CURRICULUM DEVELOPMENT FOR DEVELOPING COUNTRIES

BY

PROF. O.O. AYENI

Department of Surveying
University of Lagos
Lagos, Nigeria

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ABSTRACT

Five components of the curriculum development process are recognised as aims and objectives, content, methods, assessment and feedback and analysis. The principles and rationale for developing an appropriate curriculum in Photogrammetry at four training levels —sub-technician (Operator), technician, technologist and professional— are examined within the context of the needs of developing countries. An attempt is made to define the contents of curriculum modules for each level with due recognition of the peculiarities of developing countries. Methods of training at these various levels are discussed and the need for proper assessment and feed back is emphasised in a continuous but cyclic curriculum development process.

KEY WORDS: *Developing Country, Education, Photogrammetry, Training.*

1. INTRODUCTION

Curriculum development in Photogrammetry has assumed great importance in recent years. Some national and international institutions have modified and reviewed their curricula, taking into consideration internal and external factors, thus portraying curriculum development as a dynamic process while in others, particularly in developing countries, curricula in Photogrammetry have remained relatively static for some length of time. The objective of this paper is to examine the principles and rationale for developing appropriate curricula in Photogrammetry at all training levels with particular reference to developing countries.

2. PRINCIPLES AND PROCESS OF CURRICULUM DEVELOPMENT

Curriculum development may be defined as a process in which the learning opportunities, materials, equipment and other resources are constantly planned, assessed and reviewed with the aim of bringing about some positive changes in the students being taught. It is clear from this definition that curriculum development should be guided by certain principles and that it is a dynamic process. The components of the process are identified as follows:

(i) setting up the aims and objectives to be achieved by the curriculum;
(ii) determination of the content of the curriculum;
(iii) choosing the methods to be adopted in the organisation and the presentation of the contents to the students;
(iv) measuring or assessing the progress and performance of a student;
(v) obtaining a feed back from graduates or products of the curriculum and analysing the data so as to review other components in the curriculum process.

The dynamics and cyclic process of curriculum development, which is based partially on Nicholls et al. (1980) is illustrated by Fig. 1. A very important principle of curriculum development is that the elements depicted in Fig. 1 are not mutually exclusive, rather they are interdependent and they do interact as illustrated in Fig. 2. The objective of this paper is to apply this principle and process to the development of curriculum in Photogrammetry.

3. AIMS AND OBJECTIVES

3.1. Although the cyclic nature of the curriculum development process suggests that there is no starting point, for the purpose of convenience we begin this consideration from the point of view of aims and objectives. Also for the purpose of clarity, we distinguish between aims and objectives. The aims of a curriculum are supposed to indicate the general direction of a course or training programme whereas objectives define the changes in behaviour of a student or what a student should be able to do, at end of a training programme. This is sometimes called behavioural objectives. The determination of the aims and objectives of a curriculum is usually influenced by the teacher's skills, the student's need, the labour market and the facilities and time available for the course.

Let us consider what should be the aims and objectives of the following four categories of training in Photogrammetry viz: operator, technician, technologist and professional as depicted in Table 1.

It should be noted that in a developing country, these four levels suffice whereas in a developed country one may define only three levels of training — technician, technologist and professional because there is really no need for separating operator's training. In some countries there are only two levels: technician and professional.

From Table 1, one can surmise that the aim of the technician and operator's training is to answer the question "how" while that of the technologist is to answer the question "Why" and "How". The professional however seeks to answer more of "why" than "how" (see Ayeni (1989) and Ghosh, (1984). The long term behavioural objectives in Table 1 may be classified as intellectual, professional, emotional and social objectives. These will constitute a dominant factor on the curriculum content.

In developing a curriculum for any of the four levels of training depicted in Table 1, there is a need to prepare a series of courses or course work which will lead to the realisation of the overall aims and objectives for each level. Before developing the general trend of the curriculum contents of each of the courses at each level corresponding short-term aims and objectives must be defined, which should be consistent with the long-term aims and objectives.

4. CONTENTS

4.1. Definition and Scope:

By content we mean the subject matter, the professional skills, knowledge, laws and ideas to be learned during a programme or course. Apart from the short-term and long-term aims and objectives, other factors to be taken into account in developing the content of a curriculum for Photogrammetry are the type and calibre of the teachers, the type of equipment, the type of text books available and the state of the art. In designing a curriculum, the concept of "Depth", "Breadth" and "Spread" must apply (Ghosh (1984) and Ayeni (1989)), particularly for the technician, technologist and professional levels of training (See Fig. 3).

