Chapter V

PREPARATION AND VALIDATION OF RESEARCH INSTRUMENTS

Introduction

This chapter deals with the collection/preparation of instructional materials, preparation/validation of teaching-episodes, preparation/validation of achievement test & interview schedules and training of teachers & orientation to mentors followed by actual conduct of the experiment. So, this chapter is divided in different sections.

Section I: deals with the collection/preparation of instructional materials.

Section II: deals with the preparation/validation of teaching-episodes.

Section III: deals with preparation and validation of achievement tests.

Section IV: deals with training and orientation of teachers and mentors.

Section V: deals with the actual conduct of the experiment.

Section I

COLLECTION/PREPARATION OF INSTRUCTIONAL MATERIALS

Introduction

The investigator was very careful while collecting instructional materials. He prepared and/or collected instructional materials which could be easily available and not expensive and also used in teaching different topics of mathematics with a view to save the time and money. Sufficient number of transparencies, tangrams, fractional cutouts, balance were gathered to make use of them as and when required in the classroom teaching.
Section II
PREPARATION/VALIDATION OF TEACHING EPISODES

Selection of Contents

Instead of testing only in one unit of mathematics curriculum, the investigator wanted to see if the other contents were feasible to teach through constructivist approach. Thus the investigator selected different content areas from the curriculum on the bases given below. The subjectivity in selecting the contents of study was reduced by reviewing the following two literatures and considering the opinion of the teachers.

i) **Second International Mathematics Survey (SIMS)** reflects that fraction, measurement, equation and classification of plane figures are very important ideas for lower secondary and secondary level.

ii) Similarly in the National curriculum of U.K it is recommended that an early grasp of fundamental ideas such as: place value, fraction, measurement, equations and ratio are essential to children’s later mathematical development.

iii) **Opinion of the teachers**: Some teachers of lower-secondary level were asked to suggest which of the fundamental topics of primary level mathematics they considered the most important bases for lower secondary and later on for secondary levels. Most of them suggested the following topics: Fraction, Measurement, Equation and classification of plane figures. These sources provided insight and confidence to the investigator to take up the most common topics which is highlighted as: Fraction, Measurement, Equation and Angle for the experiment.

Preparation of Teaching-Episodes

After the selection of four topics the number of teaching-episodes for each topic were prepared. The number of teaching-episodes varied according to the contents to be covered in a particular topic. Similarly execution modes and method of evaluations were decided. Skott (2000) writes:

-55-
"In order to exploit the development potential of individual student, the teacher must set tasks within the students proximal development, i.e. beyond the child’s actual level of development, but within what he or she can do under guidance."

For this the following different but relevant textbooks, research based materials and different projects were reviewed:

1. Curriculum and Evaluation Standard For School Mathematics prepared by NCTM
5. Geoboard 3-4 the Super Source written by Judith Adams
6. Tangrams 3-4 the Super Source written by Judith Adams
7. Mathematics... A way of thinking written by Robert Baratta-Lorton
8. Elementary School Mathematics: Teaching Developmentally written by John A. Van De Walle

On the basis of the review, different tasks were identified. By selecting different tasks appropriate for the students the investigator prepared different teaching-episodes for the four selected topics. These episodes were then distributed to senior colleagues and other teacher educators for the purpose of reviewing whether the teaching-episodes follow the axioms of constructivism. Revisions of these tasks were made by incorporating their suggestions and comments.

Number of teaching-episodes: First draft of revision was made approximately in the form of teaching module (here named as teaching-episodes). The number of different episodes for different topics was: 8 for fraction and expected to be taught for 45 days. There were 5 teaching-episodes for measurement which were expected to be completed in 23 days. There were 4 teaching-episodes for equation and expected to be completed in 12 days. Similarly there were 3 teaching-episodes for angle and expected to be completed in 7 days. These teaching episodes are given vide Appendices B, C, and D.
Validation of Teaching-Episodes

So far the validity of teaching-episodes is concerned, Anastasi (1988) focuses and discusses on the validity of achievement test only. Anastasi (1988, p. 140) writes:

"Content validation permits us to answer two questions that are basic to the validity of educational achievement tests: (i) does the test cover a representative sample of the specified skills and knowledge? (ii) is test performance/task reasonably free from the influence of the irrelevant variable?"

In order to satisfy these criteria, the investigator distributed those teaching-episodes in a small group of teacher educators and teachers trainers to evaluate if these teaching-episodes covered the contents in a unit, and secondly in accordance with the axioms of constructivism. In this way content validity was judged by the help of experts jugement whether these contents could be taught.

