

ABSTRACT

A STUDY OF JUNIOR COLLEGE LEVEL PHYSICS IN GERMAN SPEAKING EUROPE

By

Roderick Douglas Riggs

The purpose of the study was to analyze physics instruction in the countries of West Germany, Austria, and German speaking Switzerland at educational institutions that offered instruction at a level comparable to that found in the junior colleges of the United States. This analysis of German physics teaching was then compared to the physics instruction offered at Jackson Community College.

Staff members and students were interviewed at thirty educational institutions and six governmental agencies in the three European countries. The study was conducted during the time period between January and May of 1969. Educational institutions visited included Gymnasien, universities, Technische Hochschulen, a Pädagogische Hochschule, a Polytechnikum, Kollege, a Berufsschule, Höhere Lehranstalten, and a Technikum.

The author also visited physics classes to observe teaching techniques and to become familiar with the learning environment in each school.

Data were collected under the three major headings: students, curriculum, and evaluation. Comparisons of findings were made among these three major categories for the three European countries and then with Jackson Community College.

Findings and conclusions for physics programs at the European educational institutions and Jackson Community College were presented also. Under the category of students, findings and conclusions were presented in these specific areas: student admission processes, socio-economic backgrounds of students, student vocational aspirations, and the percentage of students successfully completing the various physics curricula at each type of educational institution.

Under curriculum, findings and conclusions were presented in the following areas: the types of physics curricula offered at each of the schools, a determination of the level of sophistication of these physics offerings, the level of mathematics studied by students who were enrolled in physics, and a discussion of the total physics teaching environment, including the pedagogical techniques used by the various teaching staffs.

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Under the topic of evaluation, findings and conclusions were presented concerning evaluation at entrance, evaluation in physics during matriculation, and evaluation processes conducted at the conclusion of the school experience.

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Roderick Douglas Riggs

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CHAPTER I

THE PROBLEM

Statement of the Problem

The purpose of the study was to analyze physics instruction in the German speaking countries of West Germany, Austria, and German speaking Switzerland at educational institutions that offered instruction at a level comparable to that found in the junior colleges of the United States. This analysis of German physics teaching was then compared to the physics instruction offered at Jackson Community College. Thus, the Jackson Community College physics program served as the basis of reference for the study. It was felt that by making such a comparison there would be information, insight, techniques, programs, and other possible facets of physics instruction in German speaking Europe that could be of value to Jackson Community College. If Jackson Community College were a representative example of the comprehensive junior

college¹ in the United States, then there was the possibility that other similar institutions could profit from this study.

Need for the Study

The desire for excellence in United States junior college physics instruction can best be comprehended by analyzing the part that these junior colleges play in relationship to the total picture of higher education in the United States. The American Association of Junior Colleges² listed some 931 institutions for the academic year 1968-69 with a total enrollment of 1,860,000 students. This compared to 2,847 institutions of higher education³ with a total student enrollment of 7,235,186 students. Thus, the junior college represents a significant fraction of our higher education establishment. If one analyzes these figures to look only at the education of freshmen and sophomores, the junior college takes on even greater

¹The comprehensive junior college or community college is identified by the objectives of providing college-parallel instruction, terminal-technical instruction, programs for general education, continuing and adult education, counseling and guidance services, and makes these programs available to all high school graduates under what is called the "open-door policy."

²Edmund Gleazer, "The Junior College Picture," Junior College Journal, XXIX (March, 1969), 24.

³The National Beta Club, 1969-1970 College Facts Chart (Spartanburg, S.C.: The National Beta Club, 1969), p. 62.

importance. The junior college is also a rapidly growing part of higher education, and there is every reason to believe it will play a still more important role in the future.

To turn to physics instruction specifically, the junior colleges are providing and expect to continue to provide quality physics instruction. These institutions will face this challenge during what has been referred to as a crisis period in physics education. The number of students who take physics in high schools has been decreasing at an alarming rate. The drop was from 25.8 per cent in 1948-49 to 19.6 per cent in 1964-65.¹ This decrease was taking place in an increasingly technical environment when the demand for people with some science background was increasing at a high rate. This concern extended to higher education as well. The professional physics community has agonized because there seemed to be too few physics majors in 1966 and 1967 to fill the demands of that time. Then in 1969 and 1970 there appeared to be too many physicists for the available market. This situation related to the supply of graduating physics majors at the Bachelor's, Master's, and Doctor's levels. Since the junior college deals with students at a much lower level

¹Wayne W. Welch and Herbert J. Walberg, "Are the Attitudes of Teachers Related to Decreasing Percentage Enrollments in Physics?" Science Education, LI (December, 1967), 436-42.

than the senior and graduate institutions, it is difficult to define the role of the junior colleges in the development of professional physicists. It is much simpler to chart the growth of higher educational opportunities in the United States, note the increasing contribution of the junior colleges to this total growth, and predict that junior colleges will teach physics to a sizable student population in the coming years. This is an important task regardless of what vocation these students choose and can be regarded as significant if only to satisfy the arguments of those who feel that some college level physics is a necessity for the well-rounded, college educated citizen in modern technical America. Regardless of what conclusion is drawn, however, there is no question that the junior college will teach physics to a significant number of students. This college-parallel function is only one facet of junior college physics programs. Certainly the other objectives of a comprehensive junior college will have an impact on the physics programs offered since students other than transfer physics majors will also take physics during their freshmen and sophomore years.

The role of a physics program in such an environment of contrasting objectives is rather interesting since there are different physics courses at Jackson Community College designed for each of the institutional

objectives with different student inputs. In other words, such a physics program is unique from virtually any existing high school, college, or university program; and so there may not be much assistance available by observing working models at these institutions. On the other hand, the junior college is in the position of providing the solutions to the problem itself; and the source of solutions could lie almost anywhere students study physics. Thus, it appeared appropriate to look in a part of the world that provided much of the existing physics heritage to see if current practices could contribute anything to the United States junior college.

Delimitations of the Study

It must be recognized that there is no existing European educational institution that is the exact equivalent of the United States junior college. Therefore it was necessary to investigate physics instruction at a variety of educational institutions that served students in the same approximate age range as found in the junior college. Also the combination of objectives from these various European institutions was compared to that found at the junior college level. To establish a basis for comparison, a spectrum of institutions was studied. Included were the general and technical universities, the various types of Gymnasien found in the three

countries, the engineering colleges, and other special purpose institutions that provided high school programs for adults.¹

Plan of the Study

Chapter II includes a survey of the pertinent literature related to physics instruction in German speaking Europe as found in both foreign and United States publications.

The procedure and methodology used in conducting the study and in obtaining the data are presented in Chapter III.

Chapters IV, V, and VI present the findings of the study as derived from the observations made and the data extracted from the questionnaires. There were some fifteen major questionnaire topics,² many of which had several subparts. Not all of the data collected from this broad range of questionnaire topics can be regarded as pertinent to this study, and thus is not included in this report. Those major characteristics which were singled out for comparison come under the general headings of Students, Curriculum, and Evaluation. Within each of these major divisions, the educational institutions from each of the three

¹A glossary of terms relating to the educational programs of German speaking Europe is found in Appendix A.

²The complete questionnaire is included in Appendix B.

countries were analyzed and compared to Jackson Community College. This allowed for comparisons between corresponding institutions from the European countries and also allowed for the comparison of all European institutions with Jackson Community College.

A summary of the findings and conclusions is presented in Chapter VII along with suggestions for future research. A special attempt was made to identify those aspects of the European physics programs which would be of value to the Jackson Community College program.

CHAPTER II

REVIEW OF THE LITERATURE

The survey of current literature concerning the topic of physics instruction in German speaking Europe revealed a lack of information available in either English or German language books or periodicals. After a brief historical introduction, the literature pertaining to each of the respective countries will be presented separately.

Bolton¹ discussed the historical development of the German Gymnasium and related it to the Gymnasium in Switzerland and Austria. This turn-of-the-century picture described the pattern of Gymnasium types that are still present today in all three countries. He included many of the requirements for teaching in these schools. A certain amount of practice teaching was required of all teachers in Germany in 1897.² The physics program was spread over the last five years of

¹Frederick Elmer Bolton, The Secondary School System of Germany (New York: D. Appleton and Co., 1900), pp. 1-13.

²Ibid., p. 80.

the Gymnasium.¹ Bolton also concluded that the institution most closely comparable to the high school in the United States was the German Realschule.²

Holme³ offered some insight into the development of universities in the United States in relation to their German influences; but he also indicated the close relationship that existed prior to 1920 among the German speaking countries of Germany, Austria, and Switzerland regarding systems of education, even to specific subject areas such as physics. The scope and content of most programs was almost exactly identical.

West Germany

It is appropriate that while considering physics in the school programs of West Germany some background concerning the general school environment be cited. Because of the responsibility of the United States for education during the occupation following World War II, there is a good deal of information regarding the general school program of West Germany.

¹Ibid., pp. 251-52.

²Ibid., p. 355.

³E. R. Holme, The American University: An Australian View (Sydney, Australia: Angus and Robertson Ltd., 1920), pp. 8-18.

Pilgert¹ discussed the policies of the United States and their relationships to the reconstruction of the West German school system following World War II.

Prange and Lindegren² presented the curriculum and subjects carried by students in the elementary and secondary schools according to the type of school and the age of students enrolled for a number of West German states. Their data reflected the situation in 1954, a period of intense United States interest during the occupation. In 1954 the elementary school consisted of only eight years. (In 1969 it was nine.)

McKay³ described the extreme change in German schools immediately following World War II. He pointed out that the schools appeared to change markedly between 1932 and the end of the war. McKay further pointed out that in the years since World War II the school program had reverted to its 1932 status.

¹Henry P. Pilgert, The West German Educational System (Historical Division, Office of the Executive Secretary, Office of the U.S. High Commissioner for Germany, 1953).

²U.S., Department of Health, Education, and Welfare, Office of Education, Division of International Education, "Education in the German Federal Republic," Studies in Comparative Education (Washington, D.C.: Government Printing Office, November, 1954).

³Llewelyn R. McKay, "The 'New Look' in West German Schools," History of Education Journal, VII (Summer, 1956), 144-51.

A more recent document was a bulletin of the United States Department of Health, Education, and Welfare--Office of Education¹ which described in a rather comprehensive fashion the school programs in West Germany from pre-elementary through the university level as of 1959. This document described in particular detail the requirements for the various types of certificates and degrees. It also indicated where physics was a part of the more general program.

Wenke² discussed the specific objectives of the various schools in West Germany, and this presentation allowed a much clearer classification of institution by objectives. It was interesting to note that there were no comprehensive institutions at the elementary and secondary levels; and that according to their objectives, most existing institutions had only one specific purpose.

Although beyond the scope of this study, it was of interest to note the contrasting situation in East

¹U.S., Department of Health, Education, and Welfare, Office of Education, Educational Data: Federal Republic of Germany, Information on Education Around the World, Pubn. 35 (November, 1959).

