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INTRODUCTION

In this paper, we consider a model for teacher inservice that is informed by constructivism. Initially, we consider the criteria for identifying conceptual change, briefly examine research on the roles which teachers engage in when implementing innovations, and describe the different knowledge bases needed in using teaching approaches informed by constructivist referents. Secondly, we describe an inservice programme for science teachers in one high school, and thirdly show how a five-stage model to introduce teaching/learning approaches informed by constructivism was developed.

Approaches to teaching and learning which are informed by constructivism focus on the learner's conceptual knowledge because in constructing knowledge each learner's conceptual framework will change. A model of conceptual change developed by Posner, Strike, Hewson and Gerzog (1982) has received wide currency in science education circles and has "accepted constructivism as a powerful perspective for understanding, interpreting and influencing student learning in science and other disciplines" (Hewson & Thorley, 1989, p. 541). Hewson and Hewson (1988) proposed the conceptual change model to examine the processes and conditions whereby students of science construct scientific concepts. The model also has been used in teacher education. For example, Baird and Mitchell (1986) used the conceptual change model to explain teacher change resulting from an extended inservice programme to promote effective learning in the classroom, and Gunstone and Northfield (1988, p. 1) adapted the model for describing teacher change because "constructivism and conceptual change need to be considered in the same way for students, teachers and researchers." Tobin (1993) has suggested that, in the process of encouraging changes in teaching, there is a need for a change in the referents that teachers use when implementing new pedagogical approaches. The referents, which act as organisers of teacher knowledge and take the from of beliefs and images, need to change from being centred on an objectivist to a more constructivist orientation.

Considerations for Conceptual Change

When considering a new conception, the teacher/learner needs to decide whether three criteria are met (Hewson & Thorley, 1989). Firstly, the new conception has to be intelligible – the new concept needs to make sense to the learner. Secondly, the new conception has to be plausible – the difference between this condition and the first is that for a concept to be plausible the individual must believe that the concept is potentially true. Even though an individual may believe that a concept is intelligible, this alone does not mean that the concept is regarded as being true. Plausibility incorporates the condition of a concept being intelligible as well as the possibility of truth. Thirdly, the new conception has to be fruitful – to accept a new concept, that concept needs to be useful to the individual in, for example, solving problems that were not previously solvable, or helping provide new ways of examining a situation. The number of possible ways to view a concept as fruitful depends on the individual's conceptual framework and the relevance of the new concept to that framework. A conception becomes a source of dissatisfaction to the learner when it loses plausibility or fruitfulness or both, that is, an individual must lose faith in the ability of existing conceptions to solve some problems before initiating a search for new concepts (Hewson & Thorley, 1989). Dissatisfaction lowers the individual's commitment to the existing concept and may be considered as a precondition and necessary criteria for conceptual change to occur.

Gunstone and Northfield (1988) added a fifth criterion of *feasibility* for conceptual change when considering teacher inservice activities. A concept becomes feasible when individuals give greater priority to the new concept raised in an inservice session than others which are part of their professional and personal lives. Even though a concept may be intelligible, plausible and fruitful, conceptual change may not occur unless the individual places greater importance on the new concept in comparison to the old concept. Building on the work of Hewson and Hewson (1992) who define the status of a individual's conception as being the extent to which a new conception meets the three criteria of intelligibility, plausibility and fruitfulness, we will include the criteria of feasibility. Hence the status of a new concept has risen if all four criteria are met, but if, for example, the new conception is viewed by a teacher as being intelligible, plausible and fruitful, but not feasible, then it will be in conflict with the learner's existing feasible conceptions and thus have a lower status. According to this conceptual change model, a major factor of the learning process is the status that new and old conceptions have for the learner.

The five criteria of intelligibility, plausibility, fruitfulness, dissatisfaction, and feasibility were used to frame an approach to the inservice programme informed by constructivism that is described in this paper. By modelling such an approach in an inservice programme with a group of science teachers, we were attempting to fulfil the five criteria for conceptual change needed for successful inservice recommended by Gunstone and Northfield (1988).