Also the investigator himself taught these teaching-episodes to grade V students. It was found that the expected outcome occurred while teaching through constructivism. This confirmed the content/construct validity of teaching-episodes.

Steps in Teaching Through Constructivism

According to the requirement of constructivism, the number of steps in teaching-episodes was decided by reviewing the different steps of constructivist way of teaching with the help of two different sources: (i) internet and (ii) literature.

(i) Source Internet: http://www.miamisci.org/ph/1pintro5e.htm:

From this source, a Biological Science Curriculum Study (BSCS) suggests a model where the process of constructivism is explained by employing five "E"s. These are Engage, Explore, Explain, Elaborate and Evaluate. The details are given below:
**Engage**

At this stage, the teacher gives a task and the students first encounter and identify the instructional task. Here they make connections between past and present learning experiences, lay the organizational groundwork for the activities ahead and stimulate their involvement in the anticipation of these activities. Asking a questions, defining a problem, showing a surprising invent, and acting out a problematic situation are all ways to engage the students and focus them on the instructional tasks.

**Explore**

In the exploration stage the students have the opportunity to get directly involved with the phenomena and materials. As they work together in teams, students build a base of common experience which assists them in the process of sharing and communicating.

**Explain**

The third stage is the point at which the learner begins to communicate. Language provides motivation for sequencing events into a logical format. Communication occurs between peers, the facilitator, or within the learners himself.

**Elaboration**

In the fourth stage the students expand the concepts they have learned, make connections to other related concepts, and apply their understanding to world around them.

**Evaluation**

The fifth "E", is an on-going diagnostic process that allows the teacher to determine if the learner has attained understanding of concepts and knowledge. Evaluation and assessment can occur at all points along the continuum of the instructional process.

**(ii) The Other Literature**

The figure 5.1 Diagram I, Diagram II given below are the simple examples of the important steps in constructivist cycle of teaching as well as cooperative teaching as suggested by Millroy (1992, p. 26) and Whetley (1991).
Millroy in her thesis used the first diagram which involves problematic, action and reflection. Where as Wheatley gave the second diagram for co-operative teachers which involves Viable task, working in group and concensus in sharing while teaching mathematics.

These two cycles along with the " 5 E's" initiated the investigator to find out a common steps in very simple form that covers all of the bases of constructivism.

**Diagram I**

- Problematic
- Action
- Reflection

*The Constructivist Cycle*

**Diagram II**

- Viable Task
- Working in Group
- Consensus through Sharing

*Cooperative Teaching Cycle*

**Figure 5.1: Figure Showing Steps in Constructivism and Co-operative Teaching**

Based on these sources the investigator decided to prepare three steps for teaching-episodes. So, in constructivism teachers attempt to facilitate mathematical learning by initiating situation in which the students are expected individually to construct taken-as-shared mathematical concepts and skills through process of social interaction in small group or in whole class settings. They often use everyday language prior to standard mathematical terminology and symbols. These steps are given below:

**Step 1: Introducing Task Through Different Exposures**

In the first step viable tasks are given in the form of open ended problem (problematic task) describing the relevant situation which makes the students want something to do the task and which provides a challenge and a clue to perform the task individually. This step is designed for maximum of 10 minutes. (For details see Appendix A)
Step II: Exploring on Their own or Within the Group

At this stage each student has autonomy to carry out his planned action individually and then work in small group, for minimum of 25 minutes. Each student must do something in order to reduce dissonance or tension.

The second step generally requires collaborative work to open-ended contextual problems. The students report to the group or whole class what they get. As for example: Explore the three cities on the map of Nepal which are situated at right angle. (For details see Appendix B)

Steps III: Summarizing Through Reflection

Students reflect on what they found, thought and shared their findings. The student must get something from what they do. Reflecting and explaining their experience is called metacognition. Students remember their thought process, images in their imagination, and languages in their internal dialogue. (For details see Appendix B)

Section III

Preparation/validation of Achievement Test

Introduction

It is the measurement aspect, which makes the effectiveness of new methodology over the old one extremely difficult. Since teaching of mathematical skill in new methodology is very different, (constructivism from that of conventional methodology), achievement tests were constructed to measure contents taught to suit the students taught by new methods of teaching. Most of the questions were taken from the prescribed textbook.

