and learners, and to start them evaluating these beliefs; second to provide an example of an alternative teaching/learning approach from which the student teachers are, largely, genuinely learning. The range of beliefs is well illustrated by Figure 3. Responses there include a number which have strong constructivist underpinnings (e.g. Nos. 4, 5, 7, 11, 19), clear recognition of the affective dimension of "cognitive" learning (e.g. Nos 16, 20) as well as more predictable responses (e.g. 1, 2, 6). The list returned to the student teachers is used as a resource through the program, both when new ideas are introduced and for promoting evaluation and possible reconstruction of existing views.

This example also illustrates the importance of the content which provides the learning context for an experience concerned with recognition etc. of existing views of learning and teaching. This content has two necessary attributes for an experience with these purposes very early in the program: it is content which most of the student teachers recognise as important (i.e. they may have to teach it in science classes in schools) but which they know they do not

understand; it is content for which conceptual resolution and significant gains in understanding are possible in the two hours of the experience. (This latter point in this case comes from the fact that text books and physics/science teaching have made understanding unlikely by totally ignoring the physical origins of the normal reaction force, the distortion in surfaces).

Example 3: (The one-to-one experience) The first formal teaching of pupils undertaken by the student teachers is of one grade 7 high school science pupil for one class period (50 minutes). This context is used so that the first formal teaching is without the two concerns which often distract student teachers from considering pupil learning - management and their own understanding of the content to be taught. The student teachers determine the content they will teach, and the very rare individuals who have management problems with their one pupil are most unsuited for teaching. Our purpose here is the obvious one - to have them beginning teaching with a focus on pupil learning as paramount.

Example 4: (Teaching for understanding) Serious systematic consideration of alternative pedagogies commences after the first period of teaching practice and is initially approached by using alternative strategies to teach content that student teachers will likely have to teach in schools but which they do not understand. A detailed description of part of one case of this, teaching D.C.

electricity to biology majors, already exists (Gunstone, 1990). Hence our description here is very brief.

The strategies used include concept maps, predict-observe-explain, relational diagrams, and question asking (rather than answering). (These and other strategies are described in White & Gunstone, 1992.) Approaches to fostering linking by learners across teaching sessions, understanding approaches to laboratory work, and other such metacognitive issues are also raised. Our purposes include using a genuine learning experience to enhance understanding of the strategies, showing that the teachers value the strategies, and using reflection on the experience to begin student teacher thinking about pupil views of learning/teaching etc. and the implications of these views for classroom practice.

Example 5 (Journals) In the foundations subject TAL a journal is required. Students are encouraged to extend the journal across all experiences in the program. Our purposes for this requirement are of the same general form as argued by Fulwiler (1987).

> When people write about something they learn it better. That, in a nutshell, is the idea behind asking students to keep a journal. While some of us... might argue about what they should be called... we would not disagree about their purpose and value: writing helps our students learn things better and these notebooks provide a place in which to write informally yet systematically in order to seek, discover, speculate, and figure things out (p.9).

The journal is a private communication between the student teacher and their TAL tutor (teacher). The teacher responds in writing in the journal in ways intended to further encourage reflection, analysis and speculation by the student teacher.

The TAL teacher also keeps a journal which must, because it is available to all members of the class, be a little more general. For most teachers the focus of their journal is on their planning and classroom decisions.

Example 6: (A classroom anecdote) The most significant aspect of the preceeding five examples is that they are examples of the translation into practice of the general issues given at the beginning of this section. It is our intention that these general issues permeate all interactions with students, that the anecdote which follows is representative of all teacher behaviour.

The anecdote involves one student teacher who was grappling with having been introduced to constructivist perspectives on learning and the tenacity of pupils' alternative conceptions. "But pupils will believe what I tell them because I am the classroom teacher" the student teacher said. The teacher in the pre-service program responded "I am the teacher here and I say that pupils won't automatically believe you." The teacher's intention was to provoke a deeper reflection on these issues than had, to that point, been forthcoming from the student teacher.

