A Conceptual Approach to Inservice for Science and Mathematics Teacher Educators in Papua New Guinea

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Teacher education in Papua New Guinea is undergoing significant restructuring which involves transition to a three year preservice course and extensive inservice for teachers' college lecturers. This paper reports a two week inservice workshop for mathematics and science lecturers from the Community Teachers' Colleges in Papua New Guinea. Emphasis was placed on the adoption of a conceptual framework and the application of concept mapping for program development and integration. This paper reports on the conceptual model, the Mathematics and Science strands and the evaluation of the workshop.

Introduction

Teacher education in Papua New Guinea is undergoing a period of significant change involving a fundamental reconception of the objectives and major reorganisation of the mode of planning and delivery of courses. The catalyst for these changes was a report of a National Teacher Education Research Project Task Force, 'The Future Direction of Community School Teacher Education' (McNamara, 1989), known as the McNamara Report. In the McNamara Report, a call is made for community school (primary) teachers who are

...capable of critical and analytic thinking, habitually using this mode of thought in daily classroom interaction with children, peers and the community (McNamara, 1989:39).

The content and emphases of the preservice teacher education course experienced is clearly a major factor in determining the characteristics of teachers. In Papua New Guinea, community school teachers have undertaken their preservice training in Community Teachers Colleges. There is one government college and eight church affiliated colleges of which six are
Since the early seventies, courses in these colleges have emphasised basic skill levels in English and mathematics for their students, who have entered colleges from either grade 9 or grade 10. Centrally determined National Objectives for Teachers College Courses featured extensive lists of "behavioural" objectives. Department of Education instructions to the effect that graduates from all colleges must have mastered the basic skills and content of the highly prescribed courses resulted in teaching methods in colleges which, in the main, were mechanistic and formal and promoted rote learning.

McNamara (1989:41) described the products of this training in the following manner:

Many teachers are considered still to operate in a rigid and inflexible way, allowing very little scope for pupil involvement in learning, unable to vary their teaching methods to attend to different pupil characteristics, and insecure in the knowledge of their teaching subjects.

Dissatisfaction with this state of affairs has become evident in recent years, (Matane,1986) particularly since the kind of community school teacher espoused by McNamara in the first quote above, is unlikely to emerge from such teachers college courses.

The Papua New Guinea Government has recognised the crucial role of teachers colleges in transforming the teaching service. For example, the Commission for Higher Education (CHE) supported McNamara's call for the establishment of a National Institute for Teacher Education (NITE) in its National Higher Education Plan for 1990 (CHE, 1990:56). When established, NITE will be responsible for the administration of teachers colleges. One anticipated outcome of the establishment of NITE is the release of the teachers colleges from the direct control of the Department of Education and a shift in style to processes of negotiation and not an extension of the bureaucratic model of authority presently governing colleges' (McNamara, 1989: 55). Colleges will be nurtured to become 'tertiary' institutions offering the kind of preservice and inservice courses which will prepare teachers who can

...analyse a wide range of teaching and learning situations, provide opportunities for students to develop strategies for developing appropriate learning environments, encourage students to reflect on these strategies and on their own performance, and, on this basis, learn to modify teaching strategies for different contexts.' (McNamara, 1989: 6)

The Papua New Guinea Community Teachers' College Lecturers Professional Development Project
The Australian Government, through the Australian International Development Assistance Bureau (AIDAB), has been an active partner with the Papua New Guinea Government since 1973 in the professional development of Papua New Guinea Community Teachers College staff. A detailed account of the changing context of this partnership, and the background to the most recent manifestation of cooperation between the two governments in this area is given by Burke (1991). He describes the Papua New Guinea Community Teachers' College Lecturers Professional Development Project (CTC Project) which is managed by Queensland University of Technology (QUT). Designed to operate from 1990 to 1994, the CTC Project's principal goal is "to improve the educational standards of Community Teachers' Colleges through the professional development of their teaching staff." (QUT,1990:21)

There are two components of the CTC Project. The first involves cooperation between QUT and the University of Papua New Guinea (UPNG) to provide both pre- and in-service Bachelor of Education courses for teachers college lecturers in a split campus arrangement. Under this scheme, potential and serving teachers college lecturers are supported by the Papua New Guinea Department of Education and AIDAB to study at QUT for one of the years necessary for them to complete a BEd from UPNG. The second component of the CTC Project does not involve course work for a formal tertiary qualification. Rather, it comprises a series of inservice workshops, each of two weeks duration, conducted by QUT staff in Papua New Guinea. The workshops are designed "to strengthen the serving and associate lecturers' competence and confidence in English language, subject specialisation, and curriculum development and pedagogical skills." (QUT,1990:21)

The first workshop for science and mathematics lecturers conducted by the CTC Project in Port Moresby in May 1991 is reported in this article because of its unique approach to Inservice Education. Not only was a conceptual model used as the framework for the development of this course, but also the same model was then presented as the primary element of the course for CTC lecturers.