Three parallel forms of achievement tests Set I, Set II, and Set III were made consisting of three levels of Bloom’s Taxonomy.

a) Conceptual understanding: Questions from knowledge level

b) Procedural understanding: Questions from comprehension level

c) Application level: Questions from application levels of Bloom’s Taxonomy
First of these levels refers to very simple form of mathematical skills which can be expressed in terms of action verbs. Such as: to tick, recognize, label, colour, write, read, and compare. Payne (1990, p. 170) writes:

"Conceptual knowledge of any content involves connections between and among real-life experiences, concrete models, oral language, and written symbols".

The weightage given to each question of this level was one point. As for example:

Tick the box that shows the volume occupied.

(a)  
(b)  
(c)  

Second level refers to the skills to add, subtract, multiply, and divide the whole numbers and decimals, or read data from table and figures. At this level, student is expected to demonstrate abilities in the mathematical operations, such as selection, estimation, verification and justification using concrete model or symbolic methods to calculate using numerical and graphic data. The questions of this level requires higher skill than the first level and emphasized the procedural aspect. By providing clue in the form of diagram or situation, this level questions were constructed. Payne (1990, p. 27) writes:

"Connections to concepts can be made at three points in the execution of a procedure. First we interpret the symbol and decide what rule or procedure to use, then carry out the procedure, and finally present our answer".

To test whether student can transfer of learned concept, the same concept was also asked in procedural level. So, the weightage given for each question of this level was of 3 marks. Example of this type of question is as follows:

Which rectangle below has an area 2(5x) ? Tick and explain why it is an equivalent expression of 2(5x).
Third level refers to the problem solving and reasoning skills that require students to use their understanding of numbers and numerical concepts and their computational skills to solve simple problems of daily life relating to units: Fractions, Measurement, Equations and Angle. Payne (1990, p. 40) writes:

"Thinking through, involves using previously learned concepts and skills appropriately and applying them to the new situation".

The third level questions require the highest level of skill among these three levels encompassing other two levels conceptual and procedural understanding. So, the weightage given to each question of this level is of 5 points. To test whether the transfer of learned concept & skill took place or not, it was also asked in application level. Students were required to understand the questions, sketch the situation in diagram form and then solve the problem. As for example:

Make the hands of the clock to show 8 o’clock and judge the measure of the obtuse angle made by the hands of the clock.

(a) Draw the hands of the clock (b) what is given in this problem? (c) What is required? (d) What procedure do you use to find the answer (e) Give the answer.

In this context, Jaime-poster (1993, Ph. D.) advised to make paper and pencil tests closer to clinical interviews so that it improves the amount of information about the attainment of the student while reasoning for their answers.

To ensure that all the three sets were parallel, the investigator followed the criteria suggested by Freeman. Freeman (1962, p.72) has listed the criteria for two forms to become parallel are:

- the number of items should be the same;
- the kinds of items in both should be uniform in respect to content, operations or
traits involved, the range of difficulty and the adequacy of sampling;

• distribution of the index of difficulty of items in both should be similar;

• both test should have the same degree of homogeneity in the operation or traits being measured which can be shown either by inter-item correlation or by correlating each item with subset scores or with total test scores;

• the means and standard deviations of both forms should correspond closely;

• the mechanics of administration and scoring of both forms should be uniform.

First Draft

Sample tests was made in four different content areas of Fraction, Measurement, Equation and Angle. The sample test in each area contained two questions on knowledge level of 1 marks each, two questions on comprehension level of 3 marks each, and three questions on application level of 5 mark each. Thus the number of questions was 7 and total weightage given in terms of mark was 23 points in each content area.

Expert opinion was taken for the validity of the contents by providing the content grid. The purpose of trial test was to see the feasibility of the test.

First Tryout

The administration of sample test was done on 62 students studying in grade VI in different schools (not sampled here) in Birgunj municipality in Nepal. Two sample tests on Fraction & Measurement were administered before the tiffin break and other two sample tests Equation & Angle were administered after the tiffin break in each of the school.

All the data of 62 students were plotted in one sheet so that reliability of the whole test could be calculated. The reliability coefficient of the sample test was found to be 0.52. This gave a green signal to the investigator to proceed further.
**Final Draft of the Test**

Since the reliability coefficient of the sample test was moderate $r = 0.52$ the investigator increased the number of questions in each level in all the four content areas. Thus the final draft of the achievement test contained a total 12 questions of 36 marks in each of four content areas. Thus in all there were 48 items in each of the achievement test. The revision of content grid was made in all the three achievement tests in each of the content. The revised content grid is given in Appendix E.

After the preparation of the achievement tests in English, the translation in national language Nepali was done for all the three forms. For the establishing of equivalence, these parallel achievement tests and for the accuracy of translation two experts of Nepali and English languages were consulted.