According to Ayeni (1989) and Ghosh (1984), "Depth" assures that the curriculum content produces competence in one discipline or speciality, while the "Breadth" guarantees that the content allows acquisition of knowledge in other cognate disciplines such as Cartography, Remote Sensing, Photography and Land Surveying. It is possible to distinguish between primary and secondary "Breadth" as illustrated in Fig. 3. The concept of "Spread" ensures a broad-based education in other ostensibly unrelated disciplines. These concepts are used to develop the sample modules for operator's, technician's, technologist's and professional training programmes in Tables 2A and 2B, which are by no means perfect modules.

4.2. Operator's Course (sub-technician course):

Considering that this is the lowest level of training and taking into account the aims and objectives of the operator's course as contained in Table I, a curriculum content has been outlined in Table 2A. The content of the course concerns only the fundamentals of Photogrammetry under the "Depth" module and no emphasis is placed on the "Spread" module. Practical work is emphasised.

4.3. Technician's Course:

Emphasis in the content of the technician's course is having a good coverage of essential photogrammetric topics under "Depth" modules as well as a good background of cognate disciplines under "Breadh" modules. This course is meant to give a good training in the mathematical subjects under "Spread" modules (see Table 2A). The content under "Depth" includes instruments maintenance given the lack of maintenance culture in developing countries. Practical work is also emphasised.

4.4. Technologist's Course:

For the same reason given in Section 4.3., the content for the technologist under the "Depth" modules incorporates basic servicing, maintenance and repairs of photogrammetric instruments. Elements of managerial training is introduced as part of the "Depth" module as shown in Table 2B.

4.5. Professional Course:

The modules for professional training presented in Table 2B include what is expected in any graduate or post-graduate degree courses at M.Sc. and Ph.D. levels. It is important to note that most curriculum contents in developing countries do not usually include the following very crucial aspects of photogrammetric training:

(i) Geographical Information System (GIS) or Land Information System (LIS), for lack of computer facilities;
(ii) Non-topographic applications, for lack of appropriate photogrammetric equipment, and

(iii) Design and repairs of instruments, due to lack of teachers and/or equipment to implement such elements in the curriculum contents.

These three aspects have been deliberately included to emphasise their growing importance in the Photogrammetry Curriculum. It is becoming increasingly important that users of instruments should have an input in the design of instruments suitable for developing countries. Non-topographic applications and GIS/LIS are very crucial to developing countries and should be included in Photogrammetric curriculum.

4.6. Other Issues Related to Content:

4.6.1. The modules presented in Table 2A and 2B should be broken down into subject blocks. These subjects should be arranged in an orderly sequence and should have their own separate curriculum contents and their associated aims and objectives. Pre-requisites for taking the sequence of subjects must be set out clearly.

4.6.2. One other important issue related to content is the entry qualifications for admission at various levels of training, as the former has a strong influence on the latter. It must be admitted that the entry qualification may also influence the curriculum content. Environmental factors such as the level of educational development in a country may also exert influence on the entry qualification.

4.6.3. Practical training: this is a very important aspect of photogrammetric training as it is directly related to the behavioural objectives. A set of objectives and/or topics of practical work should be defined for photogrammetric training at all levels. These topics should be directly related to the curriculum contents in Tables 2A and 2B.

4.6.4. Nicholls et al. (1980) has defined four criteria which a content should satisfy before being included in the curriculum as follows:

(i) Validity: that is the content must be authentic, true and current;
(ii) Significance: which implies that the content must have sufficient "Depth" and "Breadth";
(iii) Interest: which indicates that the content must take into consideration the students' interest but should not solely depend on it;
(iv) Learnability: which requires that the content should be learnable in the way it is presented.

This last criterion leads us to the importance of the method of presentation of the content to the students.

5. METHODS

5.1. Factors Influencing Choice of Methods:

It has been demonstrated that the content must be developed in relation to the aims and objectives. The question is what methods are needed to implement the content so as to achieve the aims and objectives? There is always a mutual interaction between the method, content and aims and objectives as illustrated in Fig. 2. By method we mean the organisation of the content and the manner of its presentation by a teacher to the students. The choice of method(s) in Photogrammetry is also usually influenced by the level of the course, the type and calibre of teacher, the facilities available for training, including technical equipment as distinct from educational equipment and the students who are the target beneficiaries.

5.2. Choice of Methods:

Since different methods may achieve the same objectives, it is hard to state what is the best or the right method(s). Some of the methods for the presentation of photogrammetric contents at various levels of training are now discussed.