Teaching Roles When Implementing Innovations

In this study, teachers were encouraged to change their conceptions of teaching and learning in science and develop new pedagogical skills which were informed by constructivist referents. As teachers make such changes, Simon (1989) has stressed that change does not take place all at once, and that teachers need to try the new approach, practice the necessary pedagogical skills, and discuss the results obtained when implementing any new approach in the classroom.

As teacher's apply theoretical knowledge in the practical situation of the classroom, they begin to develop an understanding of the relationship that occurs between the two. However, not all teachers will achieve a complete level of this understanding. Grundy (1987) has suggested, on the basis of the work of Habermas, that three levels or interests are attained in the process of reaching an understanding between theoretical knowledge and practice, namely, technical, practical and emancipatory. Each of these levels or interests, which are reviewed by Ewert (1991), represents an evolving development within the teacher and determines the role he/she will adopt within the classroom. For example, Grundy defined technical interest as "a fundamental interest in controlling the environment through rule-following action based on empirically grounded laws" (p. 12) which implies controlling student learning. The basic orientation of the practical interest is toward understanding, where teacher and students interact in order to make meaning of the world, and practical interest may be defined as "a fundamental interest in understanding the environment through interaction based on a consensual interpretation of meaning" (Grundy, 1987, p. 14). Emancipatory interest is concerned with empowerment, the ability of individuals or groups to take care of their own lives in autonomous and responsible ways, and may be defined as "a fundamental interest in emancipation and empowerment to engage in autonomous action arising out of authentic, critical insights into the social construction of human society" (p. 19).

Earlier research by James and Hall (1981) suggested that teachers move through seven stages of concern when involved with inservice programs which focussed on implementing new teaching approaches. In their study of the effects of a two-year inservice programme on the adoption of approaches to the teaching and learning of mathematics informed by constructivism, Simon and Schifter (1987) identified similar stages of development to James and Hall. They noted three stages: firstly, no knowledge of or use of constructivist epistemology, secondly, a mechanical application of constructivist approaches in which teaching behaviours are the focus rather than student learning, and thirdly, a focus on student learning rather than teaching behaviours.

However, there are difficulties in directly comparing the different stages for implementing innovations proposed by different authors because not all stages of the different authors have equivalent steps. For example, Grundy, in describing Habermas, does not define progress through the technical level in the same incremental manner as do James and Hall, and Simon and Schifter. Similarly, Simon and Schifter do not discuss an empowerment stage, whereas Grundy and James and Hall do. Examination of these interests or concerns is important because of the impact that each has in determining the role adopted by individual teachers in implementing his/her classroom practice.

Different Knowledge Bases

To effectively develop the skills for implementing a teaching/learning approach informed by constructivism, we believe that teachers need to distinguish between content knowledge, concept knowledge and subject matter knowledge. For example, there is a need for clarity in the way in which content knowledge is defined and how it is interpreted by teachers. Wilson, Shulman and Richert (1987, p.113) have stated that

> teachers use their content knowledge - their understanding of the facts or concepts within a domain - as well as their grasp of the structure of the subject matter. Teachers must have knowledge of the substantive structures - the ways in which the fundamental principles of the discipline are organised.

This definition of content knowledge is further reinforced by Smith and Neale (1989, p.2) who indicate that teachers' substantive knowledge of content will include "declarative, procedural and conceptual understanding" of the subject. The importance of the organising structure of the discipline, that is, the links between facts, ideas and concepts is noted by Prawat (1990, p.30) who in discussing the difference between traditional and constructivist teaching approaches suggests the major difference between the two is that

> the traditional approach [views] transfer as a *decontextualised* process -- one that involves, quite literally, the separation or lifting of knowledge from context -- constructivist take the opposite tack. According to the constructivist perspective, there is little reason to distinguish between knowledge and knowledge-context connections.

This emphasis on exploring the relationships between ideas, facts and concepts provides for total coverage of the content knowledge of the discipline; however, this coverage does not totally address the concept of subject matter knowledge. In defining subject matter knowledge Wilson, Shulman & Richert (1987, p.118) suggest that it includes not only the substantive structures as defined for content knowledge but also syntactic structures of the discipline which "involve knowledge of the ways in which the discipline creates and evaluates new knowledge" .