**Validity of the Test**

Later these tests were distributed to mathematics teacher educators to give their comments by providing the revised content grid to ensure the content validity. The school’s teachers were asked to give their opinions. They praised the test as really good. But they expressed that they usually did not stress on conceptual understanding. They did not use geometrical drawing while teaching arithmetic and algebra, which form the sound bases for mathematics.

The investigator administered these three parallel sets in two schools one public school having 32 students and other in private school having 20 students. The investigator went to the same school and to the same section thrice for pretest, posttest and delayed-posttest. On the interval of 15 days, the investigator went to the same school and to the same section to administer the parallel form.

**Reliability of the Test**

Every time test score did not increase but showed approximately the same mean and variance in their test score.
The reliability coefficient, using Kuder Richardson formula (K-R 20), of three parallel sets of whole achievement tests were 0.607, 0.612 and 0.620. For the achievement test these reliabilities are satisfactory score according to Singh (1986, p.78). In this context Tuckman (1975, p. 257) says:

"Published tests usually require test reliabilities of 0.85 or above when based on the agreement among test items while teacher built tests are usually considered adequate with reliabilities of 0.60 or above".

Preparation and Standardisation of Interview Schedules

Before the actual conduct of the experiments, the investigator prepared three interview schedules one for experts one for teachers teaching in child-centred method, and one for the project teachers who used the method of constructivism for more than five months.

The validity of the interview schedules was established by expert judgements. The interview schedules are given vide Appendices F.G and H.

Section IV

ORIENTATION TO MENTORS & TRAINING OF TEACHERS

Introduction

Training and orientation the project teachers and mentors were done in different steps. The detailed description is given below:

Orientation to the Mentors

Constructivism encourages autonomy and non-interference both for the teachers as well as for the learner. The mentors in this study were assistant headmasters from each of the four schools. They were all M. Ed. whose responsibilities were to supervise the teaching learning activities as well as little experiences with the core activities of mentoring. Mentoring activity was supposed to be followed by discussion with project-teachers, so that immediate feedback can be possible. The investigator gave orientation to mentors about how they have to work with
and guide the project teacher: what structures and resources facilitate their works and how mentoring fits into broader frameworks of professional development and accountability. Project teachers were to learn new kinds of teaching method.

**Training to the Project-Teacher**

The training of project teacher was done with respect to:

i) Training in child-centred approach (ii) Training in constructivist approach.

**Step I: Training in Child-Centred Approach**

- Since the child-centred method is closed to constructivism, the project teachers got training conducted by Rato-Bangala, a renowned school of Kathmandu valley in Nepal for child-centred-learning. Project-teachers got three months long training on child-centred learning for primary level of schooling. The investigator himself joined as a participant in the training programme to see what activities were being carried out and to ensure whether or not assumptions of constructivism were met.

**Step II: Training in Constructivist Approach**

In order to enable the project teachers to teach in accordance with the requirement of constructivism, the investigator demonstrated different lessons using some teaching-episodes. Project-teachers were given exposure in all of the teaching-episodes viz. Fraction, Measurement, Equation, and Angle.

The training started with simple introduction (i) about student's knowledge of mathematics (ii) about methods of mathematics teaching (iii) about the hierarchy of particular content. The training lasted for 10 days, working intensively for 3-4 hours a day.

**Components of Training**

1) **Methods of Teaching Mathematics**

The investigator gave a demonstration lesson on the "Divisibility test of arithmetic lesson
by 2, 3, 4, and 5 using teacher-centred and student-centred methods of teaching. The project teachers were excited to teach the class applying different methods.

**ii) About the Hierarchy of Particular Content**

The investigator presented the teaching-episodes with the help of Skemp's schematic chart (1993) for arithmetic, algebra, and geometry. The investigator demonstrated how one could benefit from Skemp's chart. The charts are given vide the Appendices B, C and D.

During training, the investigator explained the basic assumptions, philosophy, rules, and steps of constructivism by highlighting that the role of the teachers changes from talking and describing to listening and asking questions to the students.

After the demonstration lessons the teachers were asked to do trial teaching according to the teaching-episodes prepared by the investigator. After the trial, they were given necessary remediation to handle classes using constructivist approach.

**Guidelines for the Teachers**

One page guidelines handout was distributed so that teacher can work independently in the absence of the investigator. The ground rule for the use of teaching-episode is not to deliver the solution to the students right away. Students learn by taking in information from the world/materials and constructing their own meaning from the experience as opposed to someone telling them. Teachers were told to create an environment in the first place, where students must want something and notice something. In the second step students must do something to satisfy their own query or satisfaction. In the third step they get something from their attempts/actions. It may be through reflection. (For detail see Appendix A).