²Hans Wenke, Education in Western Germany; a Post-War Survey (Washington, D.C.: Library of Congress, Reference Department, European Affairs Division, 1953), pp. 48-63.

Germany as described by Smart¹ where it is indicated that there had been a serious attempt to develop comprehensive school programs to include more of the masses and not to become as selective at the secondary level as was the case in West Germany. The East German school program had taken many of its elements from the program in the United States, according to this author.

Hirlekar² gave an outsider's impression of West German education. He was particularly shocked to find that only 19 per cent of the West German youngsters began the Gymnasium with the other 81 per cent remaining in the elementary school. Another point for those who wish to compare the Gymnasium with the high school in the United States was the fact that less than 4 per cent of the West German nineteen- and twenty-year-olds finished the Gymnasium and successfully passed the comprehensive examination, the Abitur.³

¹K. F. Smart, "Education in East Germany," Educational Forum, XXV (May, 1961), 463-71.

²Yamunabai Hirlekar, Education in Germany: Personal Impressions and Experiences (Bombay, India: Popular Book Depot, 1955).

³Ibid., p. 40-43.

Lindegren¹ presented yet another look at the entire spectrum of West German education from pre-elementary to university with comments on specific subject areas such as physics and mathematics. The book contained a good deal of historical material and showed how the current school pattern was really a return to the routine of the 1920's.

Hylla and Kegel² discussed yet another post-World War II phenomenon, the influence on education of the great influx of refugees from East Germany during the years 1945-1957. They were primarily Protestant from industrial centers in East Germany and were quite a contrast with the rural Catholics of the Bavarian South. The book also contained a discussion of the teaching of physics in the elementary grades.³

Blättner⁴ presented a comparison of the Gymnasium of West Germany with the high schools and universities of

¹U.S., Department of Health, Education, and Welfare, Germany Revisited; Education in the Federal Republic (Washington, D.C.: Government Printing Office, 1957).

²Erich J. Hylla and Friedrich O. Kegel, Education in Germany; An Introduction for Foreigners (2nd ed.; Frankfurt on Main, West Germany: Hochschule für Internationale Pädagogische Forschung, 1958), p. 11.

³Ibid., p. 61.

⁴Fritz Blättner, Das Gymnasium; Aufgaben der Höheren Schule in Geschichte und Gegenwart (Heidelberg, West Germany: Quelle und Meyer, 1960), pp. 443-46.

the United States from a German point of view and made a strong argument that the German Gymnasium system of education was superior to the educational program of the United States.

Huebner¹ wrote of the general characteristics of West German education in the late 1950's and also presented an impressive array of statistical data on a variety of school programs for the various states of West Germany. The book showed the relative enrollments as a function of time for the time period from 1945 to 1960.²

Arlt³ discussed a facet of education unique to West Germany, the Kolleg. This "second way" to the Abitur, without attending the Gymnasium, allowed an avenue for university admission to those who had been unable to participate in the long nine-year Gymnasium program.

The state of North Rhine-Westphalia published an annual report to the people of that state in the form of

¹Theodore Huebner, The Schools of West Germany: A Study of German Elementary and Secondary Schools (New York: New York University Press, 1962).

²Ibid., pp. 52-53.

³Fritz Arlt, Der Zweite Bildungsweg (Munich, West Germany: Isar Verlag, 1958).

a book by the Ministry of Culture.¹ It discussed the role of the Kolleg in the total scheme of education and how the physics curriculum in the Kolleg was comparable to that found in the last three years in a Gymnasium.² The fact that all educational programs within North Rhine-Westphalia were under the control of the state was illustrated in this document.

Whiting³ pointed out yet another pressure on almost all of the elementary and secondary school programs in West Germany. This pressure was brought about by the various church denominations. This situation became quite complex since the church groups were intimately involved with the political parties and the churches were financed by public taxes. Added to this was the fact that many schools financed primarily by public funds were directly operated by churches. Bavaria seemed to have the most complicated relationship involving the Catholic church, the political climate, and public funds, with both clerical and lay faculty teaching in public and private schools.

¹Bildungswege an den Schulen des Landes Nordrhein-Westfalen (Rottingen, West Germany: A. Henn Verlag, 1964).

²Ibid., p. 22.

³Charles H. Whiting, "Religion and Politics in German Schools," Educational Forum, XXXII (November, 1967), 93-96.

Bavaria has been moving in a direction that tends to simplify the situation somewhat. The relationship between the church and the schools is not quite as direct as once was the case.¹

Warren² outlined the system of technical education in West Germany, the highest level of general technical instruction being found at the Polytechnikum, or engineering college. The Technische Hochschulen, or technical universities, prepared engineers with a more scientific and research orientation and were more rigorous than the Polytechnickum.

The best information related to specific West German educational institutions was found in the catalogs of the respective institutions. These are listed in the Bibliography.

An excellent compilation of West German school statistics was found in the series of pamphlets published

¹Bayerischen Staatsministerium für Unterricht und Kultur, Schulordnung und Ausführungsbestimmungen für die Gymnasien in Bayern 1968 (Munich, West Germany: Franz X. Seitz und Val. Höfling, 1969).

²Hugh Warren, Vocational and Technical Education: A Comparative Study of Present Practice and Future Trends in Ten Countries (Paris: United Nations, Educational, Scientific, and Cultural Organization, 1967), pp. 112-14.

annually by the Statistisches Bundesamt, Wiesbaden.¹ The most recent publication date was for the year 1967 and contained the student populations for various school levels in all the types of elementary and secondary schools for all eleven West German states.

Another recent publication of extremely high quality that related to the entire West German educational scene has been written by Knoll.² The booklet concentrated on recent trends in higher education as found in the universities and advanced technical schools.

The book that is most highly recommended to those interested in West German education by the Bonn educational office has been written by Schultze and Führ.³ This volume contained descriptions of all the educational enterprises by state and by type including the statements of philosophical objectives for each. A wealth of recent statistical information was presented as well.

¹Statistisches Bundesamt, Wiesbaden, Bevölkerung und Kultur, Fach-Serie A, Allegemeinbildende Schulen 1967 (Stuttgart und Mainz, West Germany: W. K. Kohlhammer GmbH, 1969).

²Joachim H. Knoll, The German Educational System (Bad Godesberg, West Germany: Inter Nationes, 1967).

³Walter Schultze and Christoph Führ, Schools in the Federal Republic of Germany (Weinheim, West Germany: Verlag Julius Beltz, 1967).

The Council for Cultural Cooperation in Strasbourg, France, has published a series of descriptions of school systems for each of the European countries.¹ The beauty of the presentations was that the same format was used for all countries, and this allowed comparisons of program to be made much more easily.

To appreciate fully the place that science, and particularly physics, has at the university level requires that one investigate the source of funds for research and instructional programs. There are a number of large West German business and industrial firms that generously support science programs. One of these is the Volkswagen Foundation.² Without the support of such firms it would appear that the physics programs at the university level could suffer greatly.

A general picture of physical research activities along with the source of funds for these activities was presented in the 1959 edition of Deutsche Forschungs

¹School Systems, A Guide: Federal Republic of Germany (Strasbourg, France: Council for Cultural Cooperation, 1965).

²Bericht 1967: Stiftung Volkswagen zur Förderung von Wissenschaft und Technik in Forschung und Lehre (Göttingen, West Germany: Vandenhoeck und Ruprecht, 1968).

Gemeinschaft.¹ Although somewhat dated, it was the most recent compilation of such collected information.

Although there has not been too much interest in West German physics instruction as evidenced by the United States journals, Sears² has written of a European conference held in Paris in 1960, sponsored by UNESCO to appraise the status of physics instruction at the secondary level. This same conference has been described by several other authors.

Buchta³ was one of these authors; and he concluded that the European physics educators, including West German, had the same problems as their counterparts in the United States, and that one of the tasks was to make physics more relevant to the world today so that the subject would be more appealing to a greater segment of the student population. Other conclusions reached included raising physics teacher salaries, having only physicists teach physics, and encouraging universities to keep in touch with secondary schools.

¹Deutsche Forschungs Gemeinschaft: Aufbau und Aufgaben (Wiesbaden, West Germany: Franz Steiner Verlag GmbH, 1959).

²Francis W. Sears, "International Conference in Physics Education," American Journal of Physics, XXIX (March, 1961), 151-60.

³J. W. Buchta, "Physics Education: An Account of the Paris Conference," Physics Today, XIV (January, 1961), 28-29.

Fox¹ also wrote on the 1960 Paris Conference from the point of view of the European physicist. Fox chaired one of the panels which was charged with making recommendations for a new European secondary level physics sequence. He indicated that West Germany did not appear to be too sympathetic to such a new physics sequence.

Clarke² also wrote of this proposed new secondary school physics program and cited some of the problems that faced European physics such as teacher shortages, improper approach to the teaching of physics as a set of dull facts, poor laboratory facilities, and poor programming of examinations.

Wilkinson³ stated that in West Germany, the needs of the country took priority over the needs of the students. With this philosophy, it was easier to understand how a country would concentrate on a gifted few, with less concern about the quality of education for the vast majority of students. Wilkinson also noted that there seemed to be a greater respect for teachers and education in general in

¹F. W. Fox, "Physics for European Secondary Schools," Science Teacher, XXVIII (September, 1961) 15-19.

²Norman Clarke, "The Teaching of Physics in Schools," Physics Today, XIV (January, 1961), 30-38.

³Paul A. Wilkinson, "Science Education in Europe," Science Education, XLVIII (October, 1964), 340.

Europe. Wilkinson argued that there was value in taking what was good from the European program and adapting it to needs in the United States.¹

Another factor that had implications for physics instruction was the gradual return of West Germany to its own complete control of science activities.² France had supervised the West Germans in nuclear reactor research since there was, and is, great concern about the ability of West Germany to utilize such research for military purposes. This supervision was gradually being reduced, and there is now a sizable nuclear capability in West Germany. Such autonomy could stimulate the physics programs from top to bottom as this facet of research is opened up to the West German scientific community.

Abelson³ discussed this tremendous resurgence in West German technology and indicated some of the reasons that stimulated the activity. First, the West Germans spend little on defense budgets and could concentrate on non-military technology. In addition, they appear to be hard working; and their research was extremely well-coordinated.

¹Ibid., pp. 341-44.

²John Lambert, "Power and Politics," Science News, XCIV (November 2, 1968), 454.

³Philip H. Abelson, "German Technological Resurgence," Science, CLXV (July 25, 1969), 339.

Probably the most definitive article relating directly to West German physics instruction found in the United States literature was by Lüscher.¹ Dr. Lüscher is currently a professor at the Munich Technische Hochschule and has spent several years as a professor at the University of Illinois. This range of experience provided an excellent background for comparing the systems of physics instruction found in the two countries. Dr. Lüscher was also the President of the Bavarian Physics Society for 1969-70. (The results of several interviews with Dr. Lüscher are presented in Chapter IV.)

