4. Group Report C

OPTIMUM OF SPECIALIST VERSUS GENERALIST EDUCATION

Membership: Ascher, Basile, Casimir, Eisner, Hertz (secretary), Hoselitz (chairman and reporter), Ingard, Maurer, Nagy (secretary), Scandone, O'Toole, Volz, Zangger.

4.1. Terms of reference

The group was specifically requested to formulate conclusions and recommendations on the optimum of specialist training versus general training (both with regard to physics as such and e. g. to managerial techniques) within the limits of the desirable duration of the physicist's training, and the ratio of theory to experiment.

4.2. Essentials of university physics programs; the two stages

The group considered that a university education should enable a physicist: a) to apply his knowledge effectively in industry, b) to interact fruitfully with men from other disciplines and c) to continue his education by the assimilation of new ideas in his industrial career.

All university physics programs known to the group essentially comprise two stages. The first stage, primarily of a tutorial nature lasting 3 to 6 years is followed by a second stage, a program which is principally a research project lasting 2 to 5 years [1]. Some physicists terminate their university education at the end of the first stage.

The group felt that this division is sound and satisfies the educational aims and the industrial requirements. Industry requires entrants who have completed only the first stage as well as entrants who have gained the research experience provided by the second stage.

---

1) The 2 stages are at present not necessarily completely separate and may in some cases (e. g. Germany) overlap.

4.3. The first stage

The group was unanimous that the first stage should consist of a core of general fundamental courses based on concepts and methods of physics rather than on details and should emphasize the experimental basis of physics. In the first stage students should, however, also learn to grasp the importance of mathematical formulations. The course should convey a basic understanding of and some ability to apply Mechanics of bodies and continua, Electromagnetism, Thermodynamics, Statistical Mechanics, Quantum Mechanics, Atomic and Nuclear Physics and Properties of Matter (see also Introduction).

We feel that depth of understanding and working ability is more important than completeness of coverage. The teaching of the subject matter should emphasize the unity of physics and its relevance to other disciplines.

Attention should be drawn to the unfinished character of physics, its continuing development and its close relation with human activity in all its aspects. The relative industrial importance of various topics, and their significant changes with time should be demonstrated.

Every physicist should have an adequate contemporary mathematical education, but the motivation for the introduction of various branches of mathematics should be derived as directly as possible from physics.

To convey an idea of the standards of the course (we are thinking of entrants who have had some physics tuition at school, say 2 years), the course should last not more than 4 years. The total of lectures, supervised laboratory practice and tutorial work in mathematics and physics should occupy about 400 hours (contact hours) per year (of these, 50 hours will be laboratory work).

About 1000 further hours should be spent by the student per annum in private study, project work and discussion (of these at least 100 hours should be spent on experimentation without full-time supervision).

In addition, we recommend 100 contact hours per year devoted to the humanities, social sciences and other natural sciences. We consider this an important part of the student's education. Important subjects are the history of science, economics, humanism, the art of expression, applied psychology, new techniques of creative imagination, economics of innovation, the social connotations of science, etc.

It is highly desirable that each student should gain some workshop experience, be able to do elementary computer programming and have some skill in electronics.

Each student should preferably be required to complete a project (introductory research work) preferably involving the use of modern instrumentation and the contemporary literature, giving him an opportunity to test his aptitude for innovation.

The rôle of the physicist in industry should be brought to the attention of students. Visits and summer employment in industry are valuable aspects of the student's education. The group felt that managerial training, where necessary, should be provided by industry for selected candidates.

4.4. The second stage

Industry prefers to employ men at the earliest possible age and the second stage is recommended to last at most 3 years [2].

The primary function of this stage is the training in research through the completion of a serious research project, resulting in a contribution to knowledge (thesis). The subject matter of this project is of minor importance although certain topics will obviously be of greater direct applicability to specific industries than others.

Concurrently with the research, the student is expected to gain a profound knowledge in the areas of physics relevant to his project. He will also be expected to deepen his knowledge of physics as a whole and appreciate the place of his project in the structure of physics. Although the emphasis during the second stage should be on investigation, study and research, limited formal instruction may also be appropriate.

The research project may be pursued in collaboration with industry (in an industrial laboratory) or in a university department other than that of physics. In any case it is highly desirable for the students to have contact with industry during the course of this research work.

---

2) Students may well complete a first-stage physics course followed by some other post-graduate course, e. g. business studies, engineering or other science. Such persons will readily obtain industrial employment.

4.5. Conclusions and recommendations

1. In university physics training strong emphasis on specialization at the cost of general training should be avoided.
2. A two-stage program (lasting about 4+3 years), where the second stage is principally a research project, is sound and meets both the educational aims and the industrial requirements.
3. In the first stage, which in itself should also prepare for an industrial career, depth of understanding and working ability are more important than completeness of coverage.
4. For physics students the motivation for the introduction of various branches of mathematics should be derived as directly as possible from physics.
5. Managerial training should not be included in the physics course.
6. Even in the second stage methodology is more important than the choice of the subject matter.