Design-based Research for Professional Learning for *Cultural Mathematics*

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Design-based research is being used to develop and refine the principles used in professional learning workshops with teachers from three different Papua New Guinean ecologies: highlands, coastal, and inland in a coastal province. The appropriateness of the design of principles for Papua New Guinean Elementary Schools is tried over several phases and improved with each evaluation. This design-based research approach is proving suitable for the Papua New Guinean context.

This paper discusses the design-based research methodology used in the professional learning workshops for elementary teachers who use the *Cultural Mathematics* syllabus in Papua New Guinea.

Design-based Research

Design research or design-based research is a relatively new research method (Bell 2004; Collins, Joseph, & Bielaczyc, 2004). In mathematics education, action research or teaching experiment designs have been relatively common. However, these are more focused on change within the place of research such as a teacher's classroom, although often anticipating that the findings will be more widely applicable. Design-based research goes further, researching the design of principles that guide the educational situation such as in management of education, classroom management or professional learning of teachers. Designs are based on educational theory such as learning theories, theories about early childhood education, management or teacher knowledge. In addition the design is based on experience, that is, evidence from and evaluation of practice. The design is developed, implemented, evaluated, revised and re-evaluated until it is adequate for the situation.

Wang and Hannafin (2005) defined design-based research as a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories. According to Wang and Hannafin the five basic characteristics of design-based research are that the research must be:

- pragmatic and based on reality and the variance and modifications that can be expected in day-to-day situations;
- grounded in the sense of developing from the grassroots but also the story lines to be based on the data of the research in practice;
- interactive, iterative, and flexible in the sense of involving participants in the process, repeated with improvements based on implementation, and flexible in meeting the situation;
- integrative in the sense of being holistic and taking note of characteristics of the situated learning or practice; and

- contextual: not necessarily generalisable to other populations but appropriate for the context which is taken account of in the design of principles.

The methodology is deliberately developmental since design research is based on but also develops the theoretical position.

The Elementary Mathematics Project Papua New Guinea

The design for the *Cultural Mathematics* project consists of principles for assisting teachers who speak Papua New Guinean vernacular languages to appreciate their cultural mathematical proficiencies. Previous research into cultural mathematics provided a theoretical position around recognising and using cultural mathematical proficiencies (Owens, 2012). At each implementation an evaluation of the principles is undertaken and modifications made as shown in Figure 1.
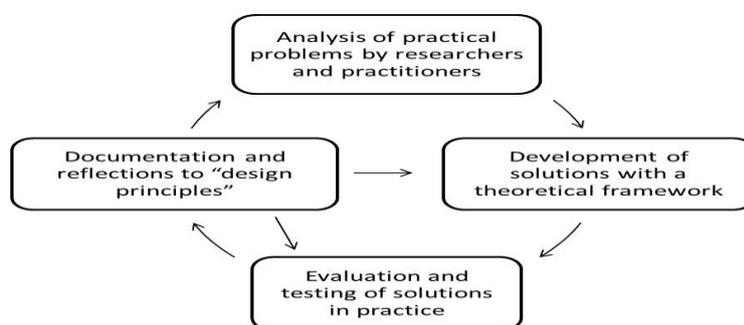

Figure 1. The cyclic nature of design-based research.

Data will also be gathered from participants and stakeholders (children and community) to assess the design in terms of implementation in the classroom. At the early stages, field notes and evaluations of the workshops have been used to evaluate and modify the designs.

Developing the Design of Principles

The preliminary design was developed by the researchers referring to theoretical knowledge of early childhood, classroom experience in Papua New Guinea, and good teaching practices. The team drew from their experiences of teaching and schools, from their different cultural backgrounds, their observations of learning, and their educational studies to develop the first design of learning principles. They considered what mathematics really was and the context of elementary schools in terms of teachers, resources, and remote communities. They considered the multiple languages of Papua New Guinea and the diversity of cultures and ecologies. Their preliminary discussions were summarised and developed into a set of linked principles.