In the article Dr. Lüscher presented statistics showing the physics preparation of students in the Gymnasium prior to matriculation at the university level, typical courses of study for physics majors at the university level, and the places where graduating physicists found employment. Dr. Lüscher also listed the types of programs in physics instruction available at all the West German universities. There was a discussion of the typical background of students entering university level physics for West Germany and also for the United States. Dr. Lüscher felt that the West German system of education tended to overemphasize the humanities at the expense of the sciences and that the best students would not choose

¹Edgar Lüscher, "Physics in West Germany," Physics Today, XIX (August, 1966), 46-54.

science as a vocation. He further stated that he felt the educational situation in the United States had a better balance between the humanities and the sciences. He said further that this was more conducive to good science education and stimulated the better students to enter scientific and technical vocations.

Austria

Much of the Austrian mode of school operations could have come from the general German influence that prevailed over both countries, going back to the Hapsburg monarchy and the common language bond even before Hitler took over Austria in 1938.

Dottrens¹ documented some of the more recent history of Austrian education during the difficult time between the two world wars. He felt that in spite of the problems, Austria, especially in the city of Vienna, was far ahead of other European countries that he visited during 1926-27.

An excellent description of more recent Austrian school programs was found in a UNESCO publication of 1966.² This account detailed typical curricula for elementary

¹Robert Dottrens, The New Education in Austria (New York: John Day Company, 1930), p. 2.

²United Nations, Educational, Scientific, and Cultural Organization, World Survey of Education: IV, Higher Education (Paris: UNESCO, 1966), pp. 190-201.

and secondary schools according to school type and also presented statistics concerning enrollments.

Another comprehensive discussion of secondary school programs in Austria was found in a book by von Klemperer.¹ A great many statistics on school enrollments were cited for the academic year 1959-60.

The School Reorganization Act of 1962² was one of the most significant events in Austrian school history. Although all of the titles have not yet been implemented, the complete act provided for a sweeping reformation of the entire school system. One of the titles provided for the extension of the Gymnasium from eight years to nine years.

The actual description of the types of schools authorized under the 1962 Act with the syllabi for each course was found in the Bundesgesetzblatt für die Republik Österreich.³ As an example, under the subject area

¹Lily von Klemperer, A Survey of Austrian Education and Guide to the Academic Placement of Students from Austria in Educational Institutions in the United States of America (New York: World Education Series, 1961).

²Federal Ministry of Education, Austria, School Organization Act 1962 (Vienna, Austria: Austrian Federal Press, 1965).

³Bundesgesetzblatt für die Republik Österreich (Vienna, Austria: Österreichische Staatsdruckerei, August 24, 1967), pp. 1,705-1,866.

Physik¹ in the second class of the Gymnasium the class would meet two class hours per week, and during that year the following topics would be covered under the introduction: measurement of length, area, volume, weight, mass, and time. Next the structure of material is introduced with molecules, atoms, and compounds. This continued with another five major topics and some forty subtitles. This detail in the syllabi was carried out in all subject areas for each school level. The conception of local control appeared to be present in Austria only with regard to a few types of specialized vocational schools.

The Council for Cultural Cooperation² has published a review of Austrian education similar to that cited earlier for West Germany. The document on Austria contained a significant amount of statistical data regarding student enrollments in various types of schools for the years 1960-1965. In addition, it cited the percentage of a particular age group enrolled by school types. This assisted in getting an accurate picture of the relationship of various schools to the total youth population.

¹Ibid., p. 1,811.

²School Systems, A Guide: Austria (Strasbourg, France: Council for Cultural Cooperation, 1965).

Goldfarb¹ has written one of the very few descriptions of Austrian physics education. It began with a general description of the Austrian school program and then took up physics instruction as it was found in the various types of Gymnasien. There was a short discussion of physics programs at the university level and on the qualifications of physics instructors at both university and Gymnasium level.

Specific physics programs were found in the catalogs of a number of the Austrian schools. These catalogs are listed in the Bibliography.

Switzerland

Probably the most provocative discussion of Swiss education versus education in the United States has been written by Admiral Rickover.² His basic hypothesis was that the average Gymnasium graduate in Switzerland had received a better education and was academically superior to recipients of the bachelor's degree in the United States. The book included a variety of data to support this argument. Disregarding the more controversial aspects of the book, it should be noted that his

¹Albert M. Goldfarb, "On the Education of Physicists in Austria and Israel," American Journal of Physics, XXIX (March, 1961), 161-67.

²Hyman George Rickover, Swiss Schools and Ours; Why Theirs Are Better (Boston: Little, Brown, and Co., 1962).

discussion of the Gymnasium programs of German speaking Switzerland in the cities of Basel and Zurich was extremely lucid and complete. The appendices of the book contained complete syllabi, course descriptions, and program outlines for all types of Gymnasien found in German speaking Switzerland.

The German speaking population of Switzerland was dominant since it constituted 69.3 per cent of the total¹ and was concentrated in the northern and eastern regions of the country which bordered on West Germany and Austria.

UNESCO has compiled a good deal of statistical information regarding Swiss school programs, and included in one publication a discussion of physics and mathematics in the various types of secondary schools.²

Pro-Helvetia, the public relations arm of the Swiss Federal Republic, has published a number of small pamphlets and brochures describing various aspects of Swiss education that had physics instruction as a part of their total program. Two rather general pamphlets which

¹Hans Bauer, All About Switzerland (Zurich, Switzerland: Swiss National Tourist Office, 1968), p. 22.

²United Nations, Educational, Scientific, and Cultural Organization, World Survey of Education: IV, pp. 1,057-68.

gave a background to the total school spectrum were Swiss Schools¹ and Education in Switzerland.²

A number of organizations in Switzerland have become concerned about adult education and particularly the need for more mathematics and physics by mature members of the community. Schneebeli³ discussed this and indicated the trends in adult science education for the future.

The Swiss National Tourist Office has published a short document describing the universities of Switzerland.⁴ It gave an excellent overview of higher education in the entire country.

Again, the Council for Cultural Cooperation⁵ has published a summary of Swiss education with accompanying statistics. These documents on all three of the European

¹Eugene Egger, Swiss Schools (Zurich, Switzerland: Pro-Helvetia, 1967).

²Eugene Egger, Education in Switzerland (Zurich, Switzerland: Pro-Helvetia, 1968).

³Robert Schneebeli, Adult Education in Switzerland (Zurich, Switzerland: Pro-Helvetia, 1968).

⁴Central Office of the Swiss Universities, Swiss Universities (Berne, Switzerland: Swiss National Tourist Office, 1967).

⁵School Systems, A Guide: Switzerland (Strasbourg, France: Council for Cultural Cooperation, 1965).

countries of interest provided most accurate bases for comparison of programs.

Catalogs of the various Swiss universities and technical schools were of value and are listed in the Bibliography.

The literature pertinent to Jackson Community College consisted of the most recent catalog¹ and the statistics relating to student characteristics which were a combination of reports from the American College Testing Service and the Registrar of Jackson Community College.

The literature cited in this chapter has been presented according to country, and within each country an attempt has been made to cite literature of a general nature and then to focus on the specific area of physics instruction.

¹Jackson Community College Catalog, 1968-70 (Jackson, Mich.: Jackson Printing Co., 1968).

CHAPTER III

PROCEDURE AND METHODOLOGY

The time period from January 21, 1969, to May 15, 1969, was spent visiting educational institutions, ministries of education, and related enterprises in the three countries of West Germany, Austria, and German speaking Switzerland. The geographical locations of the cities in the three countries visited were within a circle of 150 miles radius with Munich, West Germany, at the center. The only city outside this circle was Vienna, Austria, which was located approximately 250 miles east of Munich.

Prior to leaving for Europe, letters had been written to a number of European universities requesting an opportunity to visit their institutions. Enclosed with each request was a letter of introduction written by Dr. Stanley Ballard, Chairman of the Physics Department at the University of Florida. Dr. Ballard was also President of the American Association of Physics Teachers for 1968-69. Dr. Ballard's letter proved to be most helpful in establishing rapport with the European physics community.

Although a European itinerary was carefully planned before leaving the United States, there were considerable deviations made in the final execution as the result of suggestions and recommendations made by various European educators during the planned visitation program.

The formality of contacting the appropriate ministries of education in the countries visited was followed rigorously. Many of the educators in the Gymnasien felt that the Ministry should be informed prior to any visit to their school. Not only did the visits to the ministries follow protocol, but ministry representatives were most helpful in suggesting educational institutions for possible investigation and gave general approval to the study being conducted.

To gather the necessary data, a total of fifteen educational institutions and two ministries of education were visited in West Germany. Ten educational institutions and three ministries of education in Austria were visited. In German speaking Switzerland there were visitations at five educational institutions and at the Zurich office of Pro-Helvetia.¹ Table 1 indicates the various components which contributed to the study. Staff members at each of the various institutions were subjected to a comprehensive questionnaire to gather data that was of

¹Pro-Helvetia is the public information arm of the Swiss Federal Government.

TABLE 1.--Components Which Contributed to the Study

Country	Type of Institution	Number of Institutions Visited	Number of Staff Interviewed	Number of Students Interviewed
West Germany ^a	<u>Gymnasium</u>	5	16	12
	<u>University</u>	3	10	5
	<u>Pädagogische Hochschule</u>	1	3	3
	<u>Polytechnikum</u>	1	3	2
	<u>Kolleg</u>	4	9	11
	<u>Berufsschule</u>	1	2	1
	<u>Education Ministry</u>	2	4	0
	<u>Gymnasium</u>	6	15	9
	<u>University</u>	2	3	3
	<u>Höhere Lehranstalt</u>	2	6	4
Austria	<u>Education Ministry</u>	3	6	0
	<u>Gymnasium</u>	2	5	5
	<u>University</u>	2	4	4
	<u>Technikum</u>	1	3	2
Switzerland	<u>Pro-Helvetia</u>	1	3	0

^aIt should be noted that educational institutions visited in West Germany all were in the state of Bavaria. There was some concern about whether Bavarian education was typical of all West Germany. The federal officials in Bonn confirmed that the educational structure and program in Bavaria were quite typical of the entire country.

value in the comparisons made. It was possible to spend considerable time at most of the institutions talking with administrators and staff plus making observations, visiting classes, and speaking to students in addition to using the questionnaire.

The procedure that evolved in most cases began with a letter to the institution of interest stating the nature of the study being conducted and indicating the approval of the Ministry of Culture. The letter of introduction from Dr. Ballard, previously mentioned, was included with the credentials of the investigator. This letter usually stimulated a response extending an invitation to visit the school. A phone call was then made confirming a date and time. The first meeting with most of the schools was with the chief executive or one of his administrators. The initial meeting often included a professor of English in case some translation assistance proved necessary. There were few problems; and interviews were conducted in English or German, with a mixture sometimes being used. Typically, the physics staff was called in later in the day; and a discussion then took place in the presence of the chief executive. A tour of the entire school facility followed, and this process usually concluded the first day.

