COMPETENCY-BASED LABORATORY MANUAL : A STUDY

* PROF. JOSHUA EARNEST

** PROF. S. R. KERKAL

ABSTRACT

This paper is condensed from the dissertation of S. R. Kerkal, and written by **both he and** *his guide Prof.. Joshua Earnest, which was accepted by the Barkatullah University, Bhopal, M.P., (India) towards the partial- fulfilment for the award of the Masters in Technical Education, 1997. It highlights the experience in developing a 'Competency-Based Laboratory Manual in Hydraulics'. for this, the competencies required in the area of hydraulics were identified from the working professionals and the laboratory manual was designed, developed and tried out on the sample of students. The competency maps in the dissertation were developed in partnership with the working professional. The results of this experiment and the main features of the competency-based; laboratory manual are highlighted in this paper; which could serve as 'starter' to develop laboratory manuals in other areas.*

1. INTRODUCTION :

It is the voiced observation of the industry / society that the passouts of the diploma programmes do not possess the requisite competencies to perform the jobs when they are inducted into the profession. This was studied in detail with the working professional and the methodology to develop the skills and attitudes was also looked into.

2.0. THE RESEARCH STUDY :

The detailed action plan was the outcome of the exhaustive initial planning for the dissertation work. During the planning stage, insight was developed regarding the methodology, which included the following stages.

2.1. Identification of Competencies :

After the review of literature related to the laboratory instructions, curricula for hydraulics and the course/ contents on hydraulics, it became clear that the identification of the competencies would be the first step, as this component as missing.

Then, the working professionals in different areas of work were contacted

* Prof. & Head, Dept. of Elect. Engg. - TTTI, Bhopal.

** Head, Dept. of Civil Engg. Govt. Poly. Ahmednagar, Maharashtra.

and through series of discussions with them, the competency maps showing their job functions were developed in partnership with them. From these competency maps, various competencies were derived like :

- Determine the demand of water for urban dwellings.
- Investigate the sources of water
- Communicate orally with people effectively.

2.2. Selection of Laboratory Experience :

The process of selecting laboratory experiences, to be included in the laboratory manual, from the identified competencies, was performed by the following steps.

Step 1 : Classification of Practical Skills :

After deriving the broad practical skills from the competency maps, they were further classified into the practical skills related to the polytechnics laboratory, manual skills related to field visits and manual skills that can be developed through on-the-job short-term field training as shown in table No. 1.

TABLE NO. 1 - PRACTICAL SKILLS CLASSIFICATION

Laboratory Related Practical Skills	Manual Skills Related to Field Visits	Manual Skills Related to On-the-Job-Training
1. Measure Pressure in pipes, canals. 2. Measure flow through : • Pipes • Canals • Rivers • Nallas and Tanks 3. Calibrate devices like : – Venturimeter – orificemeter – orifice – flumes 4. Select appropriate devices and materials like : • notches of different sections • flumes of different sections • pipes of various materials • measuring instruments • tools etc.	1. Measure velocity of flow using : • select pump • current meter 2. Select pump sets 3. Measure seepages in dams 4. Maintain weirs, notches, flumes.	1. Maintenance of : • irrigation system • water supply scheme 2. Operate water treatment plants 3. Operate irrigation system.

Step 2 : Derivation of Sub-Skills :

In this step, the sub-skills (supportive skills) were derived from the *'laboratory related practical skills'* that are shown in Table No. 1. About 55 sub-skills were derived and some of them are given below. This included some from the cognitive domain denoted by 'C', some to the psychomotor domain denoted by 'P' and the rest predominantly to the affective domain denoted by 'A'.

- Select pumps for delivering the water. - C
- Explain different types of heads in pumps. - C
- Calibrate the given flume. - P
- Handle manometer with care. - A

Step 3 : Deriving the Laboratory Experiences :

From these derived sub-skills, 36 laboratory experiences were identified in discussion with the working professionals. Some of them are given below :

- Use Piezometer to measure pressure at a given point.
- Use U-tube manometers to 'measure the difference of pressures'.

Step 4 : Selecting Laboratory Experiments :

From the list of 36 laboratory experiments derived in the preceding step, the following 9 were selected for this research study. The criteria were that these would develop some psychomotor skills and attitudes in a polytechnic laboratory.