The examination of teachers' practice within the classroom does not necessarily support the breadth of definition for content knowledge put forward by Wilson, Shulman and Richert(1987). A number of major studies of science classrooms (Tobin & Gallagher, 1987; Tobin & Espinet, 1989; Tobin & Fraser, 1989; Tobin, Briscoe & Holman, 1990; Gallagher, 1991) have suggested that teachers within their classrooms are focussing on the rote learning of facts and algorithms, that is, decontextualised content knowledge. This conception of content knowledge has a much narrower definition than put forward by Wilson, Shulman & Richert (1987) and lacks the focus on concepts and organising structures they believe are important. To encompass this broad definition there is a need for teachers to have a greater understanding and awareness of the conceptual knowledge of the topic they are teaching (Bennett, 1988). There is a need for teachers to have a clear conception of what ideas or concepts are central to the discipline and how they are related to one another (Prawat, 1989). Conceptual knowledge is viewed by the authors as being derived from the relationship between content knowledge and the context within which the knowledge is constructed and recognised and has the potential for illuminating aspects of the physical and social world that otherwise would go unnoticed or unappreciated.

In reporting on a series of workshops to address this area of lack of focus on conceptual knowledge, Bowden (1988, p.260) stated that the teachers involved struggled when asked to go beyond a description of content areas, that is, they struggled with the concepts and their links. The teachers in fact realised that when focussing on teaching concept knowledge "their normal teaching practices [were] incompatible with the desired outcomes". To bring the two more closely together requires change on the "teacher's part towards a view of teaching as changing conceptions" (Marton & Ramsden, 1988, p.276). This in itself will require the adoption of new pedagogy (Millar & Driver, 1987) and pedagogical knowledge. Teachers will have to develop pedagogical knowledge which is centred on the teaching of conceptual knowledge, that is, pedagogical concept knowledge. Such pedagogical knowledge involves the use of negogiation and group work (Prawat, 1990), interpretative discussions (Mitchell,1987), and wait-time (Tobin, 1987). This pedagogical knowledge inconjunction with the pedagogical content knowledge centred on the narrowly defined content knowledge of teachers, will enable a broaden understanding of pedagogical content knowledge to be constructed which is much more reflective of the definition put forward by Shulman (1987).

THE INSERVICE PROGRAMME FOR SCIENCE TEACHERS

A group of eight science teachers from a junior high school (Years 7 -10, students aged 13-16 years old) in Bendigo, in the State of Victoria, Australia, agreed to be involved in an extended 18-month inservice programme to implement teaching/learning approaches informed by a constructivist philosophy. Their agreement was enhanced as a result of the publication by the Victoria State government of a series of curriculum framework documents for each subject taught in the secondary system, in which teachers were encouraged, and expected, to practice new teaching and learning strategies in their classrooms. The science framework document (Ministry of Education, 1987) adopted approaches informed by constructivism as the major teaching/learning strategies for teachers to use when implementing the new curriculum. However, prior to this inservice the group of teachers had no previous knowledge or experience with these types of classroom strategies. The experiences of the teachers ranged from 5 to 30 years, including a range of three to 19 years in the school where the inservice programme was conducted. Only one of the teachers had not had a position of responsibility within the school as, for example, head of the science department, curriculum coordinator, or grade level coordinator. Seven teachers had baccalaureate science and educational qualifications; one was a mathematics teacher who had transferred from the mathematics department in the school three years earlier and now taught science.

The inservice programme, which focused on each teacher's beliefs about the teaching and learning of science and not on beliefs about science (Hand & Treagust, 1991), consisted of three phases throughout which a series of semi-structured interviews, classroom observations and journal records were used to frame the data. The teachers' beliefs became the focus of the first phase of the inservice, and were continually challenged throughout phases two and three. In planning the inservice programme importance was placed on ensuring that essential features for successfully changing teachers' classroom practices (Joyce & Showers, 1980; Tobin, 1988) such as modelling of skills, presentation of theory, classroom practice and involving teachers in creating new pedagogical knowledge, were addressed.