This initial visitation was followed within a day or two by another visit to speak with the physics staff

individually, to sit in on various physics classes, to observe the lectures, and to talk informally with students. On several occasions a return visit included a lecture by the investigator to a student class on some topic in physics or more often to discuss higher education in the United States with particular reference to the junior college. Such lectures included ample time for questions and answers and proved to be an excellent place to prove student feelings on a variety of educational topics.

The types of institutions visited in all three countries included various types of Gymnasien, engineering colleges, general universities, technical universities, teacher training institutions, and schools for remedial education for adults. All of these schools had programs of physics instruction.

The questionnaire allowed the gathering of a variety of information. Principle questionnaire headings included:

- A. Basic data on institution
- B. Interviewees
- C. General descriptive data on students and school calendar
- D. Institutional objectives
- E. Relationship of school to environment
- F. Teaching staff
- G. Student input
- H. Completion data
- I. Curriculum
- J. Pedagogical techniques
- K. Evaluation
- L. Mathematics related to physics programs
- M. Key physical principles--when and where introduced

- N. Look to the future
- O. General comments based upon observations.

This same questionnaire was completed for Jackson Community College and thus served as the basis for comparisons. After consideration of the questionnaire results, it was decided to structure the presentation of the findings of the study in a manner somewhat different from the order in which the data were taken. Thus the major topic regarding Students in Chapter IV combines findings from questionnaire items C, E, G, and H. The second major topic, Curriculum, in Chapter V, combines data from questionnaire items I, J, L, and M. The final major topic, Evaluation, found in Chapter VI, includes the data from questionnaire item K. Thus, not all of the data collected with the questionnaire are included in the findings of the study. Complete data from items A, B, D, F, N, and O are not presented in the study; but some reference to this information is cited where appropriate in the discussion of the three major topics in Chapters IV, V, and VI.

There was some concern about being able to establish comparability between Jackson Community College and existing European educational institutions. Thus it was decided to concentrate on those institutions that appeared to have similar objectives to those of Jackson Community College. Thus the Gymnasien and universities were to be

compared to the college preparatory and college-parallel function of the junior college, the engineering colleges to the terminal-technical programs of the junior college, and the Kollege to the adult and continuing education role of the junior college. Although this was the original plan, there were no hard and fast preconceptions made concerning the objectives of European educational institutions that could have interfered with other kinds of comparisons.

To further assist in establishing this comparability, it was decided to investigate a student age span in Europe well below to well beyond the average junior college age span of eighteen to twenty-two years.

CHAPTER IV

FINDINGS OF THE STUDY--STUDENTS

The findings concerning students enrolled in various physics curricula in European institutions and Jackson Community College are presented in this chapter. A brief description of each educational institution, including its type and size is given along with the sex ratio of the students enrolled, daily and weekly student schedules, the annual school calendar, the admission process, and the socio-economic backgrounds of the students. Student vocational aspirations and the percentage of students who successfully complete the different programs are also discussed. The same format is used to describe West German students enrolled at the Gymnasien, the universities, the Polytechnikum, and the Kollege. A similar presentation is made for Austrian students enrolled at the Gymnasien, the universities, and the Höhere Lehranstalten. The presentation of information on the students in Switzerland includes those from the Gymnasien, the universities, and the Technikum. The final section in this chapter discusses the physics students at Jackson Community College.

In each institution, only those students taking physics will be included in the findings. The discussion may still be generalized, however, since all of the students in the Gymnasien of West Germany, Austria, and Switzerland take several years of physics. All students of the West German Kolleg take physics, as well as all students of the West German Polytechnikum, the Austrian Höhere Lehranstalt, and the Swiss Technikum. Not all university students in any of the countries take physics; so only those students taking physics during the early years of their university preparation are included. Schedules and calendars are also common to the physics students and others in any given place.

Students--West German Gymnasium

The Gymnasien visited in West Germany included the Christoph Scheiner Gymnasium at Ingolstadt, a mathematics and science Gymnasium for boys; the Maria-Theresia Gymnasium at Munich, which was also a science and mathematics Gymnasium for boys; the Katharinen Gymnasium at Ingolstadt, which was a combination modern language and social science Gymnasium for girls; the Gabriele Gymnasium at Eichstätt, a fine arts Gymnasium for boys and girls; and the Reuchlin Gymnasium at Ingolstadt, which was a combination classical and modern language Gymnasium for boys and girls. Enrollments varied widely. Scheiner had 1,070 total students and included only 45 girls. Maria Theresia

had 980 students, all boys; while Katharinen had 750 girls and no boys. Gabriele had a total of 410 students, 140 girls and 270 boys. Reuchlin had 710 students with 568 boys and 142 girls. This sampling was hardly adequate to permit one to generalize on the male versus female enrollments in West German Gymnasien, but one gained the impression that boys outnumbered girls by a wide margin. The 1967 statistics for West Germany confirmed this emphasis on Gymnasium education for boys, showing more than two boys enrolled for every girl.¹

The interview with Oberstudiendirektor Heinz Friedberger² of the Katharinen Gymnasium in Ingolstadt was quite revealing concerning student enrollments in West Germany. He supported the observation that a Gymnasium education for a girl was regarded as the exception rather than the rule, but that more and more girls were coming to the Gymnasium, attracted primarily to the social science and modern language offerings in many of the Gymnasien. He also cited some Bavarian statistics on Gymnasien that indicated the relative popularity of the

¹Statistisches Bundesamt, Wiesbaden, Bevölkerung und Kultur, Fach-Serie A, Allgemeinbildende Schulen 1967 (Stuttgart and Mainz: W. K. Kohlhammer GmbH, 1969), p. 8.

²Interview, Heinz Friedberger, Director of the Katharinen Gymnasium, Ingolstadt, West Germany, on February 4, 1969.

various types of schools. Thirty years ago there were only two types of Gymnasien, the classical schools and the mathematics and science schools; and the classical schools were the more common. In Bavaria during 1969 there were 102 classical Gymnasien and 156 mathematics and science Gymnasien. The bigger change, however, was revealed by the fact that there were 222 modern language Gymnasien and 37 social science Gymnasien in addition to the two older types. Furthermore, the evidence indicates that the newer Gymnasien were increasing in numbers every year at the expense of the classical Gymnasien, which were rapidly fading to relative obscurity.

The daily schedule followed by the students in all the West German Gymnasien visited was very similar. School met from eight in the morning through one in the afternoon with a twenty-minute break some time in the forenoon, usually about ten-thirty. Classes met for approximately forty-five minutes with five minutes between classes. School was in session six days per week, Monday through Saturday. Many students returned to the Gymnasien in the late afternoon to participate in such elective subjects as art, music, and an extra foreign language. This meant that students were enrolled for twenty-five to thirty-five class contact hours per week. In the first three years of study the load was usually twenty-eight to thirty contact hours. During the next three years this load peaked

at thirty to thirty-five contact hours. In the final three years, the load dropped back to about twenty-five contact hours. Any student who took extra electives had the above loads plus the elective subjects. It was not unusual for a student in his fourth, fifth, or sixth year of the Gymnasium to carry a total weekly load of thirty-five to forty contact hours.¹

The annual school calendar for Bavaria involved thirty-six to thirty-eight weeks of classes each academic year. The school year began in the fall; and it observed a Christmas vacation of several weeks, an Easter vacation of three weeks, and various other holidays, which left only a six-week vacation in the summer.

Most students entered the nine-year West German Gymnasium at the conclusion of the fourth year of primary school. Thus, Gymnasium students ranged in age from ten to nineteen years. In May of the fourth year of primary school, the young student was required to take an examination at the Gymnasium where he or she wished to enroll. The examination was administered by the Gymnasium staff and consisted of a German language examination and a mathematics examination. If a student had not done as well as hoped, a follow-up oral examination was usually

¹Interview, Andreas Geier of the physics staff, Scheiner Gymnasium, Ingolstadt, West Germany, on January 31, 1969.

administered to determine qualifications for admission. It was interesting to note that although the West German Gymnasium was still regarded as a rather selective institution, all staff members interviewed concluded that about 90 per cent of the students who applied to the Gymnasien were admitted. The students admitted to the Gymnasium, however, constituted only about 20 per cent of all the students completing the fourth year of primary school.¹ The other 80 per cent continued on in the primary school or transferred to the Mittelschule, often called the Realschule. This 20 per cent figure was the same figure quoted by most West German teachers and school administrators as their estimate of the percentage of eligible students transferring to the Gymnasium at the end of the fourth school year.

The socio-economic backgrounds of the West German Gymnasium students appeared to be in part a function of the type of Gymnasium as well as a function of the location of the school. Seventy-five per cent of the students from Scheiner Gymnasium came from middle class families with very few rural farming families or urban professional families. For the most part, students at the mathematics and science Gymnasien came from families with parents who had not themselves attended Gymnasien.

¹Huebner, The Schools of West Germany, p. 55.

This contrasted with the situation at the classical Gymnasien. The great majority of the students attending the Reuchlin Gymnasium, Ingolstadt, came from professional families with Gymnasium backgrounds.¹ There was another student component at Reuchlin made up of students who were studying to enter the priesthood. For the most part these students came from the rural agricultural part of Bavaria.

One could generalize that the great majority of Gymnasium students came from middle and upper class families with both an increasing percentage and absolute number of students coming from lower, working, and rural agricultural classes. Many of the interviewees commented that twenty years ago the students who attended the Gymnasien were those who came almost exclusively from upper class families.

The educational aspirations of the Gymnasium students were virtually the same. The students planned to enroll in some type of post-Gymnasium education leading to one of the professions.

The vocational aspirations of the Gymnasium students varied with the school visited. At Gabriele in Eichstätt, most of the students planned to enter the field of elementary teaching. This training program

¹Interview, Heinz Modesto of the physics staff, Reuchlin Gymnasium, Ingolstadt, West Germany, on February 21, 1969.

required three years of schooling at a teacher training college, Pädagogische Hochschule, after completion of the Gymnasium program. Students at Scheiner Gymnasium were split among law, medicine, engineering, business; and about 25 per cent of the students planned to enter primary or secondary teaching. Maria-Theresia in Munich had a higher percentage of students interested in engineering as a career but still split almost equally among the professions of law, medicine, pharmacy, social work, and law. Reuchlin students had no predominant vocational preferences but did include the clergy, teaching, medicine, law, and business. A study of all Gymnasium students in Frankfurt, in the Land of Hesse,¹ showed that male students had the following vocational preferences: engineers, 25 per cent; Gymnasium teachers, 13 per cent; law, journalism and social work, 18 per cent; business and economics, 10 per cent; medicine and dentistry, 10 per cent; and the remaining 20 per cent split among elementary teaching, science, philosophy, and religion. This same survey for girls showed: undecided, 12 per cent; teaching, 43 per cent; medicine, chemistry, pharmacy, and related sciences, 18 per cent; non-academic vocations, 16 per cent; humanities, economics, and social work, about

¹"The Vocational Desires of Grammar School Learning," Education in Germany, IVd (February, 1964), 2-6.