5.2.1. Methods for Operator's Training: Informal lectures such as tutorials, questions and answer sessions, audiovisuals with emphasis on practical exercises are very ideal for the operator's course since the aim of the operator's course is to emphasise what to do and how to perform the photogrammetric operations. The ratio of time devoted to theory and practice should be about 20:80. The content can be successfully presented with all aims and objectives achieved within 9-10 months.

5.2.2. Methods for Technician's Training: Since the aim of the technician course is to provide both theoretical and practical training, the ratio of time devoted to the former and the latter should be about 40:60. The methods of teaching is not much different from the operator's except that there is more emphasis on formal lectures rather than informal lectures. Field work is also considered important and duration by experience, in a developing country may be about 18-22 months.

5.2.3. Methods for Technologist's Training: All the methods discussed above apply but the ratio of theory to practice should be about 60:40. Reading assignment is relevant at this stage since the trainees should begin to answer the question why some operations are performed.

5.2.4. Methods for Professional Training: All of the methods so far discussed may be supplemented by a project

or research assignment, seminars, term papers, dissertation and thesis for the relevant level of postgraduate training. The learning opportunities are flexible as they are limitless as to the choice of methods once the aims and objectives are achieved. The approximate ratio of theory to practice should be about 70:30 and the minimum duration of the courses should range from 12 months to 36 months, depending on the level of professional training — B.Sc., M.Sc. and Ph.D.

6. ASSESSMENT

6.1. Factors Influencing Assessment:

One of the important elements in the curriculum process is assessment which is the measurement or evaluation of students performance. This is traditionally done by way of a final examination which may or may not have any bearing with the defined aims and objectives, the content, and the methods of presentation of the content. The behavioural objectives of a course could be assigned weights indicating their relative importance and the content of the course could be developed with these weights in mind. These weights should therefore be reflected in the assessment.

6.2. Types and Modes of Assessment:

There are many ways of assessing the performance of a student within the context of the curriculum. Some of these are listed as follows: Examination, Test, Quiz, Technical or Term paper, Project, Practical Task, Seminar, Dissertation and Thesis. These have different modes, for example: the examination may be closed-book, open-book, take-home, written, oral, objective type or essay type. A test or quiz may also be a formal type or impromptu.

There are also three types of assessment: terminal assessment, periodic assessment and continuous assessment. Many institutions all over the world are in favour of continuous assessment because it gives a chance to do an evaluation of the progress of the student from start to finish. Where a combination of types of assessment is employed the relative weights of these items should also be applied to obtain the overall grade. If the training level is that of the operators given its objective, the practical exercises will be given a weight of about 70-80 percent compared to theory's 20 percent. Sample assessment schemes are presented in Table 3A.

6.3. Result of Assessment:

The result of the assessment is important in determining the progress of students as well as their overall performance at the terminal point of the course. The result may also indicate the level of understanding of the content as well as being a pointer to the success or failure of the methods adopted in teaching the course. For the sake of completeness, one should mention here that requirements must be set up for identifying from the result of the assessment, when a student has successfully completed the course and when he has not. His level or grade of success must also be defined. Table 3B contains sample grading schemes.

7. FEED BACK AND ANALYSIS

7.1. Types of Feed Back:

Feed back and analysis is an important and separate stage in the curriculum process which more often than not has suffered much neglect. In some cases, it has often been treated as the last stage of assessment, whereas in this presentation the result of assessment will be regarded as the first stage or as a type of feed back. The second type of feed back consists of an evaluation of the course and the totality of the teacher's ability and his performance. The third type is a post-graduation evaluation of the products of a training course.

7.2. Importance of Feed Back and Analysis:

7.2.1. The result of assessment as mentioned in Section 6.3. is not only vital in measuring the student's progress and performance but it is also a response of the student to the interaction of the various curriculum components — aims and objectives, content, methods and the mode of assessment. The result of assessment of the students should therefore be properly analysed and diagnosed because they can reveal the sources of strength or weakness in the various components in the curriculum process. Amendments arising from this diagnosis are fed back into the cyclic curriculum process (see Fig. 1).

7.2.2. The evaluation of the course and the teacher's performance in relationship to the components of the curriculum is a very crucial part of the curriculum development. This evaluation is usually done by means of a set of carefully worded questionnaires about these components, viz: students may be requested to respond to questions such as: "Are the aims and objectives clearly stated by the instructor?" "How do you rate your knowledge of the course before and after the course?", "Was the instructor punctual for lectures?", "Are the examples illustrations, homework assignments adequate?" The questionnaire usually consists of multiple objective questions with graded answers. The analysis of the results

of such a questionnaire will assist the instructor in identifying his areas of weakness and strength as a person as well as those of the objectives, contents, methods, and assessment. He will therefore be obliged to make the necessary amendments in the curriculum development process, thereby making it a dynamic process (See Figs 1 and 2).