Background for Model Development

Based on an understanding of the complexity of the culture of Papua New Guinea and an appreciation of the diversity of the educational and religious backgrounds from which the attending lecturers were drawn, it was decided that this course should be developed using a conceptual model which would:

1. not usurp the 'sociopolitical process of deliberation' (Roberts, 1983, p 9) which must occur within each educational community at the time of program revision and/or development.

2. be applicable not only for this course but also be transferable to revision and planning in a wide variety of contexts, ranging from Community Teachers Colleges to Primary School classrooms.
3. be comparatively simple to comprehend, so that its essence could be mastered in the short time of an inservice course.

4. incorporate the means of putting the model into practice in the Papua New Guinea context, to ensure congruence between theory and practice.

5. be based on current educational ideals and incorporate the considerable experience of the presenters in their own curriculum preservice and inservice courses in Australia.

In response to the above concerns and in particular to the complexity inherent in the first, the following conceptual model, consisting of five domains, was developed.

The Conceptual Model

The model domains are expressed as questions. Answers to these questions, provided by users of the model, form a framework for course development or revision appropriate to the level and context of operation.

The questions which encompass the five domains of the model are:

1. What attitudes, beliefs and values will the course promote?

2. What information will the course present and what level of cognitive process will be required of participants with respect to this information?

3. What methodologies, specific to the course/discipline being taught, both theoretical and practical, will participants need to gain competence in?

4. How will the course cater for the needs of individual students, in terms of learning skills, coping skills and career awareness?

5. How will the course help students to develop societal awareness in terms of decision making and dealing with social issues?

Planning for the Science and Mathematics workshop commenced with the presenters developing answers to these five questions. The five model domains and the resulting workshop framework are elaborated in the following section.

Conceptual Model Employed in Planning the Science and Mathematics Workshop

Domain 1: Attitudes/beliefs/values promoted by this course

Elements of framework:
Lecturers should develop attitudes, beliefs and values about the education of Primary teachers which are congruent with their own personal beliefs, national imperatives, local conditions and the findings of educational research.

Lecturers should have the confidence to review past programs and develop future programs in a manner which is consistent with these attitudes, beliefs and values.

Domain 2: Information and conceptual processes required

Elements of framework:

The conceptual framework used to devise this Inservice workshop will be presented as a means of reviewing past programs and developing new programs.

Concept mapping will be taught as a means of implementing this conceptual model. It will also be used as a mechanism for the integration of disciplines.

Lecturers will be expected to evaluate critically the model and discipline information presented and selectively adopt or adapt it for their own use.

Domain 3: Methodologies required

Elements of framework:

Skills will be developed in the interpretation of this model with respect to Primary Mathematics and Science programs taught in Community Teachers Colleges.

Skills will be developed in the use of concept mapping.

Domain 4: Personal needs of Lecturers

Elements of framework:

Individual lecturers should be empowered to undertake the revision of past courses and the development of new ones with an appreciation of the fact that their efforts are consistent with modern educational theory and should be relevant to the needs of their own students. Lecturers should see that their role in program development is a creative, not merely a transmissive one.

Domain 5: Social Awareness and decision making

Elements of framework:
The cultural complexity which exists in Papua New Guinea must be appreciated and accommodated. This course must model for participants a process which can lead to the harmonious development of programs for Primary Teachers which in turn will promote the ideals of the nation of Papua New Guinea.

This model was not only used by the presenters to plan the workshop, but also, as stated earlier, it comprised a major element of the information and conceptual processes to be mastered by the workshop participants. To facilitate the achievement of this objective the model was presented during the workshop in the following form.

Generalised Form of Conceptual Model

All five of the model domains must be considered with respect to any course being revised or developed. However, experience has shown that once the attitudes/beliefs/values have been determined and it has been recognised that these attributes permeate every aspect of design AND implementation, then program development is facilitated by deriving all of the other four domains concurrently. That is, methodologies, personal needs and societal awareness are best dealt with in respect to specific information topics. This gives rise to a model in which there is one set of global emphases constant for the whole program and four sets of emphases which will be continually changing throughout the program. To simplify this statement, a set of diagrammatic models have been proposed.

Figures 1-4 illustrate the model and the potential for changing emphases in various contexts.