1. Apply Bernoulli's theorem.
2. Flow through Orifice.
3. Flow through Pipes.
4. Minor Losses in Pipes.
5. Calibration of Venturimeter.
6. Calibration of Orificemeter.
7. Calibration of Rectangular Notch.
8. Calibration of Trapezoidal Notch.
9. Calibration of Flume.

2.3. Development of Competency - Based Laboratory Manual :

For developing any skill, the *'practice-feedback-practice'* cycle has to occur. Hence to ensure the demonstration of the skills required by a civil engineering diploma holder, the laboratory manual was developed such that the skill is to be demonstrated more than once through various laboratory experiments.

So the next issue was, what should be the format to develop these identified skills and attitudes and thereby the competencies. Various types of laboratory manuals were reviewed and it was found that almost all of them were designed for verifying the theory and the focus was *not development of requisite skills.* Therefore, it was concluded that a new format need to be designed which will accelerate the development of skills. After experimenting with several formats, the following one with the main headings given was finalised for developing each experiment.

SHORT TITLE OF THE EXPERIMENT

I **Skills** (picked up from the list mentioned in step 2)

II **Experimental Objectives** (derived from the above skills)

III **Practical Significance** (to motivate the student)

IV **Minimum Theoretical Background** (just enough to do the experiment)

V **Experimental Setup** (a diagram, sketch, photograph)

VI **Apparatus** (name of equipment with specification and quantity)

VII **Precautions** (to personnel or equipment)

VIII **Procedure** (step-wise)

IX **Observations and Calculations** (preferably in tabular format)

X **Results** (in the form of graphs, numeral values, statements)

XI **Interpretation of Results** (this will be specific to this experiment only)

XII **Conclusions** (interpretation will lead to some generalization)

XIII **Assessment Scheme** (matches the specified skills and objectives)

XIV **Further Readings.**

The details of the first two headings (of this new format) of Expt. No. 1 and Expt. No. 5 from the laboratory manual are reproduced here to bring in more clarity, as the rest of the headings are self-explanatory.

Experiment No. 1 :

Apply Bernoulli's Theorem :

I. Skills and Attitudes :

This experience is expected to contribute towards the achieved of the following skills and attitudes.

1. Measure the pressure in pipelines.
2. Observe, measure and record the different types of pressure heads in canals/ conduits.
3. Handle glass devices carefully.

II. Experimental Objectives :

At the end of this experience you will be able to :

1. measure the pressure at a point by using the given piezometer.
2. experimentally verify Bernoulli's theorem in a canal conduit.

Experiment No. 5 :

Calibration of Venturimeter :

I. Skills and Attitudes :

This experience is expected to contribute towards the achievement of the following skills and attitudes.

1. Measure the discharge through the pipeline.
2. Calibrate venturimeters.
3. Work as a leader and also as a member of team.

II. Experimental Objective :

At the end of this experience you

will be able to :

1. discover certain relationship while determining the coefficient of the given venturimeter.

You will notice here that in both the laboratory experiments, the ***skills*** are generic in nature and could be developed through any suitably designed laboratory experience. In contrast, you will find that ***experimental objectives*** are experiment specific and serve as a ***vehicle*** to develop the skills.

3.0. NEED FOR TEACHER GUIDE :

While developing this laboratory manual, development of the stipulated skills / competencies was the main focus. If the laboratory manual has to be used in other polytechnics. the concepts in the mind of the researcher / designer need to be understood by every teacher in the same philosophy. Moreover, this being a revolutionary change, the necessity of a teacher guide was felt and therefore it was developed for administering each experiments in 'letter and spirit'.

4.0. PILOT TRYOUT :

After fully developing the laboratory manual and teacher guide, it was subjected to three types of evaluation.

4.1. Self - Evaluation :

To ensure the logical sequence of the experiments, correctness of laboratory instructions, apparatus to be used, duration of performing the experiments and such matters were checked by the researcher himself, as he himself is a senior civil engineering teacher in the polytechnic education system.

4.2. Appraisal by Course Teachers :

The feedback of the course teachers of hydraulics regarding the developed competency-based laboratory manual and teacher guide were taken from the same polytechnics, where the laboratory manual was tried out on the students. The details of the appraisal were as follows :

A 3 point rating scale was used in the research instrument.