10 per cent. This survey appeared to confirm what was observed during the Bavarian Gymnasium interviews.

One of the significant observations made in the Gymnasium studies related to the percentage of entering students who ultimately completed the full nine-year program. At all five Gymnasien visited, there was a general consensus that only 30 to 35 per cent of those students who entered successfully completed the nine-year program. Based upon the 20 per cent of the total student population initially enrolled in Gymnasien, this 30 per cent success figure would suggest that approximately 6 to 7 per cent of the total age group successfully completed the Gymnasium program. This 6 to 7 per cent estimate compared most favorably with the combined West German statistics, which for the years 1963 and 1964 showed that 7.2 per cent of the young people at the age of nineteen to twenty years had successfully completed the Gymnasium program. Of those who finished, only 27.9 per cent were girls.¹ Another area of consensus among Gymnasium officials concerned the percentage of their graduates who continued on to some type of higher education, either at a university or at one of the forms of Hochschule. All five Gymnasien indicated that between 90 and 95 per cent of their graduates continued their educations at some institution. Again,

¹"West German School Statistics," Education in Germany, IV (April, 1965), 21.

it is well to remember that even though the previous discussion related to general Gymnasium student population, this also applied to the students who took physics since all West German Gymnasium students were enrolled in several years of physics classes.

Students--West German University

The institutions of higher education visited included the University of Munich and the Munich Technische Hochschule, both located in Munich. Another university visited was the University of Erlangen-Nuremberg at Erlangen. The fourth institution visited was an elementary teacher training college, the Pädagogische Hochschule at Eichstätt. The University of Munich and the University of Erlangen were very similar in terms of objectives and student population. Only those students enrolled in their first physics programs were investigated to any extent. At Erlangen, with a total student enrollment of 9,257 for academic 1968-69, 548 were enrolled in the various beginning physics sequences. This last number included science and mathematics students in addition to the beginning medical, dental, and pharmacy students. More than 90 per cent of the physics students were male. Most of the females enrolled in physics courses were studying medicine. Similarly at the University of Munich, of a total student enrollment of 24,300 for 1968-69, 1,175 students were

enrolled in the first physics sequences. More than 90 per cent of this group were male students. At the Munich Technische Hochschule, of a total student enrollment of approximately 8,000 students in 1968-69, some 2,000 were enrolled in the first physics sequences. This unusually high percentage was due to the fact that all of the students at the Technische Hochschule were in some applied science program, and beginning physics was a required part of all such curricula. Although there were no statistics available, Professor Lüscher estimated that less than 5 per cent of the physics students were female.¹ The Pädagogische Hochschule at Eichstätt had a total student enrollment of 350 with almost exactly the same number of males and females. Each year about thirty-five of the students took a combination chemistry-physics sequence which taught a review of Gymnasium physics coupled with a discussion of teaching methods for elementary school science. The physics students were approximately half males and half females. From the number of male students enrolled in an elementary teacher training school, one might expect that a higher percentage of West German elementary school teachers were male than in the United States.

Classes at all four of the institutions of higher education ran from 8:00 A.M. to 5:00 P.M. Monday through

¹Interview, Edgar Lüscher of the physics department, Munich Technische Hochschule, Munich, West Germany, on April 25, 1969.

Friday with students attending only those classes in their respective curricula, much the same as students in American colleges and universities. There was no compulsory class attendance, and all students had a good deal of freedom. This was in great contrast to the highly structured Gymnasium program these students had just completed. Both the University of Munich and the Munich Technische Hochschule had classes scheduled on Saturdays because of the crowded classroom situation. There were, however, no beginning physics classes scheduled on Saturday at any of the institutions. The average class load of the physics students varied from the twelve to twenty contact hours per week carried by the students at the Pädagogische Hochschule to the twenty-five contact hour loads carried by students at the Universities of Munich and Erlangen. Even heavier loads were carried by the students at the Munich Technische Hochschule, where beginning students carried from twenty-five to thirty contact hours per week. The annual school calendar of the West German institutions of higher education consisted of approximately thirty to thirty-two weeks of classes which were spread uniformly throughout the calendar year. The first, or winter, semester began November 1, included a two-week Christmas vacation, and ended approximately

February 15. The second, or summer, semester began between April 15 and May 1 and continued into July.¹

The admission criterion for all institutions of higher education in West Germany was the same. If a student had successfully completed the Gymnasium program,² he was eligible to be admitted to any university or Hochschule in the country. Thus, the students under consideration here ranged in age from nineteen to twenty-two.

Students without the Abitur were not admitted. There were a very few exceptions to this rule in the Hochschulen and then only in a few special curricula. The medical schools also had several variations on this basic Abitur requirement. A student who applied to a medical program was not necessarily admitted to the program because of the shortage of medical training facilities. A medical school applicant also must have taken Latin in the Gymnasium and have passed a written examination in the subject as a part of the Abitur requirement. If a student were not immediately admitted to a medical school, he could enroll in the university and transfer to the medical school as space opened or even change universities

¹The University of Erlangen began and ended semesters at the ends of the months so that students renting private rooms were not penalized by paying for facilities when they were not in school.

²In West Germany completion is certified through a final comprehensive examination called the Abitur.

when and if an opening became available. This severe West German medical school enrollment problem was being articulated through a central clearing house located in Hamburg.

Professor Jakob Kranz¹ of the Physics Department at the University of Munich had some statistics to show that approximately 7 per cent of the University physics students had come from working class and farm homes and that the other 93 per cent came from families headed by civil servants, professional people, business owners and operators, and salaried employees. This ratio seemed to represent the situation at the University of Erlangen as well. Professor Lüscher indicated that approximately 10 per cent of the physics students at the Munich Technische Hochschule came from working class and farm homes, but that this figure was increasing year by year.² He said that most of their students were studying to be engineers, and that a significant number of these students came from working class families and from families headed by technical tradesmen and craftsmen. The socio-economic backgrounds of the students at the Pädagogische Hochschule

¹Interview, Jakob Kranz of the physics staff, University of Munich, Munich, West Germany, on March 13, 1969.

²Interview, Edgar Lüscher of the physics department, Munich Technische Hochschule, Munich, West Germany, on April 25, 1969.

at Eichstätt were essentially the same as at the universities with less than 10 per cent of the students coming from blue collar and rural families, and the rest of the students from middle and upper class families.¹

The vocational aspirations of the physics students were primarily a function of the institutions they were attending. At the Pädagogische Hochschule, all of the students were completing a three-year program leading to the state elementary teaching license. At the Technische Hochschule there were some 700 undergraduate and graduate students in applied physics with approximately 150 of these in the beginning physics sequences. The remaining 1,850 beginning physics students were primarily in engineering; and some students were in applied mathematics, chemistry, and geology. At the University of Munich with 1,175 beginning physics students, Professor Jakob Kranz reported the following breakdown:² 47 per cent were in the medical school, 13 per cent in the dental school, 8 per cent in the school of chemistry, 8 per cent in the school of pharmacy, and 6 per cent in biology and geography. The remaining 200 students or 17 per cent were

¹Interview, Otto Schön, Assistant Director, Pädagogische Hochschule, Eichstätt, West Germany, on February 12, 1969.

²Interview, Jakob Kranz of the physics staff, University of Munich, Munich, West Germany, on March 13, 1969.

majoring in physics and mathematics with something over half of this group preparing to teach physics and mathematics in the Gymnasien and Realschulen. At the University of Erlangen, Professor Rudolph Fleischmann reported the breakdown of the 528 beginning physics students as follows:¹ slightly more than 39 per cent were in the medical and dental schools, 12 per cent in a newly instituted engineering program, 21 per cent preparing for mathematics and science teaching in the Gymnasien and Realschulen, over 14 per cent majoring in mathematics, and the remaining 12 per cent majoring in physics but not intending to teach the subject.

There was some difficulty defining what constituted completion since only the beginning physics was being considered at the university level institutions. At the Pädagogische Hochschule at Eichstätt, between 90 and 92 per cent of the students who began successfully completed the full three-year elementary teacher preparation program. This meant that virtually all of the students had to be successful in their physics classes, which were a required part of their curriculum. Professor Lüscher at the Munich Technische Hochschule indicated that their records were incomplete, but he estimated that

¹Interview, Rudolf Fleischmann of the physics staff, University of Erlangen, Erlangen, West Germany, on May 7, 1969.

approximately 70 per cent were still there for the second year of the university. He did state that of those who were continuing studies in physics beyond the first year, approximately 75 per cent continued to successfully complete the Diplom degree in four and one-half to six years. This meant that something in excess of 50 per cent of the beginning physics majors completed the lowest earned degree from the University of Munich. At the University of Erlangen, Professor Fleischmann indicated that approximately 45 per cent of the first year physics majors received the Diplom degree in physics, taking an average of five and one-half to six years to complete the requirements. He estimated that approximately 70 per cent of all students taking the first year physics completed the sequence, but he had no data on medical and dental students and their record of success after leaving his department.

Students--West German Polytechnikum

The next type of West German institution to be discussed is the Polytechnikum, or engineering college. The specific institution visited was the Oskar-von-Miller Polytechnikum located in Munich. It had an enrollment of 4,000 male students and operated on a two-shift basis to accommodate this number of students. The first shift operated from 8:00 A.M. to 12:00 M., and the second shift went from 1:00 P.M. to 5:00 P.M. The usual schedule

included Monday through Friday classes, but occasionally there were Saturday classes for all students. The school calendar year was the same as other Bavarian institutions of higher education with about thirty weeks of classes divided into two fifteen-week semesters. The student contact hour load was dependent to some extent on his curriculum, but usually a student had from eighteen to twenty contact hours of classes each week.

The admission criteria to the Polytechnikum varied considerably from a university or Hochschule. Although a student with a Gymnasium Abitur was eligible for admission, very few such students applied. The typical background of over 90 per cent of the applicants was completion of the Realschule.¹ The student had to be at least nineteen years old and had to have acquired a minimum of two years of practical experience in some related trade or have served an apprenticeship in one of the various trades prior to application. The student then took a written examination which covered the areas German, English, technical drafting, mathematics, and physics. Of the 1,500 to 2,000 students who applied each year, only 1,000 were admitted to regular programs. Some

¹The typical Realschule graduate had four years of elementary school and then six years of secondary school. The student was usually about sixteen years old at completion.

of those rejected were allowed to enroll in remedial programs to qualify for admission at a later time.¹

Most of the students came from working class families and lower middle class homes. Many of the heads of the families were skilled tradesmen who had completed a primary school education plus an apprenticeship program. Very few of the students came from the homes of professional families, civil servants, business owners, or salaried employees.

The students were interested in completing the three-year program and receiving the engineering certification license from the Land of Bavaria. An occasional student transferred to a Technische Hochschule after receiving the engineering certificate, but he never acquired full admission status since he still did not possess the Abitur. He was allowed to take some courses in his area of professional interest; but he could not seek the Diplom degree without going back and successfully passing an Abitur examination.