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INSERT Figure 1

Generalised Model for Course Development or Revision

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The boundary lines between these domains are deliberately drawn as 'wavy' lines. It is not intended that they should be interpreted as being definitive boundaries. The emphases derived from them will overlap. The model should not be interpreted as inhibiting creative interaction between the domains or suggesting that there is only one possible interpretation or set of acceptable emphases to be derived.

Ideally, for each course, once attitudes/beliefs/values have been clearly enunciated, an appropriate balance will be established between the emphases derived from the remaining four domains. This idea is represented in Figure 2.
“Balance”, in this context, does not imply some numerical balance of emphases. Rather, it implies a deliberate choice made by the course developers to weight particular domains in keeping with their overall values statement.

For example, in a system where extreme pressure is placed on the rote learning of information, an imbalance may appear as shown in Figure 3.

It should be noted that, in a situation where course developers intentionally placed little or no emphasis on methodologies, personal needs of students or societal awareness outcomes, this pattern would not be regarded as an imbalance.

When implementing the model it quickly becomes evident that while an overall balance of emphases for a course resembling that shown in Figure 2 may be desirable, some topics within the course require differential weighting. For example, an introductory aspect of a topic may emphasise personal or social relevance, while a later aspect of the topic may hold most of the key concepts necessary for understanding the topic. Consequently, the resultant balance of emphases for a course or topic will be achieved through the sum of all the component domain weightings. See Figure 4.

INSERT Figure 2

Generalised model illustration of ideal equal balance between course emphases

INSERT Figure 3

Generalised model illustration of imbalance resulting from excessive weighting of one domain.

INSERT Figure 4
Generalised model illustration of the achievement of total course balance

This generalised model, based on the achievement of an appropriate balance across five conceptual domains throughout a course was then presented to the workshop participants as the vehicle through which they could review their existing Mathematics and Science programs and develop new ones for their upgraded teacher education programs. At this point in the workshop, Mathematics and Science strands were introduced to enable the pursuit of different objectives. These are described separately in the following sections.

Mathematics Strand

The major aim of the mathematics strand was the development of a mathematics core curriculum for use in the CTC. This core was to be developed using the conceptual framework previously discussed.

Two specific domains of the model were identified as requiring special attention. The first was the attitude/beliefs/values domain. There was a need to bolster the participants' self confidence to undertake curriculum development. The second was the methodologies domain, and involved the application of concept mapping as a tool for curriculum development.

The major concern of the participants in the mathematics strand was the development of a new three year mathematics core curriculum. It was recognised that for social, geographical and political reasons the needs of staff in each of the colleges may be different. However it was also recognised that a major component of the mathematics curriculum should be common to all of the colleges. This common component became known as the mathematics core curriculum or simply the core.

Allowance was made during the planning of the workshop for the wide diversity in content knowledge and experience possessed by the participants. Their formal mathematics ranged from completing high school mathematics to a major in mathematics at university. A number possessed university qualifications in education which sometimes included units in mathematics curriculum but did not include mathematics discipline studies. An indication of this diversity could be gauged from the initial core proposals brought to the workshop by the participants. These ranged from a solid university entrance program, proposed by a lecturer with formal tertiary training in mathematics, to one that was suited to the middle school, proposed by a lecturer with no formal mathematics beyond the high school.

Other factors were found to influence the participants' attitudes to the workshop in particular, and to curriculum development in general. These were the isolation of the colleges, availability of essential materials,
and previous experience with different methods for curriculum development.

Cognisance was taken of these factors and it was recognised that a strong role model was needed to aid with the development of favourable attitudes. Moreover participants lacked many of the skills required for the task ahead. The workshop team decided to work to overcome these deficiencies by leading the participants through the development of the number strand of the core. Presenting a confident and competent leader and having the CTC lecturers actively participate at all stages of the number work exercise produced noticeable changes to the participants attitudes and involvement in the workshop. They appeared to gain in enthusiasm and confidence as they applied the model to develop a new framework for the mathematics curriculum.

The methodology used to develop these positive characteristics and identify the model's components for the number strand was concept mapping. Some time was spent developing concept mapping skills. The success of the activities was evident by the way in which the information and methodology areas of the number strand were examined and questioned especially with respect to individual student needs and the Papua New Guinea social context. This process resulted in the exclusion of some information and concepts which had always formed part of the previous core curricula in mathematics, and the inclusion of others. Because a topic or concept had always been included was no longer accepted by participants as being a sufficient reason for inclusion.

On completion of a careful examination of the number strand participants had acquired experience and skills that could be applied to other areas. The task now was to apply them to the development of a core mathematics curriculum.