The first phase, which took place over four months, involved a series of classroom observations examining the direction and control of dialogue for each participating teacher plus the initial inservice sessions that were influenced by the observations. In beginning the process of changing the teachers' referents, we initially focussed on exploring understandings of good teaching practices by asking teachers to define criteria that they used to distinguish good teaching practices. Using these criteria as a base, the group was exposed to readings on constructivism which focussed on classroom practice (Bodner, 1986; Driver & Oldham, 1986; Watts & Bentley, 1987). Subsequent discussion was on the curriculum model proposed by Driver and Oldham (1986) and in particular on the idea of exploring students' understandings as prerequisite for planning and progressing through a unit of study. The teachers were asked to spend a session using a free-writing process adapted from Stewart-Dore (1988) as a means of determining students' knowledge on a science unit of the teacher's choosing. This process involved students writing down their thoughts about the unit and discussing these within a group format. The teachers became aware of their lack of knowledge to address the results of the exploration of students' understandings and were encouraged to further consider their own conceptual knowledge. During this phase of the inservice, teachers' current referents were observed to be inadequate for providing pedagogical approaches to address the elicited student responses.

The second phase, which took place over four months and consisted of two half-days, one full-day and two one-hour sessions, involved the teachers examining and developing new pedagogical skills for implementing teaching/learning approaches using the constructivist referents. As a result of having determined students' knowledge, and in many instances being surprised at the range of responses, the teachers were prepared to begin efforts to develop skills for a new teaching approach. Some additional readings on constructivism (Blais, 1988; Driver & Bell, 1986) were given to the teachers during this phase. Particular emphasis was placed on teachers' thoughts as recorded within the journals. Much of what occurred within the sessions was based on encouraging and extending the changing knowledge base of the teachers as recorded by them.

The third phase took place over a full school year of 10 months and consisted of implementing new science units together with one full-day and one half-day inservice sessions. During this phase the teachers were involved in developing and implementing a complete unit of work lasting from three to six weeks using teaching/learning approaches informed by constructivism. Almost daily contact, via individual and whole group sessions, was maintained to provide the necessary support structures for the teachers. Classroom observations, semi-structured interviews, and journal recordings were the data collection procedures used during this phase.

DATA COLLECTION PROCEDURES

Classroom Observations

Observations of classrooms were used to determine the number and type of interactions taking place between teacher and students. As approaches informed by constructivism are primarily student-centered, classroom observations were focussed on the number of interactions controlled by the teacher or the students. Teacher-controlled activities were those where the teacher was the sole source of information, or organised the work to be done without any input from students, or organised practical activities based on his/her knowledge without any attempts to obtain student input. Conversely, student-controlled activities were those in which students were able to determine the direction of discussion, or practical situations undertaken were designed and implemented by students in response to questions posed by themselves. One difference noted as the teachers moved from technical implementation of the new teaching approaches to a more facilitative role in the classroom was that the number of student-centred interactions increased and the direction the lesson took was controlled much more by the students; for example, classroom observations of two teachers who were adopting faciltiator roles indicated a decrease of 35% in the number of activities directly controlled by them, while for a teacher who was identified as remaining very technical in implementating the new approaches the decrease in teacher-controlled activities was only 20% (Hand & Treagust, 1993).

As a teacher became more facilitative in his or her role, much more responsibility was given to students to determine and direct the learning pathways in order to examine the concepts being addressed. Discussion sessions became more frequent and much more student-centered whereas when teachers are in a more techincal role, even though discussion sessions are held, restrictions are placed on the free flow of information because of the teacher's lack of pedagogical skills in exploring student thinking. Appropriate questioning skills needed to conduct interpretative sessions became more fully developed as teachers develop facilitative skills, for example, the use of non-value judgemental responses to students' answers and devil's-advocate type questions to ensure that students have to defend the answers they put forward.