The school director, Dr. Hammer, estimated that 55 to 60 per cent of all students who were admitted to the Oskar-von-Miller Polytechnikum successfully completed

¹Interview, K. Hammer, Director, and Anselm Vogel and F. W. Stanek of the physics staff, Oskar-von-Miller Polytechnikum, Munich, West Germany, on April 11, 1969.

their respective programs of study.¹ Physics was a part of all first-year curricula, and Dr. Vogel estimated that approximately 60 to 65 per cent of the beginning students completed this first physics sequence.² This did not mean that they had been successful, however, since there were no examinations given prior to the final examination for licensing. It simply meant that the student had decided to remain in school. The student was assumed to be very mature about his individual progress, a confidence that the staff and students felt was justified.

Students--West German Kolleg

The West German Kolleg represented a fairly new innovation in education. It dated back to the close of World War II. After the War, young people, aged eighteen to thirty, found themselves with only an elementary education or at most a middle school, Realschule, education. It was impossible for these young people to be admitted to a university without going back to the Gymnasium for a minimum of three, and often more, years to qualify to write the Abitur examination. Thus the Kolleg was created. Very often the Kolleg offered its program in

¹Interview, K. Hammer, Director of the Oskar-von-Miller Polytechnikum, Munich, West Germany, on April 11, 1969.

²Interview, Anselm Vogel of the physics staff, Oskar-von-Miller Polytechnikum, Munich, West Germany, on April 11, 1969.

the evenings so that students who were working could still qualify themselves for university admission. The Kolleg program was often referred to as the "second way," der zweite Weg, to university admission.

Three such Kollege were visited in the Land of Bavaria. One was the Bayern Kolleg at Augsburg, which was an institution operated by the Land of Bavaria and operated only during the day. It had 120 boys and 30 girls enrolled. It was a modern language Kolleg, that is, its program was patterned after the modern language Gymnasium. The second Kolleg was the Munich Kolleg, which was a city operated school. It too was a modern language Kolleg and enrolled 270 boys and 60 girls. It operated during the day. The third Kolleg was the Munich Abendkolleg, which was an evening school operated by the city of Munich. It enrolled 375 boys and 126 girls. It had programs in modern languages, economics, and also a mathematics and science program.

The daily schedule of the Augsburg Kolleg was from 8:00 A.M. to 1:00 P.M., Monday through Friday; and students attended classes three Saturday mornings each month. The Munich Kolleg met from 8:00 A.M. to 1:00 P.M. Monday through Thursdays and from 8:00 A.M. to 5:00 P.M. on Friday with no Saturday classes. Students in both of these day Kollege had weekly class loads of from thirty to thirty-five contact hours. The Munich Abendkolleg met

from 6:00 P.M. to 9:00 P.M., Monday through Friday, for a student in the first three years of its four-year program and from 3:30 P.M. to 7:30 P.M. for the student in the fourth and final year. The Abendkolleg was unique from the day Kollege in that it had a one-year remedial program plus the regular program, which was spread out over a full three-year period. The class load was twenty contact hours of classes each week. All three of these Kollege followed the same annual calendar as the Bavarian Gymnasien. There was a fourth Kolleg of a different type which was observed and studied. This was the Bavarian Telekolleg, which consisted of a series of television programs and weekly class meetings which were designed to allow a person with only an elementary education to complete the equivalent of a Realschule education in a period of three years. There were eighty-five students in the Ingolstadt area who were taking these classes and meeting every Saturday. All of the students were mature adults with sixty-three men and twenty-two women enrolled in the program. The students were enrolled in five different classes; and each evening, Monday through Friday, one of the subjects was presented in a one-half hour telecast. The broadcasts originated from Munich and utilized Gymnasium teachers and university professors as lecturers in the various subjects. On Saturday all the students met at Ingolstadt in one of the schools; and all five

broadcasts of the previous week were reviewed, one at a time, by Ingolstadt teachers who served as local teaching assistants. The Saturday schedule was from 8:00 A.M. to 1:00 P.M. with one hour for each subject. The annual calendar followed by this program was consistent with the regular Bavarian school schedule.

To be admitted to the Augsburg Kolleg or to the Munich Kolleg, a student had to be at least nineteen years old and possess at least the equivalent of a Realschule education. The age range of students was from nineteen to thirty years, with an average of twenty-four. Since the Realschule was ordinarily completed at age sixteen to seventeen, virtually all students admitted had been working at least two years prior to their admission to the Kolleg. An admission test in German, English, physics, and mathematics was administered to all applicants. At the Augsburg Kolleg approximately 30 per cent of all the applicants were accepted each year.¹ At the Munich Kolleg, approximately 60 per cent of all applicants were admitted.²

The admission criteria to the Munich Abendkolleg were slightly different from those described for the day Kollege. First, the student did not have to be a

¹Interview, Theodor Rolle, Director of the Augsburg Kolleg, Augsburg, West Germany, on March 26, 1969.

²Interview, Josef Maisch, Director of the Munich Kolleg, Munich, West Germany, on May 5, 1969.

Realschule graduate, and the student had to be only eighteen years old instead of nineteen. The ages of enrolled students ranged from eighteen to forty years with an average of twenty-six. The applicants were required to write an admission exam in German, English, mathematics, and science of a slightly less rigorous nature than at the other Kollege. Since there was a remedial year before the regular three-year program, weaker students were admitted and still went on to meet the completion criteria. If an applicant were nineteen and passed a more rigorous exam, he could be admitted directly to the second year and thus take only three years to complete. Still only about 6 per cent of all applicants were admitted to the Munich Abendkolleg.¹

There were no admission criteria to be fulfilled for the Telekolleg program, and the only selection process was the natural one of attrition that took place as people lost interest or realized that they were in over their heads.² The student ages ranged from eighteen to sixty years with an average of thirty-five.

¹Interview, Hans Christmann, Director of the Munich Abendkolleg, Munich, West Germany, on April 25, 1969.

²Interview, H. Schanzenback, of the technical staff, Ingolstadt Telekolleg, Ingolstadt, West Germany, on February 10, 1969.

There was a great deal of uniformity in the socio-economic backgrounds of Kolleg students. Virtually all of the students came from working-class, rural, or lower-middle class homes. All of the students came from definitely limited economic circumstances. To compensate for this lack of financial support, each student at the Augsburg Kolleg and at the Munich Kolleg had a scholarship from the Land of Bavaria to pay for basic room, board, and books.¹ Tuition was free to all students. At the Munich Abendkolleg, students came from the same limited economic backgrounds. These students received no stipends during the first three years of school but were expected to work during the day. During the fourth and final year, however, the students received Land scholarships, the same as day Kolleg students; and the evening students were expected to quit work to concentrate on school and the Abitur, which would climax the conclusion of their entire three-or four-year experience.

There was a good deal of consistency in the personal objectives of all the Kolleg students. They were primarily interested in completing the Abitur and enrolling in a university or Hochschule. This was in contrast to the Telekolleg students, who were merely up-grading their educational backgrounds for their jobs or personal

¹The monthly basic subsistence stipend was \$75.00, paid to the student twelve months per year.

satisfaction similar to many of the adult education programs in the United States. Not many Telekolleg students were interested in even continuing on to a regular Kolleg, passing the Abitur, and then enrolling in a university, since such a process would have constituted an unusually long and arduous route to follow.

The vocational objectives of the Kolleg students were very similar to the vocational objectives of their younger Gymnasium counterparts. The Kolleg students were male for the most part; and when compared to male Gymnasium students, showed a slightly higher preference for engineering and applied science programs. Hence, a higher percentage of the Kolleg students were looking forward to studying at a Technische Hochschule. Approximately 20 per cent of the fourth class at the Munich Abendkolleg planned to enter a Technische Hochschule.¹ Another 20 per cent planned to enroll in a Pädagogische Hochschule in order to teach at the elementary level. The rest of the students planned to enter the university to study to be Gymnasium teachers, businessmen, medical doctors, lawyers, and scientists in that order.

The Augsburg Kolleg had what seemed to be a high completion percentage. Over 70 per cent of those students admitted successfully completed the two and one-half year

¹Interview, Hans Christmann, Director of the Munich Abendkolleg, Munich, West Germany, on April 25, 1969.

program and passed the Abitur. Most of those who did drop out did so in the first semester of the program. At the Munich Kolleg, over 80 per cent of all students who were admitted successfully completed the program and passed the Abitur. The Munich Abendkolleg indicated that only about 35 per cent of those who began the program completed it successfully. It should be recalled that most of their students had weaker backgrounds at the beginning than those students at the day Kollege; yet all graduates were required to write the same Abitur. The Abendkolleg people indicated that over half of the total attrition took place during the first or remedial school year. If one looked only at the statistics from the second through the fourth years, they were comparable to those at the day Kollege. No data were available on completion percentages for the Telekolleg since it had been in operation for too short a time to yield meaningful statistics.

Students--Austrian Gymnasium

The Gymnasien visited in Austria were located in the areas of Salzburg and Vienna, two widely separated geographical parts of the country. Although Austria had a law which required nine years of Gymnasium education, nearly all schools had eight-year programs. There were very few coeducational institutions except in rural areas; however, there was some trend toward having boys and girls together in the Gymnasien. The Gymnasien visited in the

Salzburg area included the Salzburg Bundesrealgymnasium, a mathematics and science Gymnasium with a student population of 440 boys and 9 girls. The second Gymnasium was the Salzburg Bundesgymnasium, a combination modern language, mathematics and science, and fine arts Gymnasium, with a student population of 780 boys and about 20 girls. The third Gymnasium visited was the Werkschulheim located in the small town of Ebenau near Salzburg. It was a private school that received federal financial assistance. All of its staff salaries were paid by the government, while the school raised its own capital outlay funds. The Werkschulheim was a nine-year school which offered a combination of the mathematics and science Gymnasium program plus apprenticeship programs to all students. This combination of programs required of every student was what necessitated the extra year over comparable Austrian Gymnasien. The concept for the school grew out of the Boy Scout program in Austria. The school enrolled 205 boys, all of whom lived right on the campus in school housing.

The other three Gymnasien were located far to the east in Vienna. The first was the Vienna District Ten Bundesgymnasium und Realgymnasium. As the name implies, it was a combination modern language-mathematics and science Gymnasium. It enrolled 905 boys. The second school visited was the Vienna District Five Bundesgymnasium und Realgymnasium. This was another combination

school containing three parts. They were a modern language section, a classical language section, and a mathematics and science section. The District Five Gymnasium had an enrollment of 504 boys and 196 girls. The last Gymnasium visited in Austria was the Vienna District Twelve, Bundesgymnasium für Mädchen. It had two branches, the modern language section plus a mathematics and science section. It had an enrollment of 615 girls.