**Guideline for Mentors**

Before the start of the experiment all the mentors of experimental and control school were given one day orientation regarding the plan of action i.e. when to take pretest, posttest, delayed-posttest, how many different observations to be done, how to conduct the experiment.
Section V

ACTUAL CONDUCT OF THE EXPERIMENT

Introduction

Actual conduct of the experiment began by sketching the layout of the procedure of classroom activities as given in Figure 5.2.

Pretest Stage

Before the experiment all the four pretests on achievement were administered namely: on Fraction, Measurement, Equation and Angle. While administering these pretests, two tests were given to the students at a time; namely Fraction & Measurement in first sitting and another two tests Equation & Angle in the second sitting.

Duration of the Experiment

The total of 5 months time was taken to complete the experiment. The following diagram illustrates how the pretest, treatment, posttests and delayed-posttests were taken place. The time gaps between posttest and delayed-posttest varied from 20 days to 30 days.

Figure 5.2 Layout Showing the Time of the Tests and Length of the Teaching Episodes

Since pretest on all four content areas were given in two days but the posttest and delayed-posttest were given in successive period of time. The arrow which represents treatment time for the content fraction was bigger than rest of three arrows (treatment time of Measurement, Equation and Angle). For example the smallest arrow was the angle which was launched for 7 days. After
the completion of treatments of unit fraction, F2 posttest of Fraction was conducted. The length of the first arrow of the second row which is headed to M2, is the duration for the treatments given on the content Measurements.

Similarly other arrows are the representation of Equation and Angle episodes and respective posttest and delayed-posttest.

**Treatment Steps to Conduct the Classroom Activities**

In order to teach any episode the following procedure was followed by the project-teachers:

- The teacher poses an open-ended problem to the class;
- The class is divided into small groups to 6 to 8 students;
- Teacher asks the students to find out their own solutions to the problem individually or within their small groups;
- Teacher as well as the investigator facilitate the learning environment by providing necessary instructional materials (e.g. 2-D, 3-D manipulative materials) and clues through different questions to solve the problems. During the development of the lesson both the investigator and project teacher were alert to make every individual participate in the activity;
- Students try to find a solution to the problem individually or in a small group and involved a consensus, present their individual solution to the problem;
- The entire class participates in the discussion giving their solutions;
- Finally the solution to the problem is found.

In this way the students were taught and trained to learn independently and cooperatively. After one mathematical task, the same procedure was followed for the next task.

**Support Given to the Teacher**

While the experiment was going on, suggestions were gathered from headmaster, mentor and project teachers to make the experiment profitable. According to their suggestions, the investigator worked constantly with the project teachers and guided them by providing necessary
supports & planning. The investigator observed the classes of project-teacher almost everyday where the teaching-episodes were carried out to facilitate the process. On the other hand, the investigator also observed the control group’s classes to see their conventional way of teaching.

Thus the regular support mechanism for the teacher became possible since all the four schools were situated within 8 kilometres distance.

At times, both project teachers were taken to model school (Rato-Bangala) to observe the demonstration lessons given by the expert teacher on the request of the investigator on specified topics. Both project-teachers and investigator himself recorded the observation of model lesson through Classroom Observation Form vide in Appendix K. During the model-class the audio-recording was also done for further discussions with teachers.

In order to make them confident in teaching through this new methodology i.e. constructivism, the investigator himself at times, demonstrated different lessons from other subjects namely environmental science, social studies etc.,using the steps of constructivism.

Feedback from Headmaster, Mentor, Teachers and Students

In order to get the feedback about the effectiveness of constructivism as perceived by headmaster, mentor, teachers and students, the investigator discussed and took their opinion and reactions. The headmasters and project-teachers at times, expressed their reservations/doubts about the completion of the whole course during stipulated period of academic sessions. To make the project teacher confident, the researcher requested them to make the annual plan in their own ways to accomplish the course. The investigator also made his own plan. Surprisingly both the plans matched. It increased the confidence of the project-teachers to complete the course on time.

Both headmasters co-operated the investigator by adjusting the schools' routine so that the investigator could sit with one project teacher in the first half of the school time and with another at the other time. To make the both teachers equally efficient in terms of applying constructivism, they were requested to visit each other's class and exchange their comments.

Posttest Stage

After completing each content posttest was given to see immediate learning. After the posttest of a particular content, next set of teaching-episodes for another content started with the above procedures. The entire process of completing all the episodes in four content areas took about 5 months duration.