Metaphors

Lakoff and Johnson (1980) stated that "the essence of [a] metaphor is understanding and experiencing one kind of thing in terms of another" (p. 5). When applied to teaching, the type of metaphor(s) teachers use to describe their role in the classroom can be used as a guide to their beliefs about teaching and learning (Tobin, 1990). In listing the applications of metaphors for examining teachers' roles in the classroom, Tobin (1990) stated that metaphors can be used to conceptualise teaching roles and this conceptualisation can be changed in the process of changing the role. Further, when a role is reconceptualized, the teacher's beliefs previously associated with the role can be deemed no longer applicable to teaching. In describing the change in roles required when using teaching/learning approaches informed by constructivism, Marshall (1990) suggested that teachers will have to move away from a workplace metaphor that includes an authority figure who has status and power. Thus, as teachers move to adopt constructivist approaches, from previously constructed pedagogical content knowledge to newly constructed pedagogical concept knowledge, new teaching roles can be detected via the use of metaphors.

The teachers were asked to record metaphors in their journals on entry to the inservice programme and on completion of the unit they taught using constructivist teaching/learning approaches (Hand & Treagust, 1993). All the teachers initially used metaphors that indicated they were managers of classrooms. However, on completion of their teaching unit, changes in metaphors indicated that the teachers were in either a technical stage of implementing the new strategies and thus still dependent upon being managers or had become facilitators of learning; for example, one teacher changed from describing his teaching as being a ring master (manager) to being a sailor on a yacht [into the wind] (facilitator) where his responsibility was to adjust the sails for slight changes in the wind. As a consequence of this latter metaphor, he could

> get the maximum power and speed out of the boat with little effort; however without the skipper the whole thing turns into a mass of flapping sails and ropes and gets nowhere. [Before I may have been beating into a strong wind - battling the elements and working very hard.]

Another teacher who initially indicated her metaphor was that of a lecturer (manager) who "passes out information" changed at the end of teaching the new unit to a metaphor of social director (technician), that is , her guiding metaphor was still centred on an authorative role within the classroom.

Semi-structured Interviews

Two different groups were interviewed as part of the study. Firstly, teachers were interviewed prior to and on completion of the inservice to examine the concerns each had in relation to the adoption of the new approaches. The interviews were centred on three questions: How do children learn?; What teaching stratgies do you adopt within the classroom?; and Who controls learning?. Each of the interviews were coded with respect to these questions and analysised to determine if there had been a change in the concerns raised by the teachers. For example, when most concerns raised were focussed on self, then this was an indication that the teacher was at a technician stage. However, if most concerns were focussed on the students and how the new approach can best be implemented, then this was an indication that the teacher had moved to a facilitator stage. Teachers within the empowerer stage would be noted by students being free to pursue their own interests of subject matter and being encouraged and given opportunities to set their own problems.

The second group interviewed were the students of the participating teachers. On completion of the unit that was taught using constructivist teaching/learning approaches by the participating teacher, three students were selected at random and interviewed. Prior to the interview the students were asked to completed a simple questionnaire which asked them to indicate with explanation, if they had enjoyed the approach. Their responses formed the basis of the interview which was centred on determining the students' perception of the teacher's and their own role within the changed teaching/learning approach, and who they perceived to be in control of learning. Each of these interviews was coded in relation to these criteria and compared with the class teacher's interview responses. For example, if the class teacher stated that he/she was implementing pedagogical skills that were facilitative yet the students were unable to detect these skills then there was some indication that the teacher was not clearly in the teacher-as-facilitator role.

Journals

Each of the teachers plus the first researcher kept a journal throughout the period of the study. The journals were used to record notes about the inservice sessions, planning details, classroom observations, analysis of the readings and at various stages of the inservice program to record a metaphor to describe the teacher's classroom role. Information from the journals was coded with respect to the three questions used within the interviews. Results from each of the data sources was triangulated (Goetz & LeCompte, 1984; Kraft & Bretmeyer, 1989) to ensure that the emerging categories were valid and "grounded" in those data (Spector, 1984). Participating teachers were provided with results of the analysis and asked to provided feedback as to the validity of the emergent categories.

