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The Role Of The Pilot Study In Mathematics Education Research

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Abstract

It is generally accepted that a pilot study precedes the main study forming an important component of a research project. In this paper we share our experiences and reflections on three pilot studies we have conducted. The main studies for which the preliminary research was undertaken fall into two realms of mathematics education often considered distinct: the affective and the cognitive domains. Both quantitative and qualitative research techniques were used in the pilot studies. Outcomes are presented and the impact on the directions of the main studies is discussed. The advantages we perceived in undertaking the pilot studies are outlined.

Introduction

It is widely accepted that pilot studies precede the main study and form an important component of the research design. Wiersma (1991) defined a pilot study as:

> *A study conducted prior to the major research study that in some way is a small-scale model of the major study: conducted for the purpose of gaining additional information by which the major study can be improved - for example, an exploratory use of the measurement instrument with a small group for the purpose of refining the instrument. (p. 427)*

The value of conducting pilot studies was noted by Henk (1987):

> *There is no question that the methodology of an investigation can be enhanced considerably by conducting pilot studies. (p. 66)*

In this paper three pilot studies conducted by the authors are outlined. The main studies for which the preliminary research was conducted fall into two realms of mathematics education research often considered distinct: the affective and the cognitive domains. Both quantitative and qualitative research techniques were used. How the studies were devised, the purposes fulfilled by their conduct and their impact on the final research design will be discussed.

The Pilot Studies

Study A

There has been increasing recognition of the role that affective factors might play with respect to effective learning in mathematics (Grouws, 1992). Affective variables have been included in models put forward to explain gender differences, generally favouring males, found in participation rates in more demanding mathematics courses and in high cognitive level mathematics achievement (Leder, 1992). In attempting to explain the latter, Fennema and Peterson (1985) postulated the Autonomous Learning Behaviors (ALB) Model. They claimed that a relationship existed between several affective variables and mathematics learning outcomes which was mediated by participation in autonomous learning behaviours; that is, choosing high-level mathematical tasks, working independently on them, persisting with them, and achieving success.

The ALB model constituted the theoretical framework for the main study for which the first two pilot studies outlined were conducted. Aiming to examine the relationship between grade 7 students' attitudes towards mathematics and classroom factors, monitoring affective and autonomous learning behaviours inside the mathematics classroom was an integral part of the research design.

A range of instruments has been employed to measure attitudes to mathematics (Leder, 1987). Attitude theorists acknowledge that behavioural intentions form a component of the attitude construct and that contextual factors can influence actual behaviour (Triandis, 1971). While pencil-and-paper self-report data have formed the most common and the most convenient means of attitude measurement (Kiesler, Collins & Miller, 1969), less attention has been given to observing behaviours from which attitudes can be inferred.

The trial of a questionnaire was the purpose of the first pilot study described. The second pilot study aimed to validate operational definitions for monitoring behaviours in the mathematics classroom, and to provide experience in the use of videotape as a research medium.

Study A: Pilot study 1

A self-report questionnaire in two parts was developed. It was designed to provide indications of students' likely levels of engagement in autonomous learning behaviours. The instrument was tried with one class of grade 7 students.

The first section of the questionnaire consisted of a series of five mathematics questions considered appropriate for the grade level. The students were required to rank the questions from easiest to hardest and to give reasons for their choices. They were also to indicate which of the questions they would attempt during the course of a mathematics lesson, and which single question they would choose to do in a test. Again, reasons were required. In the second section the students chose and attempted solutions for two out of three more demanding mathematical problems presented. Reasons for the choices made, any assistance given, and the time spent doing each problem were recorded by the students.

The conduct and outcomes of pilot study 1

The class teacher was asked to supervise the students for the first part of the questionnaire. The second part was completed for homework. Questions asked by the students which might indicate that the instructions, the mathematics questions, or the problems were confusing or ambiguous were noted by the teacher. This feedback, an examination of the responses provided by the students, and a discussion with the teacher when the results were passed on, all proved invaluable. Minor revisions to the questionnaire resulted.

The questions asked of the teacher by the students indicated that the instructions to particular parts of the questionnaire were unclear. The revisions made were directly related to the questions raised by the students.

The responses given by some students highlighted what appeared to be a typographical error. In fact, there was no error but the size of font used and photocopying had resulted in a division sign (÷) being misread as a plus sign (+). The rank order of the level of difficulty of the relevant mathematical question may have been affected. Using a larger font for the mathematical symbols overcame the difficulty.

In the second section of the questionnaire, the reasons given by a few students for their choice of problems indicated that the order of presentation should be randomised. The students had written that they had done the first two problems and not the third because of the order in which they were offered.

The teacher was very interested in the responses given by her students. In discussion with her about the questionnaire, she asked a pertinent question which led to a further minor alteration. Many students had spent less than the fifteen minute time limit imposed on each of the two longer problems attempted and many of the solutions were incomplete. The teacher asked if it might be important to know whether the students believed they had completed the problem. Since lack of persistence could be inferred if a student gave up within the time limit before finishing a problem, an appropriate question was prepared and added to the questionnaire.

Both the researcher and the teacher felt that the findings of the pilot study should be shared with others. An added bonus to the pilot study was a joint paper (Forgasz & Romeril, 1993) prepared for a conference of mathematics teachers.

Study A: Pilot study 2

As part of another larger project, five grade 7 students were videotaped while working in a small group on a non-routine co-operative mathematical task (see Leder & Forgasz, 1992). This provided the researcher with needed experience in using videotape as a research tool. Both the potential of videotape and its limitations were experienced first hand and have been discussed elsewhere (see Forgasz, Landvogt & Leder, 1993).