7.2.3. The third type of feed back is the one carried out periodically by way of a questionnaire on the products of a curriculum at an interval of say every five years after graduation.
The purpose of this feed back is to determine whether the long-term aims and objectives are being achieved long after graduation. The questionnaire is usually designed to assess the graduates' performance at work, his progress and improved skills and also to what extent he has been making good use of the knowledge and skills acquired during training. The analysis of this type of feed back will also constitute an input to the changes to be effected in the curriculum as it will reveal areas of success and failure.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Conclusions:

The five components in the curriculum process have been identified as:
(i) Aims and objectives
(ii) Content
(iii) Methods
(iv) Assessment
(v) Feed back and analysis.

It has been established that the curriculum should be a cyclic and a continuous process (see Fig. 1). The mutual interaction amongst the five components have also been illustrated (see Fig. 2) in relationship to the curriculum development in Photogrammetry. The importance of the results of assessment and of the various types of feedback to the continuous curriculum process has been demonstrated.

8.2. Recommendations:

(a) The concept of "Depth", "Breadh", and "Spread" for developing a new curriculum content or in revising an existing one is highly recommended for training institutions in developing countries;
(b) The inclusion of instrument design, maintenance and repairs as well as GIS/LIS is also highly recommended in the curriculum content, particularly at technologist and professional training levels;
(c) Institutions in developing countries should not regard curriculum as a static process but as a continuous cyclic process. The various inputs from assessment and feedback should be considered in the process.

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TABLE I

AIMS AND OBJECTIVES OF PHOTOGRAMMETRIC TRAINING AT FOUR LEVELS

TRAINING LEVEL	AIMS	BEHAVIOURAL OBJECTIVES
Operator	To provide adequate practical training in a number of basic photogrammetric operations	Ai) perform very well certain routine photogrammetric operations such as inner, relative orientation and map compilation on specified instruments ii) perform simple cartographic work such as fair drawing.
Technician	To provide practical and theoretical training in the fundamentals of Photogrammetry required in standard photogrammetric projects at various mapping scales.	Bi) perform very well routine photogrammetric operations, including the ones in A, on any photogram metric instruments (ii) Perform certain cartographic operations such as drafting (iii) perform field completion (iv) supervise operators
Technologist	To provide comprehensive training in the theory and practice of photogrammetry and in the planning of photogrammetric projects at various mapping scales, including training in supervisory role of low-level manpower.	C i) same as in B. (ii) write simple computer programs and use installed programs in a computer for photogrammetric application. (iii) supervise techncians and operators in A and B; (iv) write draft project reports of photogrammetric projects
Professional	To provide comprehensive knowledge in the theoretical, practical and management aspects of photogrammetry, including conventional and non-conventional aspects.	D i) same as in C (ii) perform research into problems of photogrammetry (iii) write project proposal for internal/external funding. (iv) plan photogrammetric projects (v) set up and supervise a photogram metric department (vi) write sophisticated programs (vii) set up Data Basic System for Land information system (viii) write project/research reports.

TABLE 2A

MODULES FOR CURRICULUM CONTENT FOR PHOTOGRAMMETRY OPERATORS AND TECHNICIANS

LEVEL OF TRAINING	"DEPTH" MODULES	"BREADTH" MODULES	"SPREAD" MODULE
Operator	1. Elementary photogrammetry 2. Photogrammetric instruments 3. Introduction to photo triangulation. 4. Rectification of photos	1. Map reading and topography interpretation I 2. Aerial photography 3. Cartography I 4. Plate table	1. Fundamentals of Algebra, Trig. and Geometry
Technician	1. Element of photogrammetry 2. Radial triangulation 3. Instrumentation in Photogrammetry I 4. Aerial triangulation I 5. Rectification 6. Instrumentation in Photogrammetry II 7. Photo orientation 8. Aerial triangulation II 9. Orthophotography	1. Map reading and topograph interpretation II 2. Introduction to Aerospace photography 3. Basic land surveying I 4. Cartography II 5. Basic land surveying II 6. Introduction to aerial photography	1. Mathematics I 2. Mathematics II 3. Optics 4. Theory of errors