There were a number of common elements in all Austrian Gymnasien, except the Werkschulheim at Ebenau, which was a very special institution. Basically the Gymnasien were split into two parts. One was the lower division containing Gymnasien grades one through four. In these four lower grades, called Unterstufe, the program was the same for all students regardless of whether their program was modern languages, classical languages, or mathematics and science. It was in the upper four grades, called Oberstufe, that the specialization took place. The ages of the students ranged from ten to eighteen. The daily schedule of the students in the five Gymnasien was from 8:00 A.M. to 1:00 P.M., Monday through Friday, and from 8:00 A.M. to 12:00 M. on Saturday. Students did come back later in the afternoon if they were electing subjects such as music, art, and athletics, which were not offered during the morning sessions. The students generally had a load of from thirty-two to

thirty-six contact hours of classes per week. The contact hour was usually a fifty minute period similar to West Germany. The Werkschulheim at Ebenau had a more rigorous weekly schedule. Classes ran from 7:45 A.M. to 5:00 P.M. on Monday, Tuesday, Wednesday, and Friday, with a break for lunch. On Thursday and Saturday, classes ran from 7:45 A.M. to 12:00 M. The typical student load was forty-four contact hours per week. Again a contact hour was usually fifty minutes. Because of its extra year, the student population ranged in age from ten to nineteen.

The annual calendar for all of the six Gymnasien was the same. This calendar was established by the Federal Office of Education in Vienna. The schedule covered forty weeks, but most of the educators indicated that they were programmed for thirty-two weeks of actual classes. The Austrian school year followed the West German year very closely, beginning in September, with vacations during Christmas, Easter, and other holidays, and continuing through to the middle of July. Their summer vacation was about six weeks long.

It was interesting to note that during the academic year 1967-68, there were 111,721 students enrolled in public and private Gymnasien in Austria.¹ Of this

¹These figures were presented in an interview with a State of Salzburg school official, Dr. H. Hechenblaichner, Director, Salzburg Office of Education, Salzburg, Austria, on March 17, 1969. He quoted from an annual report to the United Nations Educational and Cultural Organization.

total number, 47,261 were girls, or 44.7 per cent. This percentage seemed to exceed that in West Germany by a significant amount. The figure cited for West Germany was 27.9 per cent.¹

It should be noted also that even with this higher percentage of girls in the Gymnasien, the percentage of those who successfully completed the program and passed the final examination to receive the maturity certificate or Mature constituted 6.5 per cent of the total population of that age group in 1960. This figure had risen to 8.0 per cent by year 1963.² This compared very closely to the West German statistics of 7.2 per cent of the age group receiving the Abitur for 1963 and 1964.³

Admission to all of the Gymnasien, except the Werkschulheim Felbertal at Ebenau, followed very consistent procedures quite similar to those found in West Germany. At the end of the fourth year of primary education, all students were given the opportunity to enter the Gymnasien if they wished. The alternative was to continue on in another four years of primary education.

¹"West German School Statistics," Education in Germany, 21.

²School Systems, A Guide: Austria, 29.

³"West German School Statistics," Education in Germany, 21.

Most of the educators interviewed agreed with Dr. Erich Kaforka that approximately 20 to 25 per cent of those ten-year-olds who had finished the fourth grade continued their education in the Gymnasien.¹ He also indicated that of 150 applicants per year, all but five or ten were admitted. All of the applicants passed a federally administered test which had both oral and written parts for German and mathematics. This test still seemed to allow over 95 per cent of all applicants to be admitted. In fact, an opinion expressed by Dr. H. Kargl from Vienna was shared by many Austrian educators.² The opinion was that the admission requirements to the Gymnasien were too low and that the quality of the program was suffering as a direct result of this permissive admission policy.

The admission criteria at the Werkschulheim at Ebenau were quite another matter. The standard Gymnasium examination was administered. In addition a separate three-day psychological examination was administered in an attempt to determine whether the young applicants were suitably adapted for the course of study they were to undergo. There were over 100 boys selected each year as

¹Interview, Erich Kaforka, Director, Salzburg Bundesgymnasium, Salzburg, Austria, on March 20, 1969.

²Interview, H. Kargl of the physics staff, Vienna District Ten Bundesgymnasium und Realgymnasium, Vienna, Austria, on April 16, 1969.

qualified candidates. Of these 32 were invited to enroll. The capacity of the Werkschulheim facilities was such that only thirty-two new students could be admitted each year.

The socio-economic backgrounds of the students seemed to be somewhat a function of the location of the Gymnasium. Professor Mayr at the Salzburg Bundesrealgymnasium¹ indicated that there was a fairly uniform spread of student backgrounds from middle to upper class homes. Household heads included salaried employees, civil servants, business owners and operators, and professional people. He indicated that perhaps 25 per cent of their total student body came from blue collar workers and rural agricultural homes. Boys from these blue collar and agricultural homes probably made up more than 50 per cent of the eligible students in the Gymnasium age group. Professor Mayr indicated also that he felt a higher percentage of boys from lower socio-economic homes were coming to the Austrian Gymnasien each year. Dr. Kaforka² of the Salzburg Bundesgymnasium stated that his student group came from all economic backgrounds with a slightly lower percentage coming from the rural agricultural areas than

¹Interview, Albert Mayr of the physics staff, Salzburg Bundesrealgymnasium, Salzburg, Austria, on March 17, 1969.

²Interview, Erich Kaforka, Director, Salzburg Bundesrealgymnasium, Salzburg, Austria, on March 20, 1969.

one might expect. Since his institution had a multiple curriculum, he felt it had appeal to all elements of the local population. Dr. Eschig,¹ Director of the Vienna District Ten Bundesgymnasium und Realgymnasium, indicated that virtually all of his students came from blue collar, working class homes. The school was located in a large working class residential area and served only the neighborhood population. He also indicated that very few, if any, of the parents were Gymnasium graduates. He felt that this caused some problems since the students had difficulty in identifying with appropriate adult figures, and the parents had difficulty reinforcing the education the students received at the Gymnasium. He felt that this had led to a higher drop-out rate compared to some of the other Gymnasien. The Director of the Vienna District Five Bundesgymnasium und Realgymnasium² had done some investigation and showed that his institution had quite a spread of student socio-economic backgrounds with the professional and upper classes represented in the classical language section of the Gymnasium while the rest of the students were from middle class homes. He had very few students from working

¹Interview, A. Eschig, Director, Vienna District Ten Bundesgymnasium und Realgymnasium, Vienna, Austria, on April 16, 1969.

²Interview, Josef Schindler, Director, District Five Bundesgymnasium und Realgymnasium, Vienna, Austria, on April 15, 1969.

class homes, but those who were attending were enrolled in the mathematics and science section of the school. Dr. Margarete Schuster,¹ Director of the Vienna District Twelve Bundesgymnasium für Mädchen, had students from working class homes almost exclusively. She felt that there were higher percentages of working class students in Austrian Gymnasien than in West Germany even though the general economic conditions in Austria were not as good as in West Germany. One cannot attempt to generalize on socio-economic backgrounds of students by using the Werkschulheim at Ebenau. These students came from some of the most affluent families in Western Europe. As an example, Dr. Treml² stated that over the past twenty years, thirty-two princes of the Lichtenstein royal family had attended. Many of the students came from West Germany, Switzerland, and the United States, plus Austria. Since this was a boarding school, there was a substantial tuition, which only the more financially able families could afford. Dr. Treml indicated that most of the parents were wealthy business and professional people. He indicated that this was an advantage when

¹Interview, Margarete Schuster, Director, Vienna District Twelve Bundesgymnasium für Mädchen, Vienna, Austria, on April 17, 1969.

²Interview, Richard Treml, Headmaster, Werkschulheim, Ebenau, Austria, on March 18, 1969.

attempting to raise money from parents for special buildings or other capital outlay projects.

Almost all Gymnasium students planned to attend a university or Hochschule. There was general consensus that 90 per cent of all Gymnasium graduates entered higher education. No studies comparable to the West German studies on student vocational preference were available, thus, it was difficult to verify those data obtained from individual interviews. Dr. Richard Sickinger¹ of the Austrian Ministry of Education felt that Austrian vocational preference statistics were similar to those from West Germany, and that when the School Organization Act of 1962 was implemented, the tools would become available to offer more kinds of specialized education to satisfy particular needs. It was noted that although the discussion with Dr. Sickinger took place in 1969, the School Organization Act of 1962 had been only partially implemented. Generally speaking, vocational objectives of students varied from Gymnasium type to Gymnasium type. Most of the students at the mathematics and science Gymnasien were interested in continuing their education at a Technische Hochschule in an area of engineering or applied science. A very few planned to continue their education at a university in the field of medicine or dentistry.

¹Interviews, Richard Sickinger, Federal Austrian Ministry of Education, Vienna, Austria, on April 14 and 17, 1969.

Dr. Kargl,¹ of the Vienna District Ten Bundesgymnasium und Realgymnasium, indicated that the vocational objectives of their all male student body were, in order of decreasing importance: continuation at a Technische Hochschule in engineering or architecture; continuation at a university to study medicine or law; or preparation as a teacher. A very few boys indicated that they planned to continue their education to prepare for a career in business. Male students enrolled in the classical Gymnasien, where Greek and Latin were taught, were usually preparing for continued education in medicine or law. Girls were typically planning to transfer to an elementary teacher training college, Pädagogische Akademie, or were considering a career in secondary teaching, social work, medicine, or pharmacy in that order according to Dr. Schuster in Vienna. The students at the Werkschulheim at Ebenau were almost equally divided among architecture, medicine, and law as vocational objectives.

The completion statistics at the various Gymnasien showed a considerable variation. At the Salzburg Bundesrealgymnasium only 15 per cent of their beginning students completed the eight-year program successfully and passed the Mature examination. At the Salzburg Bundesgymnasium they claimed that 50 per cent of the incoming

¹Interview, H. Kargl of the physics staff, Vienna District Ten Bundesgymnasium und Realgymnasium, Vienna, Austria, on April 16, 1969.

students successfully completed the Mature. At the Vienna District Ten Bundesgymnasium und Realgymnasium, 20 to 25 per cent were successful. At the Vienna District Five Bundesgymnasium und Realgymnasium, 40 per cent of the incoming students were ultimately successful. The Vienna District Twelve Bundesgymnasium für Mädchen had 45 to 50 per cent of their students complete successfully. At the Werkschulheim at Ebenau, 55 per cent of the beginning students successfully completed the nine-year program. It appeared that there was a wide variation in the degree of success at the various schools. It proved interesting to average out the success percentages and multiply this figure by the percentage of the total students entering the Gymnasien at age ten. The average success percentage was about 36. This, multiplied by the 25 per cent of all fifth grade students who entered all Gymnasien, yielded a figure of a little less than 9 per cent of the total age group successfully completing the Gymnasien. This compares rather favorably with the 1963 statistics,¹ which suggested that 8 per cent of the age group successfully completed.