VS-	Very satisfactory	- 3
S -	Satisfactory	- 2
U -	Unsatisfactory	-1

4.3. Pilot Tryout on Students :

The pilot tryout on the polytechnic students consisted of four parts.

(a) Performance test

(b) Achievement test

(c) Students reactionnaire

(d) Interview with students and teachers.

4.3.1. Performance Test :

The performance test comprised of a checklist consisting of ten indicators on which the students' performance during the laboratory experimentation was checked.

(a) Analysis :

The analysis of the result of the performance test was as shown in table 2.

(b) Interpretation :

The % score of performance test revealed that the minimum score of the students is 62.5%, which is quite satisfactory.

TABLE NO. 2 : ANALYSIS OF PERFORMANCE TEST

S. No.	Student	Test Scores		
		Score	Out of	% Score
1	A	6	8	75
2	B	6	7	85
3	C	8	10	80
4	D	5	8	62.5
5	E	6	8	75

4.3.2. Achievement Test :
(pen and paper)

The achievement test comprised of a pre-test and post-test consisting of the 10 test itmes. The same test was used as pre-test and post-test 10 items.

(a) Analysis :

The analysis of the achievement test was as shown in Table No. 3.

TABLE NO. 3 : ANALYSIS OF ACIEVEMENT TEST

S. No.	Student	Pre-test Score	Post-test Score	Gain in Score	% Gain
1	A	5	6	1	20
2	B	6	6	0	00
3	C	7	8	1	14.2
4	D	6	7	1	16.67
5	E	4	6	2	50

(b) Interpretation :

The % gain in score varies from 0 to 50%, implied that some gain in knowledge had taken place.

4.3.3. Students Reactionnaire :

The response of the students to the reactionnaire was analysed in the Table No. 4. The response of the students were delimited to only those three experiences on which tryout was made. It was on a 5-point scale from 'strongly agreeable' to 'strongly disagreeable'.

(a) Analysis :

Excepting one, the scoring for each and every statement of the reactionnaire was above 4.7. Only one statement scored 4.0

(b) Interpretation :

This low score was due to the fact that the students did not perform the experiences in hydraulics by the traditional method and were rated on the basis of the performance related to the course.

4.3.4. Feedback from the Teachers and Students :

In the discussion with the teachers and students after tryout, some comments were offered and suggestions were forwarded. They were incorporated in the final laboratory manual and teacher guide.

5.0 .STRENGTHS OF THE MANUAL :

As perceived by the teachers, students and working professionals, the manual has the following strengths.

5.1. As Perceived by Teachers :

(a) The manual has been developed in a scientific manner.

(b) The experiments are arranged in a logical sequence to enhance the student involvement.

(c) The supportive visuals enhance the comprehension of the activities of the procedure for performing the experiences.

(d) This innovative format for all the experiments facilitates in easy implementation.

(e) The skills and attitudes to be developed are repeated in many experiments to ensure their achievement.

(f) The teacher guide is also innovative and useful for all teachers.

5.2. As Perceived by Students :

(a) The format of the experiments motivates to perform the experiment.

(b) The practical significance, skills and attitudes, experimental objectives, along with the photographs are motivating to perform the experiment.

(c) The assessment scheme is clear and precise.

5.3. As Perceived by Working Professional :

(a) Design and development of the manual is performed in a systematic manner.

(b) Format of the experiment is much impressive.

(c) The practical significance, skills and attitude mentioned in each experiment is helpful for motivation and acquisition of skills/attitudes by the students.

(d) Inclusion of photographs in the manual is a novel idea.

6.0. LIMITATIONS OF THE MANUAL :

This being the first attempt of its kind to develop a competency-based laboratory manual the :

- teachers were not conversant with this new methodology of performing the experiments.
- Students were also not conversant with this new methodology.

Hence, some prior orientation in this regard is essential for effective implementation.

7.0. CONCLUSIONS :

The following were the major conclusions of this research.

1. The manual can be of help for the students to develop the requisite skills and thereby the competencies in the polytechnic laboratory itself.
2. Not only the manual, but also the competency-based print material can be of great help to develop the needed the competencies in the technicians.
3. If such type of manuals are developed and adopted for the other courses also, then the requisite skills and competencies can be developed in the technicians in a more effective and efficient manner and thereby useful to the industry.

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