Example 7: (An in-service context) We have already made passing mention of a 10 month full-time in-service program. This was conducted in 1990 at Monash for 34 selected Filipino physics teachers, with the broad purpose of enabling the 34 to become in-service trainers in their own country. In addition the program aimed to substantially develop their understanding of physics. Hence, much of the first half of the program was devoted to the learning of physics via use of pedagogies new to the participants. Time was also devoted to discussion of the pedagogies. Throughout this period participants kept journals (termed "diaries") in which it was intended that they reflect on their own learning of physics, on the value or otherwise of the pedagogies, and on changes in their understandings. This was fostered by formal tasks such as writing after physics classes: "the main points of today's lesson; ways in which I have changed or extended my understandings after today's lesson; questions I still have, things which still puzzle me after today's lesson."

When, mid-year, the focus of the program shifted to learning relevant to being an in-service teacher (or, shifted to learning about fostering conceptual change in others), one of the major starting points was an assignment based on the change participants had themselves undergone in the program. The assignment is reproduced in Figure 4.

figure 4 about here

THE CONSEQUENCES OF THESE APPROACHES - DATA ABOUT CONCEPTUAL CHANGE

Given our strong commitment to providing experiences to enable student teachers to recognise, evaluate and perhaps reconstruct existing ideas and beliefs, then much of our teaching has the potential to provide data of relevance to this section of the paper. We also have data collected with more formal research purposes, and relevant, if informal, observations about the subsequent professional behaviour of student teachers when they are employed in high schools.

Consequently we present data in two parts: data arising from our teaching during the program; data collected with research intent during the program. As in the previous section, we give examples only here.

Date arising from our teaching.

It might appear that the examples below divide into conceptual change in discipline content and conceptual change in teaching/learning/roles for teachers and learners. We do not so divide because the examples which have an obvious concern with discipline content are also used in our teaching, as appropriate, to foster change in pedagogical ideas and beliefs.

Example 1: This has similarity to Example 2 (Learning about learning) in the previous section, except that here the primary focus is on conceptual change in discipline knowledge (in this case, physics). Early in the program, those undertaking the specific Physics method component answer the questions about force on a ball thrown vertically up as it is rising, at the top, as it is falling which have been widely used in research studies with pupils (Osborne & Freyberg, 1985, p.45). Each year 15% - 20% of these intending Physics teachers assert that the force at the top of the ball's flight is zero, thus exhibiting an alternative conception common among pupils. The teaching purpose of the task is the subsequent focussed discussion in the group about answers and reasons, and answers and reasons from other groups (previous student teachers, school pupils, practicing science teachers). During the discussion convincing data always emerges to show conceptual change (and why) among at least some of those who originally answered zero force at the top, and to show greater understanding of and confidence in the correct answer among some who gave this answer (also conceptual change, although not as dramatic). For some student teachers this experience, and subsequent discussion of the teaching/learning approach, leads to some restructuring of ideas and beliefs about physics learning and teaching. Again, the convincing data is in the teacher/student teacher discussion.

Similar episodes, drawn from the extensive research on pupils' alternative conceptions, are used in methods contexts. Example 4 (Teaching for

understanding) in the previous section (teaching D. C. electricity to biology majors) is another example of this. The detailed description of this case already referred to contains some discussion of resulting conceptual change.

The most persuasive evidence of student teacher conceptual change from these episodes arises quite unpredictably. Sometimes the student teacher on subsequent teaching practice is required by the school to teach content, with purpose, for which these episodes are relevant. Informed use by the student teacher of the methodology used in the episode is strong evidence of change in discipline knowledge and/or pedagogical views. Such use does sometimes occur.