The transcripts derived from the videotapes and their subsequent analyses assisted in supporting many of the operational definitions used in the main study for monitoring affective and autonomous learning behaviours in the classroom. Excerpts from the transcripts served to illustrate the operational definitions employed. In undertaking the task, it was revealed that the process of extracting data from videotape is very tedious and time-consuming. However, the wealth of information provided by this rich data source makes the exercise worthwhile. The pilot study also confirmed that videotape was the appropriate research tool for the main study.

Study B

When investigating the role of knowledge in problem solving, Simon (1980) suggested that even though a person might possess the knowledge relevant to solving a problem in a given situation, there is no guarantee that the knowledge will be accessed and applied when needed. Burkhardt (1988) claimed that there was a five year gap between learning mathematics imitatively and using it freely, effectively and autonomously in solving a problem.

Kaur (1993) conducted a pilot study to examine the relationship between students' ability to complete the actual mathematics content of a mathematical problem and to solve the mathematical problem itself. Three instruments were used in the study. Two of the instruments were designed specifically for the project: the first was a problems test (Test 1) comprising seven items; the second, which also contained seven items, was a computations test (Test 2). The third instrument (Test 3) was a published standardised test measuring mathematical ability. The participants were 21 grade 5 and 31 grade 6 students from a government school in Melbourne, Australia.

The study was conducted for a number of reasons:

(i) Assessing the suitability of the test instruments

Through logical analysis (content analysis), the validity of self-constructed achievement tests can be fairly easily established (Wiersma, 1991). The pilot study was conducted to establish the reliability of the two tests (Tests 1 and 2) developed for the project, to identify any confusing or ambiguous language, and to obtain information about possible responses to the items.

The tests were found to be reliable as they were predictive of the students' abilities when compared with results on the standardised test. As anticipated, the facilities of the test items were also found to be higher for the grade 6 students than for the grade 5 students.

Responses to several test items resulted in revisions being made to both Test 1 and Test 2. On Test 2, grade 5 students had difficulty interpreting the computation: $\frac{9\text{x}10}{2}$ which was subsequently changed to: 9x10÷2. On another item on Test 2, both the grade 5 and the grade 6 students were unable to compare the fractions $\frac{108}{120}$ and $\frac{51}{60}$. The question was replaced with:

120 pens cost $108. How much does 1 pen cost? 60 exercise books cost $51. How much does 1 exercise book cost? Is it cheaper to buy a pen or an exercise book?

It could be argued that changing this item to a worded question set in a relevant context may have altered the nature of the question and might impact on student performance. However, it was felt that wording the question in such a way as to guide students through the necessary steps to facilitate closure would compensate for any added complexity.

The following item appeared on Test 1:

Mary has 20 cm of wire. She makes a rectangular shape with the wire. The shape has the largest possible area. What is the length and width of the shape Mary made? Explain how you worked it out.

Responses given by the students lead to the inclusion of the following interesting question on Test 2: "Is a square a rectangle?". Both the researcher and the mathematics teacher of the pupils participating in the pilot study felt that the interesting responses to the above-mentioned item of Test 1 be shared with others. Hence a joint paper (Kaur & Murdoch, 1993) was presented for a conference of mathematics teachers.

(ii) Estimating the time required for each of the two achievement tests designed for the project

It was necessary to know the times students would need to complete Test 1 and Test 2. These were established with the pilot study.

(iii) Gaining experience in conducting interviews recorded with audiotape and videotape

The researcher had no prior experience in conducting interviews recorded with either audiotape or videotape. The pilot study provided valuable training with both. Some interviews were audiotaped and others videotaped.

(iv) Gathering qualitative data for the development of a structured interview technique

The interviews were conducted to help clarify students' thinking related to their solutions on Test 1. The interviews provided a rich source of data for drafting a structured interview format designed to assist in diagnosing individual student difficulties when solving mathematical problems.

(v) Gaining experience transcribing interviews from audiotape

Transcription was another skill for which the researcher had no previous experience. The audiotaped data provided ample practice in producing interview transcripts.

(vi) Organising a data coding system to facilitate data analysis

In order to compile a composite picture of students' abilities from the three instruments used, a data coding system was needed. A system was developed and tested with the data collected during the pilot study.

(vii) Selecting a statistical package for the analysis of the quantitative data

To determine which computer software package would be most appropriate for the statistical analysis in the main study, the data collected during the pilot study were analysed using two statistical packages with which the researcher was familiar: $SPSS_x$ (1988) and CSS (1991). The CSS package was found to be adequate for the purpose.

Overview of the third pilot study

As suggested by Henk (1987), several important aspects of the study were tested during the pilot study. As a result, the methodology for the main study was amended: Test 1 and Test 2 both underwent minor revisions; the sample size of the main study was adjusted to make it more economical; the data coding system was changed to make it more user friendly and efficient; a draft of a structured interview format was written; and the CSS statistical package was selected for the quantitative data analysis of the study.

Through personal field experience, the researcher gained valuable insights into the mechanics of the study for which no amount of reading could substitute.

As the main study was conducted in Singapore, a second pilot was conducted in Singapore to account for local cultural norms. The second pilot also assisted in trials of the structured interview format.

Conclusions

No matter how well conceived, some aspects of a research study may not run entirely to plan. However, the quality of a research project can be enhanced by investing time in trials (Henk, 1987). As illustrated by the pilot studies presented in this paper, several potential flaws in the instruments and in the procedures were identified. Appropriate feedback enabled the researchers to make revisions aimed at overcoming identified weaknesses and improving on the study design or the methodology for the main studies. Additionally, valuable practice was gained in using previously untried test materials and research techniques. Data analyses suggested that the research findings from the main studies would be fruitful and likely to make valuable contributions to the knowledge in the relevant fields of mathematics education.

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