With constant supervision, encouragement and guidance from the workshop leaders, the participants worked in small groups on the development of the mathematics core. In doing so they utilised the five domains of the model. Occasionally the total group reformed to gain consensus about specific components of the proposed curriculum. At times participants were daunted by the magnitude of the task in which they were engaged. When this occurred the workshop leaders redirected attention to the model and offered support and encouragement. As a result the task proceeded and eventually resulted in a complete mathematics core curriculum. This product was accepted by all lecturers and representatives of the National Department of Education.

From the enthusiasm exhibited by the participants, toward the end of the workshop, it became obvious that they were very impressed with their new abilities. They were now able to use concept mapping to develop elements of a formal curriculum which were based on the theoretical model.
Science Strand

The approach used in the science strand differed from that used for the mathematicians. A science core curriculum for the new three year College course had already been developed by participants in a National Department of Education Workshop some months previously. When this new curriculum is implemented in Community Teachers' Colleges, primary teacher trainees will be expected to gain competence in teaching Science as an integrated subject. That is, the Science, Agriculture, Physical Education and Health components of the new Science curriculum will have to be taught in an integrated fashion. Accordingly, Community College lecturers have been trying to devise satisfactory methods of integration for their own College courses as exemplars for their students.

As the conceptual model for curriculum development and revision, proposed in this workshop is ideally suited to this task, the science strand of the workshop adopted an extra dimension of applying the model to achieve integration of all science curriculum components. This task was undertaken in the following manner.

In the initial combined sessions for all workshop participants the five domain model was introduced, explained and justified. While still working with mathematics colleagues from their own institution, science lecturers were asked to answer the question associated with domain 1 with respect to their own science courses.

Once lecturers had formalized the attitudes/beliefs/values which they wished to develop through their course, it was stressed by the workshop leaders, that all subsequent actions, especially the use of assessment instruments, must be completely congruent with these statements. (It is planned that all future workshops will aim to strengthen this concept of consistency of theory and action.)

The two strands of the workshop then separated. The science lecturers chose a partner, not necessarily from the same College, and after some deliberation each pair chose a topic from the new core curriculum which they wished to integrate across two or more of the discipline areas in the curriculum. For example, one pair chose to integrate the topic of Soil across the discipline areas of Agriculture, Health and Science.

The technique by which this integration was to be achieved depended upon several steps involving the Conceptual Model, Concept Mapping and a constructivist model of learning. The steps were:

1) the topic was examined from the perspective of each of the disciplines that were to be integrated. This was done by answering the remaining four model questions about the topic from the perspective of each of the disciplines to be integrated. For example, when the topic of "weather" was to be integrated across the disciplines of Science, Agricultural Science and Health, the four questions about information,
methodologies, personal needs and societal relevance were answered from the separate perspectives of Science, Agricultural Science and Health. The answers to the questions were written down as single word or short phrase concepts, each one on a separate small piece of paper.

b) These pieces of paper were then colour coded using a two dimensional coding system. For example, a colour such as yellow could be used to designate that the concept was an agricultural one and if the paper was then crossed with vertical lines it could signify that the concept had been derived from the personal needs domain of the model.

Many lecturers were astounded by the large number of concepts generated in this manner.

c) The workshop leaders explained the principles of concept mapping. Emphasis was placed upon the construction of meaning through the relationships joining concepts. The development of hierarchical maps and spider maps was practised using sets of given concepts, until lecturers felt confident enough to tackle the mapping of their topic concepts.

d) A concept map was generated using the concepts identified in b) above.

Initially, some lecturers found it difficult to develop an integrated map using the concepts from two or three discipline areas. They apparently were so conditioned to think only of the integration of information concepts that it was necessary for the leaders to insist that they re-examine the concepts they had derived from the right hand side of the conceptual model and in some cases generate some more. Once they had accepted that the 'balance' postulated by the model demanded that they incorporate these right side concepts as integral components of the topic and not as just a few extra examples to be tacked on, they found that they were often able to use these right hand side concepts as pivotal concepts for integration across discipline areas.

This process brought about several unintended outcomes. For example, many lecturers were amazed at the large number of concepts which they expected their students to understand, often with slightly different interpretations in each of the disciplines taught. This prompted the comment of "How could they do anything else but rote learn them? There are so many." Also, some lecturers began to question their own teaching methods and whether or not they were facilitating student meaningful learning or just acting as information transmitters.

In fact, so extensive were the discussions which flowed from the experience of concept mapping for the integration of disciplines within Science that the workshop leaders were convinced that the Personal Needs of Lecturers domain of the workshop had been highly successful.

