# CURRICULUM IN PHOTOGRAMMETRY - A WORLD CONSENSUS

(An Invited Paper)

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## ABSTRACT

Photogrammetry continues to play an ever increasing role in the world of mapping sciences. Its present needs and future trends are analyzed. Various levels of education are identified. A realistic annual rate of student intake is considered. Various conceptual models are discussed. The associated areas of science and technology and their roles in the wide academic structure are indicated. A pattern of courses and its arrangement is suggested in view of the current need in the world and of the changing technological developments.

## SOMMAIRE

La photogrammétrie continue à jouer son rôle toujours croissant dans le domaine des sciences cartographiques. On y analyse ses besoins actuels ainsi que ses tendances. Les niveaux divers d'éducation sont identifiés. On y considère un taux annuel d'admission des étudiants qui est réaliste. Des modèles conceptuels divers sont élaborés. Les domaines scientifiques et technologiques associés et leurs rôles dans l'immense structure academique sont indiqués. Un modèle des cours et sa disposition a été suggéré. Ceci est élaboré en considération des besoins à travers le monde et en vue du développement technologique en constante évolution.

## INTRODUCTION

Poincaré, the famous scientist of France wrote a century ago that science is built up with facts like a house is built with stones; but a collection of facts is no more a science than a heap of stones is a house. This concept would lead us to our premise. Our cameras and sensors as well as instruments and computers are admirably efficient in collecting facts. But unless we understand their significance and have appropriately trained people to do the job, the "heap" of facts would not provide us our "home".

Photogrammetry may be considered as an independent discipline, although it is still an important component in the complex system of modern Surveying and Mapping (S&M). Recent United Nations' studies (1983) on the status of mapping in the world and the efforts of the ISPRS Working Groups VI-1 and VI-7 (on Inventory and Education, respectively) indicate that photogrammetry has reached an effective level of efficiency and would remain for years to come the most efficient base technique for producing topographical and other maps with the use of aircraft and satellite base imageries. This technology must be maintained, understood and utilized with care until something better comes forward, if at all, to replace it for use in S&M.

It is also evident that photogrammetry and remote sensing, regarded in the past as two separate disciplines, are coming closer. They are emerging as an extended discipline, sharing common technological challenges with respect to data acquisition, data processing, data analysis, instrumentation and applications.

These would, undoubtedly, have strong influence on future approaches taken in education. These would even necessitate a complete re-structuring of curricula and course patterns at our institutions. The traditional educational links between engineering and S&M have been strong in the past. These seem to continue. Nonetheless, the alliance that visibly started during the 1950s -- the alliance with scientific disciplines concerned with natural resources and planning, need now to be forged further. These disciplines are emerging as more important users of our services.

We are now in a time of rapid changes. This necessitates that our education should have two fundamental components. Firstly, it should provide the education of "know-how". Secondly, it should be directed toward equipping the graduate with the materials of change in order to keep up with the advances of technology, user expectations and (even) the intricacies of disciplines other than ours to which our services and products will have to relate.

The technology also continues to change in our own field, with the digital computer playing the key role at present. Continuous imaging of the earth surface from orbiting satellites is a reality as are on-line computer assisted mapping and on-the-job calibration of the working system, amongst others. We have witnessed during the past three decades a shift in photogrammetry from an analog based discipline to one which is digital data based. Considerable advancement in software applications is expected. We are seeing now the beginning in the development of instruments for processing digital imagery, either original records created by array cameras or derived records by scanning conventional frame photographs. The end result would give a unique blend of the digital processing techniques of photogrammetry and the digital analysis techniques of remote sensing.

Our world is "shrinking". We have started realizing the utility of using one properly structured geo-coded data-base instead of sixteen or more ellipsoidal data-base systems. The development, maintenance and utilization of such land information systems now interjected by photogrammetry and remote sensing are bound to have the greatest impact ever on S&M activities.

Education (in terms of both, curricula and programs) must respond to these changes. Our objectives must be formulated in these regards. This means that we should be prepared to restructure our educational programs and even to help other disciplines restructure themselves in view of our impacts on sciences and technologies.

The program and course designer should avoid indiscriminate elimination of older techniques simply because they are old. For example, even though certain analog photogrammetric procedures may not be practiced any more, they can be used advantageously in the classroom to demonstrate certain basic concepts. Disciplines other than ours can benefit from our approaches. Photogrammetry and remote sensing would be excellent carriers for demonstrating practical applications of theories of physics and mathematics; for example, in the areas of matrix and vector algebras, transformation theories, numerical analyses, electromagnetic radiation, information theories, concepts of scale, standard, unit and so on.