Example 2: As part of the first serious considerations of constructivist perspectives on the teaching and learning of science, student teachers undertake a particular predict-observe-explain (POE) task. The task requires prediction, with reasons, of the relative times of fall for a shot put and rubber ball of the same diameter dropped from a height of 2 metre. (POE's are described at length in White & Gunstone, 1992). One set of responses is given in Figure 5. These form the basis of similar discussion to that described

Figure 5 about here

for example 1. However the major purpose of the task is to confront student teachers with the theory dependence of observation, and to begin their consideration of the pedagogical consequences of this. This is done by presenting data about prediction and observation in the manner shown in Figure 6. This alone causes some to begin to restructure their ideas and beliefs about observation and its role in science teaching.

Figure 6 about here

A general comment on examples 1 and 2: Apart from particular cases of student teacher practice in schools, as already mentioned, the major data source showing conceptual change is in the journals student teachers write. If a student teacher chooses to write about, for example, the POE experience described above, and does so in ways which show a recognition of previous views, current new views and reasons for change, then the likelihood of conceptual change having occurred is high. Not all student teachers choose to write about all experiences of course, so, again as part of our teaching, we sometimes specifically require them to write along the lines described in Example 7 (An in-service context) in the previous section (main point of today's experience; ways understanding has been extended or changed by today's experience; issues still of concern). The difficulty with this approach is that choosing to not write about personal conceptual change is not evidence that it has not happened, while being able to plausibly describe a personal

change does not mean a necessary shift in ideas and beliefs. However, given the centrality of metacognition to conceptional change, we argue that something so implicit that it cannot be described by the individual cannot be conceptual change.

Example 3: In the TAL subject, student teachers are asked early in the program to draw a teacher. (The task is taken from Harmin & Gregory, 1974). At this point the task is used to help student teachers recognise existing views of teaching/learning/roles. The task is often repeated near the end of the program, student teachers then given their first responses, and then asked to consider both, any changes and the extent to which they are comfortable with the implied changes. Early drawings are often of didactic form, later drawings tend to be more interactive. Examples from students in our program are given in White and Gunstone (1992, p.99).

Example 4: Fortune lines (White & Gunstone, 1992) are attempts to show quickly the ways in which attributes like feelings or perceptions of personal understanding change across experiences. The fortune line is a sketch graph, with the attribute on the vertical axis and the experiences on the horizontal axis. Tasks such as "draw a fortune line showing how your confidence in your ability to teach has changed through the X months of the program" provide both a powerful indication of the student teacher's perception of him/herself

as a teacher, and a very useful stimulus for reflection on change seen to have occurred.

Example 5: Two of many possible examples from the 10 month in-service for Filipino physics teachers are now given. First, for the task reproduced in Figure 4, some participants gave highly informed personal accounts of personal change, both in physics and in pedagogy. Some of these accounts were given greater validity later in the program when the participants prepared modules for use in in-service work which derived from the self-reported changes in physics and pedagogy. Second, considerable change in views of teaching and learning is shown by considering one initial reaction of participants in comparison with later behaviour. When the participants first arrived the aims of the 10 month program were known and accepted by all parties involved. Those teaching the in-service did not have a detailed weekly program of content and activities prepared, for the obvious reason that they could not forecast in detail where the participants' learning would be for the whole program. The participants arrived with didactic views of teaching and learning and, consequently, literally could not initially cope with not having a detailed timetable for the whole year. After several months they not only accepted this but could readily give insightful accounts of the pedagogical reasons for not having a detailed program. This was clear evidence of conceptual change in pedagogical views.

Date arising from res ·arch studies.

Here we refer to 3 examples of formal research studies, but do so relatively briefly because published accounts of 2 already exist and the third is still in progress. In addition, the 2 completed studies were of particular influence on aspects of our thinking and practice.