AN INSERVICE MODEL FOR IMPLEMENTING TEACHING/LEARNING APPROACHES INFORMED BY CONSTRUCTIVISM

Throughout the inservice programme, participating teacherswere given the opportunity to examine the changes they were making in adopting and implementing teaching/learning approaches informed by constructivism. Teachers readily acknowledged their development of pedagogical skills enabling them to determine student understandings, be non-judgemental in responding to student answers, and allow more student-centred discussions. As each of the science units were completed and implemented using the new approaches, each teacher signaled the need for a concept-based curriculum. Recognition was given by them to the development of a new form of pedagogical knowledge, that is, pedagogical concept knowledge, although they did not use this term. In developing this knowledge, the teachers accepted that there was a changing role for them within the classroom. There was a greater acceptance in handing over more control for

learning to the students, that is, they were changing from a managerial role to a more facilitative role. On completion of the inservice programme the teachers were provided with opportunities to discuss the inservice model developed by the researchers. Planned science faculty meeting time allowed the teachers to discuss, examine and comment on the model. The teachers' major focus in these discussions was on the manager role identified by the researchers.

The inservice model describes stages in the development of teachers' pedagogical knowledge, discusses how these stages fit the criteria needed to promote conceptual change, and illustrates how these developments in knowledge bases and teaching roles can be examined as teachers experience the inservice programme. As the teachers' pedagogical knowledge changed as a result of their involvement in the inservice programme, we identified five stages of change as a result of the data collected from classroom observations, teacher and researcher journals, questionnaires, and semi-structured teacher and student interviews. These stages are presented in Figure 1 and illustrate developments of the teachers' knowledge bases and roles, and of the five criteria for conceptual change. The first four stages of this inservice model closely resemble the four phases described by Driver and Oldham (1986) for a constructivist approach to curriculum development -- documentation of current practice; review of background issues including the findings of research on children's ideas in the selected topic areas; development of revised teaching strategies and programs, and implementation of the review strategies. At the same time, the inservice model explicitly fits the conceptual change criteria of Posner et al. (1982), and Hewson and Hewson (1988), and extended by Gunstone and Northfield (1988). The inservice model attempts to fit teaching roles to the teachers' progression through an inservice programme based on teaching and learning approaches using constructivist referents and subsequent adoption of such approaches by the teachers.

Stage 1: Teacher knowledge of classroom practice

Prior to the inservice, teachers were asked to describe the teaching strategies they used in the classroom. Observations of the teachers indicated that all were working in an information transfer mode with an emphasis on ensuring that students were receiving correct scientific content knowledge. In other words, throughout this stage all the teachers emphasised control of students and content knowledge; the role adopted was managerial as noted by the metaphors the teachers used to describe their teaching, for example, a ring master, a coach of a football team, and a lecturer (Hand & Treagust, 1993).

Stage 2: Teacher identification of students' knowledge of science

Teachers were asked to determine students' understanding of a particular topic of their choosing and the researchers helped them use appropriate strategies to achieve this task, such as the free-writing process. During this stage, teachers were not asked to change their pedagogical approaches, only to conduct one lesson to examine students' ideas. As a result of having determined that students' ideas were different from what they had been perceived to be, the teachers began to become dissatisfied with their pedagogical approaches. As an example of this dissatisfaction, during a discussion into the process of how to determine essential concepts to be addressed within a teaching unit, the teachers asked, after exploring the students' ideas, "what do we do now?" As the first author noted in his journal, this question also was posed by teachers individually during interaction during school visits:

> It was out of this discussion [on concepts] that the role change came about. It was a little surprising to hear that "I don't know where to go from here" - even though they had the [students'] misconceptions in front of them. Gary was the only one who was not troubled by this. He stated that by jumping the barrier to address what the students knew was a little scary, but was the obvious thing to do.

Teachers at this stage stage had insufficient pedagogical knowledge of how to plan in order to challenge students' ideas and, apart from Gary, they were reluctant to attempt to do so.

Fig. 1: The five stage inservice program to implement constructivist teaching/learning approaches and the criteria which have been fulfilled

Stage of Inservice and its focus	Teacher's Knowledge Base Emphasised	Teacher's Role Characterised	Conceptual Change Addressed	
Stage 1 Teacher's knowledge of classroom practice	Old Pedagogical Content Knowledge	Manager		
Stage 2 Identification of students' knowledge	Student Understandings		Dissatisfaction	
Stage 3 Developing pedagogical concept knowledge	Conceptual Focus Pedagogical concept knowledge	New Pedagogical Knowledge	Technician	Intelligible Plausible
Stage 4 Broadening and refining pedagogical content knowledge	Broadened and refined Pedagogical Content Knowledge		Fruitful Facilitator Feasible	
Stage 5 Development of a constructivist teaching framework	Pedagogical Subject Matter Knowledge	Empowerer		