## LEVELS OF EDUCATION

As in any field of applied science or engineering, with regard to the level of required education and attained proficiency of individual students, one can consider the following three categories in photogrammetry:

A. Photogrammetry Technicians (e.g., plotter operators), starting with a higher secondary or lower level educational background and requiring technical skills of a practical nature, obtainable within one year.

B. Photogrammetry Professionals, starting with a higher secondary level educational background and requiring college level education of around four years. This would correspond to baccalaureate or under-graduate college/university education.

C. Photogrammetry Postgraduates, after having completed one or more years of education beyond baccalaureate.

In searching for a desirable ratio of the number of persons among the three categories in a country, Ghosh (1975) found the ratio A:B:C varying between the limits of 4:3:1 and 20:3:1 in the world, the former being in a country very highly developed (technically) and the latter being in a so-called developing country. Brandenberger (1972) found that on a world wide basis, there exists an average ratio of 5.4:3:1. The interesting fact is apparent which is the ratio between the categories B and C, i.e., 3:1. This seems to be the same and thus enjoys a general consensus in the world for education at the college/university level.

Furthermore, for educational planning in any field, an annual intake of 1/20 of active manpower in that field is realistic. This rule of thumb ratio is used in numerous countries by their ministries or departments of education. Obviously, course curricula should take into account these two primary and realistic considerations, viz.,

- An undergraduate to postgraduate ratio of 3:1; and
- An annual freshman student intake of 1/20 of the average (existing, active and necessary) working population in S&M in the country.

One must recognize that the strength of a profession is directly related to the strength of the available system of education. The strength would be visible in the profession's organizational structure both out of the school as well as within the school. We ought to maintain the tempo in the right direction. If readily available, the sensible courses of instruction would even relieve the burden of on-the-job training by the employers as are often necessary simply because our programs and curricula are not always adequately realistic.

## CURRICULAR DEVELOPMENT

S&M curricula in general and of photogrammetry in particular have undergone drastic changes during the last three decades. On the other hand, remote sensing has just started making a headway.

Educators and practitioners in the mapping fields have been experimenting with curricula while the society at large has been demanding more complex and yet more comprehensive and extensive services. There has been also tremendous developments in terms of equipment, procedures and general understanding in the basic subject areas of our field as well as in other associated areas like mathematics, physics, computer technology, etc.

Clearly, the profession has responded well to these needs in view of the developments. These two forces continuously at work have helped the crystalization of the disciplines. Thus the S&M profession is no longer contented with having only one or two courses in a civil engineering curriculum or having the geodetic and astronomic concepts taught in a geographical study program. A carefully upgraded university education in our field should be the logical outcome. This, however, is not yet evident in the world.

In order to ameliorate the situation, this author makes several conceptual observations:

Concept I : With regard to undergraduate level education, the core discipline in S&M, i.e., photogrammetry and remote sensing, can not be complete without the following four associated subject areas (Fig.1):

(a) Mathematics, Physics and Computer sciences;

(b) Earth and Environmental sciences (including, specifically, Geodesy and Astronomy);

(c) Engineering technologies, Graphics, Electronics, etc.; and

(d) Liberal electives (Literature, Law, Economics, etc.).