Example 1: In 1982 some student teachers from our program were subjects in a study of conceptual change in discipline content. The study is reported in Champagne, Gunstone and Klopfer (1985). That report gives strong evidence of conceptual change in the area of physics on which the research focussed. What is particularly interesting for the current paper is the evidence from that study of the importance of metacognition in the observed conceptual change. The many data sources in that study included written reflections by the participating student teachers on their learning and other reactions at the end of each instructional session. Many of these reflections were metacognitive and of great significance to subsequent conceptual change, e.g. "Some people fight hard not to change preconceived ideas", "..[it's] as if we are trying to turn a blind eye to the truth. It's comforting to try to keep certain ideas forever even if there's a chance that they may be wrong", "I'm mentally exhausted after each session and the effort to hold out when I'm wrong is very draining."

Example 2: In 1987 we undertook an intensive case study of one seminar group of sciences student teachers for the whole of their pre-service program. Data sources included observation of course experiences and teaching practice, regular interviews (including both relative open and focused by particular tasks) with student teachers and their teachers, journals from both student teachers and teachers, and various reflective tasks undertaken by student teachers and their teachers (the most substantive of these involved participants taking all the interview, journal, etc data they had produced during the year and writing an evaluation of the year for themselves). Data from this study form a large report (Baird et al., 1989), some of which has previously been reported at AERA (Gunstone et al., 1989). Here we give only a very brief snapshot from the large report which is relevant to conceptual change.

One student, for whom conceptual change was most obvious, came to the program with quite transmissive views of teaching. (Evidence: in seminar discussion of a 5 minute microteaching exercise done by another class member in the second week of the course he was very critical of the small amount of content covered; wrote in the first week about the ability to "present material..." being a fundamental attribute of a teacher; etc). By the third week he was explicitly evaluating his views: after his own microteaching he wrote "hit home later that I had presented an information presentation rather than a learning exercise". By mid year he was offering thoughts such as his journal being "my learnings rather than my lecture/seminar notes (which until recently

contained only other people's notes) and handouts which are others' notes", "our writing a critique of [the teachers] teaching is - in a way - an assessment of the strategies they have been helping us learn all year. They practice what they preach - any assessment by me is an evaluation of what they practice and what they preach." In his end-of-year course written personal evaluation he wrote insightfully and at length about his initial views, changes in views and courses of these changes.

For the other student teachers involved, similar data shows there were various degrees of change. For the individual at the other end of the spectrum to the person just cited, the total change was, crudely, zero. Throughout the year this individual moved like saw-teeth through a cycle of small growth then reversion repeated many times. This individual had major personal problems which were of much greater individual significance and demand than was our program.

Example 3: A doctoral study in progress (Loughran, 1992) shows, again, that conceptions of teachers and teaching/learning do change substantially for many student teachers. Further, this study also shows that whether or not student teachers choose to reflect on their experiences is a major influence on this change, and that in turn, the choice to reflect is influenced substantially by the pedagogies used by the teacher.

CONCLUSION

In our presentation of conceptual change data we have said little about the generality of change. Any attempts to generalize must be qualified in two very obvious ways - we do not achieve change with all students, nor do we achieve the same change with those student teachers who do change.

In the previous section, in presenting evidence about conceptual change, we have given greater prominence to data derived from teaching/learning activities than to data derived from specific research studies. While this is compatible with some aspects of some of the research studies having already been published, there is another issue here. We have given this prominence to teaching-derived data in order to emphasise that a necessary consequence of our view of conceptual change is that such data must explicitly emerge from teaching. To have student teachers being more metacognitively informed is to have student teachers explicitly aware of their own conceptual changes. That is, teachers need to have the drawing out of data about any conceptual change as one of their teaching purposes. Further, the teachers themselves must be metacognitive in their own approaches, something for which student teacher conceptual change data is a necessary component.

This emphasis on the inter-relationships between teaching and seeking to understand the teaching should lead us to undergo informed conceptual

change of our own about our approaches to pre-service education. This we attempt, and our final statement in this paper is a description of our current thinking about issues important to fostering conceptual change in teacher education students.