This was further evidenced by the high level of self confidence eventually
displayed by lecturers in the creativity of some of the maps developed. For example, one pair of lecturers was having difficulty in deciding whether to use a spider map based on the centrality of the most inclusive concept, or a hierarchical map based on a subsumption model of concepts. After extensive discussions they solved their dilemma by building their map on the outside of an umbrella. This allowed them to construct a three dimensional model incorporating both centrality and subsumption models with a complex web of relationships between concepts.

To complete the exercise, lecturers were asked to justify the concept map of their integrated topic to their colleagues. This sharing of ideas promoted further discussion, particularly with respect to the societal relevance of science teaching in Papua New Guinea Primary Schools.

Action Plans

At the completion of the workshop participants were asked to draw up an action plan of what they proposed to do when they returned to their own college. A copy of this action plan was retained by the workshop leaders. Participants were advised that they would be contacted two months after the workshop to see how they were progressing.

Typical plans developed at the end of the workshop included:

- Conduct seminars on this workshop for other lecturers
- Review present courses using the model
- Develop new programs for the rest of the year and next year
- Use concept mapping in teaching and planning
- Develop integrated programs in Science
- Reflect on role as a lecturer to see whether meaningful or rote learning is encouraged.

Workshop Evaluation

Three forms of evaluation were used on this workshop.

1. Formative evaluation

As the workshop progressed, the leaders continually monitored the 'tone' of the workshop in a formative manner. They were able to do this by observing the level of interest shown by participants and the spontaneous level of discussions which took place in association with each planned activity.

All of the data collected indicated that there was a high acceptance of the conceptual model which had been used to plan the workshop and its usefulness. In Mathematics, most interest was generated by discussing approaches to teaching mathematics coupled with the realisation that alternatives are available. In Science, concept mapping provided the greatest impetus for lively discussion.
2. Immediate formal evaluation

Participants completed a two-part evaluation form at the end of the workshop. The first part of the evaluation focused on the purposes of the workshop. Participants rated each purpose in terms of 'how well it was achieved', 'how well it met their needs', 'how well the relevant part of the workshop was organised' and 'how well that part of the workshop was presented'. A 5-1 scale was used in which 5 was a very high rating and 1 a very low rating.

However, as the workshop changed in response to lecturers' needs as they arose during the workshop, some aspects of the planned program and therefore the evaluation sheet became redundant. With respect to the remaining areas of the workshop conducted by QUT workshop leaders an average score of greater than 4 was achieved with only one person expressing any dissatisfaction about the materials presented.

In the second part of the questionnaire, participants were given the opportunity to write about significant ideas gained, how they thought their College would benefit and concerns they had about the workshop.

A summary of results showed that concept mapping skills was most popular with strong support for teaching for student learning and the conceptual framework used in the workshop. Benefits for the Colleges were reflections of the action plans, because most lecturers referred to inservice seminars which they intended to conduct on their return to their College. With respect to concerns about the workshop, it appeared as though everybody had some, but no single concern was expressed by more than one person.

3. Delayed formal evaluation

This evaluation was conducted by sending all participating lecturers a copy of the action plan they wrote during the workshop along with a 'Reflective Review and Evaluation' questionnaire. At the same time, College Principals were sent a 'Principal's Reflective Review and Evaluation of Workshop' questionnaire. The Principal's questionnaire stated clearly that a confidential report on workshop participants was NOT required. This form of evaluation was designed to use the Principals as independent observers of what has happened in Colleges since the workshop, which could be directly attributable to the workshop. These evaluations were used in an attempt to ascertain the 'real' effects of the workshop.

With a postal strike in Papua New Guinea, not all of the replies have been received. Of the Principals' replies that have been received, all have been aware of follow-up activities conducted by staff who attended the workshop. These activities have ranged from formal seminars to program reviews and informal staff discussions. Principals have reported that staff returned with very positive views about the seminar and were very happy to share their experiences with other staff.
The lecturers themselves reported that most of them had begun to put their action plans into practice. Only one has stated that the plan wasn't going to be implemented because of pressures of 'completing the semester three course'.

As future workshops are planned it is most important that the emphasis be placed on the needs of the CTC lecturers. The CTC's are so diverse that it is very difficult to ascertain these needs. Therefore, it has been reasoned that if lecturers return to their College after a workshop and implement some aspects of the workshop, then the workshop has successfully satisfied some of their needs. Evidence of this will be invaluable for planning the next workshop.

The workshop organisers are satisfied that they are gaining a comprehensive evaluation of the workshop and that they can already claim that the workshop has produced positive developments IN the Community Teachers' Colleges. It is anticipated that the complete evaluation will have a major impact upon future science and mathematics workshops conducted in Papua New Guinea.

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All Figures and Tables are available from:

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