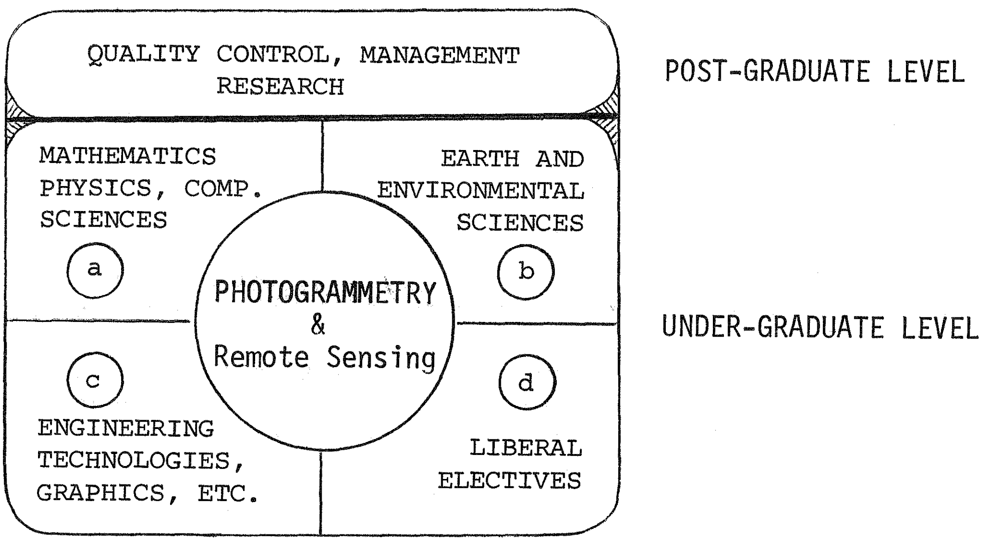


Fig.1 : A conceptual model for education in photogrammetry

Concept II: With regard to postgraduate level education, some preparations are necessary in the advanced levels of Quality Control, Management and Research. However, this must be built on top of the broad based undergraduate program. The associated areas (a,b,c and d above) are generally well established in most institutions. The curricula and programs must then be developed by concentraing on the core area of our concern.

Concept III: The development of the core area of photogrammetry requires a logical approach. The question is, what is the most appropriate logic? Some necessary elaborations are discussed later.

Concept IV : A student needs to be prepared not only for his employment in the immediate future but also in the distant future. Thus our eyes and ears must be open to realize the trends and changes in the opportunities to unfold in the days to come.

## CLASSIFICATION LOGICS

The classroom development of any subject should follow certain logic to permit necessary compartmentalization of the subject with respect to semesters, terms, quarters, etc. as well as to accomodate the progressive difficulties and complexities encountered in advancing the knowledge. Individual courses are usually developed by following such classification logics.

If photogrammetry is treated as a minor part of a vast area like surveying or civil engineering, its curriculum may be dominated by that discipline. However, the time has arrived when a specialization in photogrammetry requires its own logics to be followed. The question is, which logic? The following considerations may help us towards structuring our courses:

Logic I : The areas of science (photogrammetry) as followed by ISPRS in its seven commissions, viz.,

1. Primary Data Acquisition;
2. Instruments for Data Reduction and Analysis;
3. Mathematical Analysis of Data;
4. Cartographic and Data Bank Applications;
5. Other Non-cartographic Applications;
6. Economic, Professional and Educational Aspects; and
7. Interpretation of Photogrammetric and Remote Sensing Data.

Note: The divisional structure of the American Society for Photogrammetry and Remote Sensing (ASPRS) is in accordance with similar logic. It would, however, be apparent that such classifications, while valid for already trained and practicing professionals, can not be relevant to various levels of instruction and would not be acceptable for academic programs.

Logic II : In following the historical growth pattern of our science, one can consider a classification according to the various approaches to solutions of problems, viz.,

1. Graphical approaches;
2. Analogical/Empirical approaches; and
3. Analytical/Computational approaches.

Note: While we can realize and appreciate various possible approaches, the development of theories and concepts in the class room would be impossible in courses following such a classification. This is because there are numerous physical-mathematical concepts common to all the three categories. Academic development and growth are better consecutive than commutative. Course development should be like building a house, base first and then the walls and the rest in upward and sideward directions.

Logic III: Classification according to the procedures or working steps as are generally followed in photogrammetric operations, viz.,

1. Data Acquisition;
2. Data Processing;
3. Data Analysis; and
4. Applications.

Note: These are the steps generally taken in practice for execution of projects. However, in view of various available techniques and concepts (relevant to each step separately) requiring diverse levels of academic matirity, photogrammetry courses following this logic would be confusing and often irrelevant and, therefore, impractical in any academic structure.

Logic IV : Classification according to the basic working units and corresponding mathematical theories and supporting equipment, viz.,

1. Single image photogrammetry (plus fundamentals);
2. Double image (stereo) photogrammetry; and
3. Multiple image photogrammetry.

Note: This classification would be in accordance with the progressive development of data handling (for example, from two-dimensional to three-dimensional, or from fewer to more numerous parameters) as also with regard to progressive complexities of instruments and physical-mathematical theories. The course materials can be easily compartmentalized as any teacher with sufficient experience in photogrammetry would corroborate.

Logic V : Classification according to the developments in a text book. The books like those authored by Hallert, Moffitt or Wolf, each, provides a scheme. However, one would see also that in general they follow a developmental pattern in the line discussed under Logic IV above.

Our Logic IV seems to be the best under the circumstances. Furthermore, it would give the greatest common approach amongst all text books of photogrammetry, and thus a unified approach in the world.