The seven principles given in the introduction to the paper are, of course, fundamental to approaches to the promotion of conceptual change. These, as we have already stated, have been broad guides to us for over a decade. The general issues listed below represent our current elaborations of the principles. They are intended to be somewhat more specific than the seven principles, and to hence provide direction for actual classroom practice in the pre-service program.

(i) Learners have a dual agenda in teacher education programs - learning the content being taught, and learning about pedagogy by example. Put another way, all teachers in teacher education programs are models. This modelling must be positive, and student teachers should be metacognitively informed in their learning from this modelling. This requires, inter alia, teachers discussing their pedagogies with student teachers and linking these with their pedagogical purposes, and, whenever appropriate, teachers using the pedagogies argued to be important for student teachers to embrace.

(ii) Student teachers need ideas (from broad philosophies to specific new teaching/learning strategies) about teaching/learning/roles of learners and teachers in order to have an informed basis for the evaluation and possible reconstruction of existing ideas and beliefs. These new ideas must be advanced in ways which show that the teachers value the ideas.

(iii) Conditions which encourage intellectual risk taking by student teachers must be provided. Trust and support are needed when student teachers are trying to acknowledge and restructure existing views, and trying to understand and evaluate new views. This risk taking is needed both during the university based component of the program and during periods of teaching practice. One dimension of the origins of the risk-taking is that often experience precedes understanding when learning to teach.

(iv) A genuine understanding of the content the student teacher will teach is a necessary component of a student teacher's ability to conceptualise and implement alternative pedagogies. Hence an understanding is needed by teacher educators of the conceptual areas of the content student teachers will teach for which student teachers hold alternative conceptions, and of the detail of these alternative conceptions. This allows the teacher to use contexts which involve real conceptual

learning for the student teachers as vehicles for the exploration of pedagogies.

(v) Discipline content, as discussed in (vi), is a significant context for change of ideas and beliefs about teaching/learning/roles. That is, some content is more appropriate for effecting conceptual change about pedagogies.

(vi) The teacher (of pupils or student teachers) is central to conceptual change. Put another way, a necessary consequence of our embracing of constructivist perspectives on learning is that we must accept that our ideas cannot be handed directly to others; they must construct their own understandings of these ideas, whether they are our student teachers or other teacher educators.

(vii) Many of the above issues require, as a minimum condition, a genuinely collegial approach. This is not only collegiality between teachers, but between teachers and student teachers and student teachers themselves. In addition, the collegiality provides safeguards against perceptions that seeing learning as the learner's responsibility is to believe that all learning is relativistic, than any outcomes are acceptable.

From both of these collegial issues, the positive importance and the safeguard against perceived relativism, it is also then clear that a single teacher in a teacher education program will find it very difficult to adopt our philosophies. Alone, with other teachers embracing different philosophies, he/she runs the risk of being dismissed by student teachers.

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- Why is the teacher doing this?

- How do the purposes match the learning/teaching methods being used?

- Would I do it differently?
  If yes - how? and why?
  If no - why not?

- Do I understand what I am supposed to be doing in this session?
  If not - what do I do about this?
  If yes - do I agree with my role?

ETC.

Figure 1: Questions given to student teachers to encourage analysis of their program experiences.

AIMS OF THIS MORNING'S SESSION:
(LECTURE AND SEMINAR)

(i) To illustrate the absurdity of thinking that organising the content is all that matters in teaching.

(ii) To show we are serious in wanting you to critically analyse the learning situations you will experience this year.

(iii) To begin your thinking about ways of teaching.

(iv) To illustrate that judgement of teaching should always be in terms of learning, or the lack of it.

(v) To illustrate that "good" teaching (i.e. teaching which seriously tries to achieve worthwhile objectives) is often a high risk activity for the teacher.

(vi) To illustrate our seriousness in believing it to be vital that you come to control your own learning in this first of 40?? years of personal and professional development.

Figure 2: Purposes of Example 1, as discussed with student teachers.

What have I learned about my own learning?