TABLE 2B
MODULES FOR CURRICULUM CONTENT FOR TECHNOLOGISTS AND PROFESSIONALS

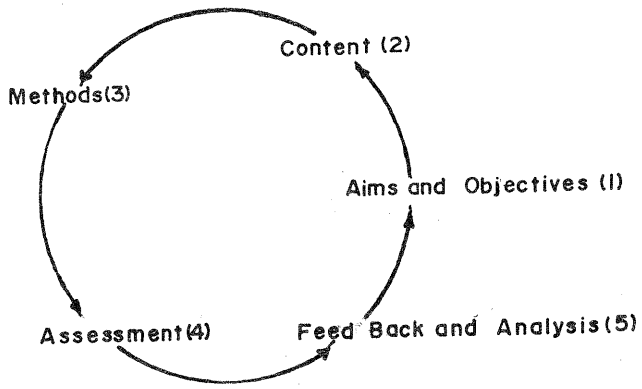
LEVEL OF TRAINING	"DEPTH" MODULES	"BREADTH" MODULES	"SPREAD" MODULES
Technologist	1. Introduction to photogrammetry 2. Instrumentation (including instruments maintenance) 3. Theory of Orientation 4. Aerial triangulation and adjustment 5. Organisation of photogrammetry unit 6. Organisation of photogrammetry project 7. Practical project.	1. Cartography III 2. Land Surveying III 3. Introduction to Remote Sensing 4. Methods of map production	1. Advanced Mathematics I 2. Advance Mathematics 3. History of Technology 4. Project Reporting.
Professional	1. Elements of Photogrammet 2. Instrumentation 3. Stereo Photogrammetry 4. Aerial triangulation and mapping 5. Analytical Photogrammetry 6. Application of Photogrammetry (including non-topographic) 7. Methods of map production 8. Digital Mapping/LIS 9. Administration of a Photogrammetric Departme 10. Planning and Execution of photogrammetry projects 11. Practical project research.	1. Elements of Cartography 2. Elements of Remote Sensin 3. Elements of Photrography 4. Elements of Surveying 5. Methods of Map production	1. Mathematical Methods 2. Statistical Methods 3. Computer Science 4. History of Science and Technology 5. Technical Reporting.

TABLE 3A: SAMPLE ASSESSMENT SCHEME

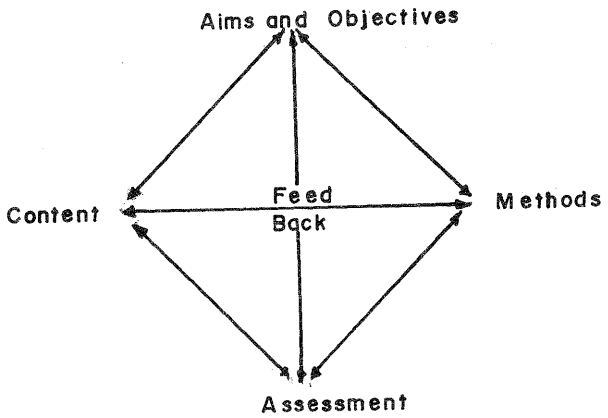
	UNDERGRADUATE (Percentage)	POST-GRADUATE (Percentage)
Course Work Exercises	20	20
Tests	10	10
Practicals	30	20
Final Exam.	40	50
	100	100

TABLE 3B: SAMPLE GRADINGS

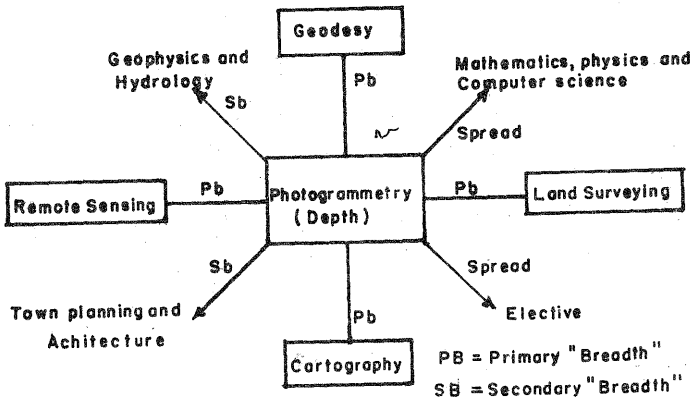
UNDERGRADUATE GRADING			POST-GRADUATE GRADING		
Marks	**Grades**	**Remarks**	**Marks**	**Grades**	**Remarks**
85 and above	A	Excellent	80 and above	A+	Excellent
70-84	B	Verty Good	70-79	A	Very Good
60-59	C	Good	60-69	B+	Good
50-59	D	Credit	50-59	B	Pass
40-49	E	Pass	Under 50	F	Fail
Below 40	F	Fail			



Fig·1 CYCLIC CURRICULUM DEVELOPMENT PROCESS.



Fig·2 INTERACTIVE CURRICULUM DEVELOPMENT PROCESS.



Fig·3 PHOTOGRAMMETRY AND COGNATE DISCIPLINES.