## SPECIFIC PATTERN OF COURSES

In view of the above, it may be suggested that a course pattern following Logic IV should form the core for the undergraduate level (Fig.1). There would be, however, certain allied courses necessary for supplementing the program. On the other hand, certain additional courses would be necessary to build up the postgraduate program. In this spirit, the following list of courses is suggested :

(1) Single image photogrammetry (with definitions and fundamentals);

(2) Double image (or, stereo-) photogrammetry;

(3) Multiple image photogrammetry (or, phototriangulation);

(4) Instrumentation in photogrammetry (starting with cameras and ending with stereo- and analytical plotters);

(5) Economics and operational practices in photogrammetry; and

(6) Unconventional photogrammetry (on understanding unconventional data acquisition systems as well as on unconventional applications).

The first three would form the core in developing the basic theories, in discussing various data acquisition and data processing techniques. In-depth and practice oriented instructions on various instruments (Course 4) could be presented during or immediately after the first three courses. It is, however, better to separate and discuss the instruments after the background theories in courses 1 and 2 have been presented. This is when the instrument utilization and their theories are better appreciated. This course may even be split into two, being complementary to courses 1 and 2.

Courses 5 and 6 are better presented at the postgraduate level. While the former would be addressed to future executives, supervisors and operational engineers, the latter would be addressed to the specialist involved in non-mapping/surveying areas as well as to the researcher in view of the growth potentials of the science. Courses 5 and 6 need not be sequential, while courses 1, 2 and 3 must be sequential (Fig.2). Depending on specific circumstances, the contents of courses 5 and 6 may be integrated with the other courses or may be developed into further specialized courses.

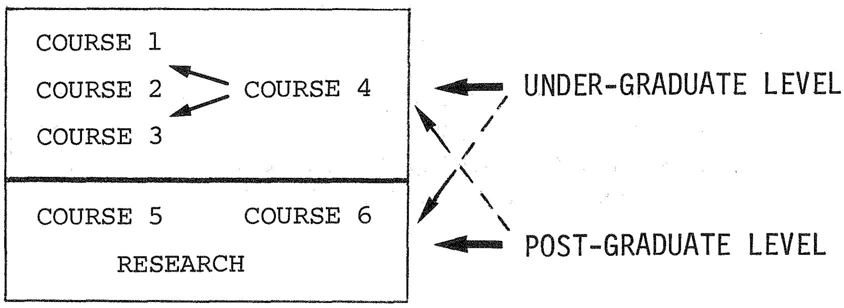


Fig.2 : Suggested course sequence in photogrammetry

The above gives a logical spread through the entire "gamut" of photogrammetry. With this basic structural pattern, one would be easily able to even elaborate each course in accordance with the demands of specific situations. For example, each course can be detailed into two sequential courses at two different levels of education. After having this course structure, the contents of specific courses can be easily developed and followed by a teacher at any level. The same structural pattern can be followed for the courses designed for technicians.

In deciding the associated supplementary courses from other fields, one has to consider the institute's program philosophy as well as the specific need of the student. The above would give, this author believes, a unified approach which is satisfactory and workable in any country or at any institution where a specialized program in photogrammetry would be desired.

Nonetheless, one must not ignore the role played by research in education. Research is vital, especially at the postgraduate level for any dynamic subject like photogrammetry. Research can be defined along the three broad categories, (a) Basic research; (b) Applied research; and (c) Development (Ghosh, 1976). The term "Research and Development" (R&D) as generally used is assumed to embrace all the three. For the purpose of convenience, at least in the academic world, one differentiates between Research and Instruction. However, in a university, these two are generally very closely related. Furthermore, it is entirely appropriate, and indeed desirable, that the coupling of Research and Service in the context of the "Teaching and Learning" mission of an institution should be encouraged and be allowed to continue.

## CONCLUSION

At an institution where a program is desired to be elaborate and to be catering to the requirements of the technician, the professional and the postgraduate, it (the program) needs to be progressively flexible. Basic areas listed under Concept I would provide the most important base. Later on, as the student progresses, he may obtain ideas from other fields of specialization like Computer science, Geodesy, Statistics, etc. Thus, depending on his advancing needs, he may be permitted to advance at his own pace.

The set of courses in photogrammetry has been outilined here in the belief that any revision of curricula would be easily possible in recognition of the technical trends with which the student would have to cope.

The author would like to express his profound appreciation for the numerous ideas he obtained in this regard from numerous colleagues all over the world during the last seven years in his capacity as the Chairman of Working Group VI-7 (Education). The above seems to be the consensus.

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