Stage 3: Developing pedagogical concept knowledge

Having undertaken the previous task and completed some of readings on constructivism, the teachers participated in a series of discussions to determine the new pedagogical skills, such as conducting interpretive discussions needed when implementing teaching/learning approaches informed by constructivism. Particular emphasis was placed on the need for the teachers to combine a conceptual knowledge focus rather than a content knowledge focus when teaching science with the new pedagogic skills being implemented, that is, pedagogical concept knowledge. The researchers emphasised the need to provide new knowledge that was both intelligible and plausible for the teachers to examine and discuss during this stage. To encourage teachers to try these new pedagogical approaches and at the same time reflect on their old pedagogical knowledge, small and whole group discussions were held. During the trials that occurred during this stage, the teachers acted as technicians (Hand & Treagust, 1991) as they would only implement the teaching/learning approaches outlined for them in the inservice sessions, rather than attempt to explore the effects of the new approaches. For example, all the teachers relied on the free-writing process as the one method to explore student concepts. As all the teachers were unfamiliar with the new pedagogical skills learned during this stage, they were concerned about the need to ensure that they followed the implementation process, discussed during the inservice session, as closely as possible.

Stage 4: Broadening and refining pedagogical content knowledge

The teachers were allowed time to develop their own pedagogical concept knowledge. After trying various new skills, in particular defining student concepts, and reflecting on approaches to teaching and learning informed by constructivism, all participating teachers were asked to select a science unit to teach. Each teacher then was given time to develop and implement, in consultation with the researchers, a science unit informed by constructivist philosophy. Teachers were asked to record in their journals the planning sessions and observations made in implementing the approach, particularly student concepts, the processes in teaching those concepts, and the reactions of students to the new approaches. These journal entries enabled the teachers to actively reflect upon the fruitfulness and feasibility of the teaching/learning approaches being implemented. If the teachers were to change from their current practices to teaching/learning approaches informed by constructivism, they must see the new strategies as being fruitful and feasible.

As the teachers developed the necessary pedagogical concept knowledge through classroom implementation, they were able to judge both the fruitfulness and feasibility of using these approaches in the classroom. As a consequence, the role of each teacher changed from that of technician to facilitator, where issues were explored that directly focussed on the students rather than on the teacher. Initially the teachers' concerns had centred on such issues as syllabus coverage and a consequential focus on time, catering for all students within the classroom and determining essential concepts to be addressed within a unit. On completion of the inservice programme, concerns expressed by the teachers now were centred on practical interests (Grundy, 1987) such as changing the syllabus to incorporate the new teaching/learning approaches, re-organising the classroom set-up to allow greater student involvement, and exploring application in a much wider range of topics. This change was noted as teachers developed confidence in implementing the new teaching/learning approaches resulting in students being given more opportunities to become involved in classroom learning processes, and teachers beginning to experiment with the application of new pedagogical skills (Hand & Treagust, 1991).

Stage 5: Development of a constructivist teaching framework

This stage centred on the development of a coherent teaching framework informed by constructivism. Teachers were encouraged to examine both their pedagogical content knowledge and their newly acquired pedagogical concept knowledge to promote a much broader and deeper understanding of pedagogical subject matter knowledge. The role of teachers in this stage becomes that of empowerers in that they allow students to become problem-setters, not problem-solvers, and provide much more opportunity for students to set the direction of the topic of work under review. Whilst the teachers in this inservice programme did not reach the fifth stage in the development of using teaching/learning approaches informed by constructivism, we believe that this stage is a natural progression of the inservice model for teachers.

SUMMARY

In using a teaching/learning approach informed by constructivism to conduct an inservice programme with a group of science teachers, the researchers developed and implemented a model that monitored teachers' understanding of new pedagogical knowledge and their roles in relation to the new teaching approaches. The inservice model is based on the five criteria for conceptual change and on the development of knowledge bases and teaching roles as participants experience the inservice programme; further, the inservice model is comparable with previous work on stages that teachers undergo in implementing innovations. In proposing the inservice model, we have illustrated how changes in teaching/learning approaches informed by constructivism can be observed and described. In this manner, the model has a role in helping inservice programme implementers, administrators and teachers develop an awareness of the processes and consequences of implementing change in the classroom.