- Mathematical ways of thinking
- Language treasures
- Cultural activities and other cultural impacts
- Activities appropriate for children
- Cultural capacity of teachers
- Assessing learning as feedback to both mathematics and language

Implementation

The principles were discussed with elementary teacher trainers in Port Moresby and at a one-day workshop attended by some teachers in the Goroka area. Workshop materials were developed including a manual elaborating the principles with exemplar learning plans; mathematical books for early readers; a children's interview to assess their mathematical understanding; and an electronic version of the manual in an offline 'website' with videos of children learning mathematics and of cultural activities, and documents on Papua New Guinea's many counting systems and measurement practices.

The first training workshop occurred in Tubusereia village in the National Capital District. The training was done in a school. The researchers were able to see the teachers teach before and during the training and to assess the workshop and design in practice. It met our requirement of being a school using vernacular language, in this case, Motu. However, the proximity to Port Moresby means that the teachers and villagers also speak English well, many families have incomes from the capital, there is electricity, regular transport to Port Moresby, and homes are mostly made of permanent materials.

The team then refined the design of principles using their own reflections and the participants' evaluations of the workshop. The inquiry model of learning proved appropriate for the study. More was needed on early learning of mathematics, particularly arithmetic. The cultural activities engaged the teachers but they needed more work on planning for children to learn through investigative activities. The revised design resulted in the addition of two new principles:

- Early mathematical thinking, and
- Learning experiences to promote children's efficient mathematical thinking.

As further training of researchers delivering the workshop occurs and more workshops are conducted, analysis and evaluation continues. Further redesigning of the principles may occur.

The Research Project as an Example of Design-Based Research

Pragmatic Nature of the Research Design

The workshop must meet the needs and experience and training of the teachers in the Papua New Guinean context. Some teachers have received minimal training, some have not; some are paid, some are not; some have electricity, some have not; some have permanent buildings, some have not; some have technological resources, some have not; some have paper, some have not; all have their own environmental materials; and class sizes vary. The language of instruction in the classroom might be Tok Ples, Tok Pisin, and/or English. The workshop allows for all this.

Grounded Nature of the Design-based Research

The project is grounded in both theory and practice. The design was developed from the experience and cultural backgrounds of the researchers, and from observations. Implementation in workshop involves practitioner participation.

Interactive, Iterative, and Flexible Nature of the Design-based Research

In the workshops, practitioners are involved in evaluating, reflecting, making decisions about what cultural practice to use to identify mathematics; and researchers observe actual teaching during training. The design is modified and the workshop repeated in different formats and places. We deliberately planned to cater for the different ecologies and language groups, as there are enormous differences in the terrain, cultures and amount of contact between peoples in the central highlands, in coastal areas and in the mountains or land near the coasts. We are also flexible about unexpected changes in group size reschedule around landslides; cope with electricity or equipment failures; and cater to a wide variety of teachers. The English level of teachers varies enormously.

Integrative Nature of the Design-based Research

The design is holistic, covering early childhood education, good mathematics, language and other issues, and ecologies. For example, we have information including videos and example plans that cater for the different ecologies. The interactive nature of the workshops also allows for diversity in delivery so that it is appropriate to the particular teachers and their communities.

Contextual Nature of the Design-based Research

The research is designed for the Papua New Guinean context, developed and implemented by Papua New Guinean people for Papua New Guinean situations. Its evaluation has been by Papua New Guinean people. The design is implemented in different ecologies of the country.

Conclusion

The iterative nature of design-based research means that with each workshop we are able to improve and refine the principles and the delivery of the professional learning. The approach provides the adaptability and flexibility required to support teachers in what are sometimes very remote regions, with multiple languages, with varied educational backgrounds, and at times very limited facilities. The refined principles themselves remain appropriate. The challenge now is to begin to deliver the professional learning on a greater scale while retaining the local contextualisations. Providing links to new objective-focused curriculum resources will also need consideration in future implementations.

References

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