1. "My retention [of previous learning] is there, I just sometimes need reminding."
2. "To understand something requires not only application of formulae and theories, but direct involvement and observations."
3. "Generally I don't question why - just accept it as true. We were never meant to question at school and if I did the answer was never forthcoming."
4. "I had misconceptions about ideas I thought to be fact."
5. "I tend to see what I already believe."
6. "Accepting a concept is not learning. I must ask questions and actually think about what is being said."

What have I learned about the learning of others?

7. "... I think we all gained an understanding."
8. "Each person's learning goes at a different pace. People may not realise the prejudices/biases that they have."
9. "Group discussions [can help] those having trouble and also those who already think they understand."
10. "Just because I understand doesn't mean others can 'know' what I am saying if I don't use their 'language'".
11. "Everyone's experiences are different and so is their background knowledge."

Connections between teaching and learning or lack of learning?

12. Learning helped when "teacher makes me think that understanding is just around the corner (but it's not a race to get there)."
13. "Using students to comment provided better learning."
14. "The way the concept was taught was confusing. I was expecting an explanation on a material level rather than a 'rule' type explanation..."
15. "How I learn will probably be how I teach."
16. "I feel OK about being in a minority [with voting on the table pushing up] because I was confident of the outcome."

Any other comments?

17. The class "really made me consider how important it is to illustrate or use examples in order to teach. It is also equally important that while you teach you must not get carried away with examples. You must listen and observe the very important reactions of students."
18. "Perhaps the use of a range of examples and ways of saying things confused as many people as it helped. That confusion could be good - make people think - or it could make other people just give up."
19. The teaching was an "example of teaching a fundamental aspect of physics through a very clear and step by step build up in confidence of beliefs. My only concern is that about a month from now - lacking any reinforcement of the concept - some people will forget how this explanation fitted together and will return to their original belief discounting this as a time when they were led into believing what [the teacher] wanted them to believe."

What have I learned about physics?

20. "I hate it more now than ever before"
21. "A topic I thought I knew, I didn't fully understand until it was put in another context."
22. "People tend to have problems with simple ideas because they are taught badly."

Figure 3: Student teacher responses from teaching example 2.

PASMEP Assignment 3

Learning and teaching

The object of this assignment is to trace two changes which you have experienced since the start of the PASMEP Program.

The changes should be

(a) a conceptual change, relating to physics.

and (b) a conceptual change, relating to learning and teaching.

You should trace the exprience of each change, referring to entries recorded in your diary.

Please do not copy our large sections from your diary - just mark the diary entry and refer to it by date. Your diary should be submitted as part of the assignment. Conceptual change is rarely smooth, and it is common to go through periods of doubt, confusion and uncertainty. Both the 'backwards' and 'forwards' steps in the change should be recorded, and you should examine the factors which contributed to the change, those which facilitated it and those which hindered its progress.

For each change you should conclude by answering the following questions:

What did you learn about your own learning from this experience?

How 'tranferable' do you think this experience is, i.e. do you think it tells you something useful about how other people learn?

Figure 4: Assignment used to focus on change via personal experience for participants in a long-term in-service program.

Predictions and Reasons

Shot put falls first: 17
(Shot has greater weight or greater gravity force on it: 9
tried it/seen it: 5
air resistance affects shot more: 2
no reason given: 1)

Same time to fall: 7
(gravity pulls the same on all things: 3
tried it/seen it: 2
told so/read this/taught this: 2)

Rubber ball falls first: 0

Observations

Same time: 9
Shot put first: 10
? Perhaps same, perhaps shot first: 3
Cannot tell: 2

Figure 5: Responses from 24 science graduates to a predict-observe-explain task involving a shot put and rubber ball dropped from 2 metres.

	Observation			
Prediction	Same time	Shot first	? Same or shot first	Cannot tell
Same time	7	-	-	-
Shot first	2	10	3	2

Figure 6: Links between individual predictions and observations for the data in Figure 5.