While the teachers' own conceptions of science were not the focus of the study, consequential action of members of the group of teachers reflects their acceptance of the model and acknowledgment of the five criteria for conceptual change. Four of the participating teachers have been involved in writing articles for national and state science teacher association journals (Hand, Lovejoy & Balaam, 1991; Vance & Hand, 1991; Vance, Miller & Hand, 1993, 1995). Several teachers have developed and participated in inservice programs to help other science teachers implement teaching/learning approaches informed by constructivism. They also competed in a regional curriculum innovation award, finishing second, in which they promoted their own teaching/learning approaches and the changes they were making in teaching science. This group of teachers had accepted ownership of their pedagogical changes, were able to identify and elucidate their changing roles, and were looking to expand the implementation of these new teaching/learning approaches in their own classrooms and those of teaching colleagues in other schools.

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PUBLIC SPEAKING FOR GRADUATE STUDENT TEACHERS IN THE DIPLOMA OF EDUCATION.

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ABSTRACT:

Graduate student teachers in the Diploma of Education took part in a 10 hour elective on speaking in groups, aimed at helping those who were communication apprehensive or shy to overcome their fears. Confident speakers also took part, to provide modelling and assistance, and to learn ways of teaching oral communication in school. McCroskey's (1977) Verbal Activity Scale (VAS) and Personal Report of Communication Apprehension (PRCA) were used with a questionnaire evaluating the programme (EvalProg) to compare the reactions of the more and less confident speakers to the activities. The less confident speakers claimed to benefit from the programme, which is outlined. Certain activities were preferred by confident speakers, and others by less confident speakers, reflecting the different ways each of the groups view themselves and their audience.

Public speaking for graduate student teachers in the Diploma of Education.

Teachers need to be able to speak to groups. The importance of their ability to interact with students is detailed in a review of research by Nussbaum (1992). Teachers need to help their students to interact with others, too, since class work is group work. In the one-year Diploma of Education for graduates, a ten-hour, five-session elective aimed to attract both confident and shy speakers, the confident acting as models and also helping the shy. In additiion, the exercises would provide examples for their own teaching of confident talk in the classroom.

Activities were designed to help shy students and to create situations where others would help them. Also important was motivational talk of the kind: "Everyone should help others to take part", "Try to understand how it feels to be shy; think of something you don't do well. For instance, at school I was no good at singing", "You need to applaud everyone, whatever their efforts", "Remember, your aim is not only to do well, but to make sure that others in your group do well, too".

The activities, including whole group work, two teams groups, groups of three or four, pairs, and individual speeches, took place in a large studio. Eighteen student teachers took part .

DESCRIPTION OF THE PROGRAMME:

Session 1: Introductory exercises for being heard and seen.

(a) With everyone seated in a circle, aims and rules were introduced (100% attendance to pass; applause after every event; everyone to be included in every activity).

(b) The students were asked: 'Who is a confident speaker? Who is quite confident? Who needs more practice? Who is nervous?' The aim was for shy speakers to see that others (about half the group) felt the same.

(c) They then moved around the room to find a partner, talk with them about their history, interests, aims; take notes; and introduce them – reading if that felt safer, but thinking only about how the *other* felt, not about their *own* feelings while talking – so that shy speakers would focus away from themselves.

(d) Sitting in a circle, they took part in games where each person spoke a few words, performed simple actions, sat or stood, to get used to being heard and seen by the whole group.

(e) The group ended with a discussion of group behaviour, a theoretical base for understanding their own behaviour and the ways groups influence individual behaviour.

Session 2: How leaderless groups function.

From now on, direction of activities was handed to the group. The leader called a roll, set up activities for the session, gave directions for the following week, and called for reflection at the end (which sometimes did not happen if time ran out– a mistake).

The group was divided in half, without appointed leaders, with nine in each team.