Students--Austrian University

There were two Austrian institutions of higher education visited. One was the University of Salzburg,

¹School Systems, A Guide: Austria, p. 29.

located in Salzburg; and the other was the Vienna Technische Hochschule, located in Vienna. Very little data for the University of Salzburg will be presented since its science program was very limited, and the physics program was in the process of being developed as part of the newly established medical school. Mathematics and certain biological science courses were a part of the University curriculum at the time of the visitation. There were evidences of increased activity in the physical science area. Professor Kacowsky¹ indicated that in the far distant past the University of Salzburg had functioned as a comprehensive institution, but the institution had been closed by Napoleon Bonaparte in the year 1805. In 1850 it was reopened by the Benedictine Order of the Roman Catholic Church and had only a Theology faculty until 1962, when the institution once again began to assume its former comprehensive status. Since 1962 the University has had a Philosophy Faculty, where the physics program will be located along with the existing mathematics and biological science programs. Of a total of 1,700 students at the University of Salzburg, over 300 were enrolled in the English Language Institute preparing to become Gymnasium teachers of English. Many of the other 1,400 students

¹Interviews, Walter Kacowsky of the English staff, University of Salzburg, Salzburg, Austria, on March 18, 19, and 20, 1969.

were preparing for Gymnasium teaching in the other fields. In fact, more students were involved in teacher preparation programs than in any other vocational area.

The Vienna Technische Hochschule was founded in about 1830 and, as the Munich Technische Hochschule, prepared students for careers in architecture, engineering, and the applied sciences. Virtually all of these students took some physics during their first two years of higher education.¹ The Hochschule had a total enrollment of approximately 5,000 students. Of this total, only 300 were girls with most of the girls enrolled in the architecture curricula. It was interesting to note that of the 5,000 students, between 1,000 and 1,500 of them came from countries other than Austria. The typical student in physics had a class load of from twenty-three to twenty-five contact hours per week spread out over the five days, Monday through Friday, with an occasional class on Saturday morning. The annual calendar of the school was split up into two semesters. The winter semester began on October 1 and continued to February 15 with a two-week Christmas vacation, and concluded with a two-week period for examinations. The second, or summer, semester began about March 1 and continued to the end of June with a

¹Interview, Horst Ebel of the physics staff, Vienna Technische Hochschule, Vienna, Austria, on April 17, 1969.

two-week vacation at Easter. In all, there were approximately fifteen weeks of actual classes during each of the two semesters.

Of the total of 5,000 students enrolled in the beginning through doctoral programs, approximately 950 of these students were enrolled in the first-year physics sequences. About 350 to 400 were enrolled in the special physics for architects, geologists, and chemists. Another 400 were enrolled in the special physics for engineers. Another 150 students were enrolled in the special physics sequence for applied mathematicians and physicists. This breakdown gives the approximate range of vocational objectives for the incoming student population.

The only criterion for admission was certification of completion of the Gymnasium program, which meant that every incoming student had passed the Mature examination. By Austrian law, all such students had to be admitted to the Vienna Technische Hochschule if they applied. The socio-economic backgrounds of the students were directly related to the Gymnasium student output. Dr. Ebel felt that something between 15 and 20 per cent of their incoming students came from blue collar, working class homes. This seemed unusually high and was the direct result of the high percentage of Gymnasium graduates from such homes, plus the fact that the Hochschule was located in a large metropolitan area very close to large numbers

of working class people. He felt that the percentage of students from working class homes at the Vienna Technische Hochschule was twice as great as at some comparable West German institutions. The rest of the students came from professional, civil servant, or other salaried homes, except for foreign students who came from wealthy homes. These latter students constituted a significant fraction of the total student population.

The educational aspiration of most of the incoming students was to receive the Diplom in Engineering, the first degree granted by the Vienna Technische Hochschule. A few students entered with the desire to receive a doctoral degree, but this percentage was very low, probably less than 10 per cent. Some additional students decided to continue on for a doctoral degree after they had received the Diplom degree. The vocational objectives of the incoming students broke down as follows: 42 per cent were interested in architecture, geology, or chemistry; approximately 40 per cent were interested in careers in some kind of engineering; and the remaining 15 to 20 per cent enrolled with the thought of pursuing studies in physics or applied mathematics.

Although no hard data were available, Dr. Ebel felt that from 70 to 80 per cent of those students enrolled in first-year physics successfully completed the year. He stated that they still had significant attrition through

the second and third years. Successful completion of the first year was a little easier to document than at some West German institutions since there were periodic examinations given during the first year to determine student progress. Approximately 66 per cent of the students made it through to the Vor-Diplom or pre-diploma examination, usually taken by the student at the end of two and one-half or three years. Virtually all of the students who successfully passed the Vor-Diplom received the Diplom degree in an additional two and one-half to four years.

Students--Austrian Höhere Lehranstalt

The last Austrian institution to be studied was the Höhere Lehranstalt, more specifically the Höhere Technische Lehranstalt. A rough translation of this latter title would be higher technical college. This institution was roughly equivalent to the West German Polytechnikum. There were two such institutions visited in Austria, one in Salzburg and one in Vienna. The institution in Salzburg was called the Höhere Technische Bundeslehranstalt, and the institution in Vienna was called the Höhere Technische Bundes-Lehr und Versuchsanstalt. The two institutions will be referred to subsequently as the Salzburg Lehranstalt and the Vienna Lehranstalt. There was one significant difference between the Lehranstalt and the West German Polytechnikum. The student population served in West Germany had to be at least nineteen years old,

while the Austrian Technische Lehranstalt admitted students after their eight years of elementary education or after the fourth year of Gymnasium education. This meant that the students were fourteen or fifteen upon admission. Most of the programs at the Technische Lehranstalten were five years long so that graduates were eighteen to nineteen years old. This was in contrast to the West German Polytechnikum graduate who was twenty-two to twenty-four years old after completing a three-year program.

At the Salzburg Lehranstalt¹ the student enrollment was made up of 640 boys and 60 girls; most of the girls were enrolled in a textiles program that had an excellent national reputation. The weekly schedule of the students consisted of a forty to forty-eight contact hour weekly class load spread over six days, Monday through Saturday. In most curricula, approximately twenty-five of these contact hours were in regular classes, and the remaining fifteen to twenty contact hours were spent in a variety of laboratory classes and work experiences. The annual calendar of the school followed the Austrian Gymnasium calendar with one exception. During at least two of the student's total of four summer vacations, he was required to work a four-week period in his field of specialization

¹Interview, Anton Frisch, Director, Höhere Technische Bundeslehranstalt, Salzburg, Austria, on March 19, 1969.

for some industrial concern which cooperated with the school by providing practical experience for the students. To give some appreciation for the impact of this type of technical school, one should look to the Austrian school statistics for 1967.¹ While there were 111,721 students enrolled in the eight-year public and private Gymnasien, there were a total of 13,591 students enrolled in the five-year Höhere Technische Lehranstalten programs. Of the total students of all ages, 1,238,841, this means only 1.1 per cent of the total were enrolled in the Höhere Technische Lehranstalten. To be enrolled in the Salzburg Lehranstalt, a student had to have completed his eighth year of total schooling at either an elementary school or at a Gymnasium. He then submitted to a federally developed and supervised examination which covered German and mathematics. There was also a separate intelligence test, and the student had to pass a required physical examination. Roughly one-half of those who applied to the Salzburg Lehranstalt were admitted to one of its curricula. The Director of the Lehranstalt, Dr. Frisch,² quoted some statistics on socio-economic backgrounds of

¹Bundesministerium für Unterricht, Die Wichtigsten Daten des Schulwesens in Österreich 1967/68 (Vienna, Austria: Bundesministerium, 1968), p. 27.

²Interview, Anton Frisch, Director, Höhere Technische Bundeslehranstalt, Salzburg, Austria, on March 19, 1969.

his students. He stated that 23 per cent came from working class and rural agricultural homes, 26 per cent came from the homes of salaried white collar families, and that the rest came from professional families or business owners and operators. Nearly all of the students were interested in completing school, which meant a five-year program. The student wrote a Mature; and instead of entering a university, for which he was eligible, the student usually sought an industrial position. The school was designed to train practically oriented, engineering related personnel for business and industry.

The Vienna Lehranstalt was in many ways similar to the Salzburg school except it did have a much larger enrollment in its shorter three-year programs. Still most of the students were enrolled in the regular five-year programs leading to the Mature.¹ There were 1,200 day students and 1,000 evening students enrolled in the various programs. Less than twenty of the students were girls. The schedules were the same as at Salzburg with even the evening students carrying forty to forty-five contact hours of classes per week. The admission criteria for the Vienna Lehranstalt were similar to those at Salzburg; however it was felt that approximately

¹Interview, P. Riedl of the electrical engineering staff, Höhere Technische Bundes-Lehr und Versuchsanstalt, Vienna, Austria, on April 18, 1969.

60 per cent of those who applied were admitted to one of the curricula. The socio-economic backgrounds of the students showed a higher percentage coming from working class homes, probably 40 to 50 per cent, with the rest rather evenly spread among the rest of the general population. There were 100 students from foreign countries enrolled. The students went directly into industry after graduation with a very few continuing their education at a Technische Hochschule, which all could have done since they had received the Mature upon successful completion of the five-year program. At Salzburg it was indicated that 48 per cent of all students who enrolled successfully completed the program. The Vienna Lehranstalt showed a higher rate of completion. While the rate of success varied somewhat from one curriculum to another, an average of 65 per cent of all students admitted to the institution successfully completed their respective programs. There was no explanation for the significantly higher rate of success in Vienna versus that observed in Salzburg.

Students--Swiss Gymnasium

Both of the Gymnasien visited in Switzerland were located in the city of Zurich. The first school visited was the Kanton of Zurich Oberrealschule. It was a Type C mathematics and science Gymnasium and enrolled about 600 male students. A Type C school included only the last

four and one-half years of the Gymnasium education program. This meant that grades nine through twelve and one-half were located at the Oberrealschule. The second Gymnasium visited in Zurich was a privately sponsored Gymnasium, the Freies Gymnasium. The school was operated by a reformed Protestant denomination and had an enrollment of 530 students, half boys and half girls. Freies was a combination school, that is, it had all three types of programs in its total curriculum. It had a Type A part which corresponded to the classical language Gymnasium of West Germany. It also had a Type B part, which corresponded to the modern language Gymnasium; and it had a Type C part, which was the science and mathematics Gymnasium. There was a slight difference among the three types of Gymnasien.

All children in the Kanton of Zurich were required to complete six years of primary education. Those who continued on in the A or B Type Gymnasien transferred immediately to that school for the remaining six and one-half years of secondary education. If a student were planning to continue his education at a Type C Gymnasium, he had to take two years of intermediate schooling at a Realschule and then transfer to the Type C Gymnasium for the remaining four and one-half years. Thus the Freies Gymnasium had students in the A and B parts from ages twelve to nineteen; while in the C part, the students

ranged in age from fourteen to nineteen. Most of the students at the Zurich Oberrealschule ranged in age from fourteen to nineteen since it was also a Type C Gymnasium. The daily schedule of the Swiss Gymnasium student appeared very rigorous. Their classes met six mornings per week, Monday through Saturday from 8:00 A.M. to 12:00 M. in the winter and from 7:00 A.M. to 12:00 M. in the summer. They also had afternoon classes on Monday, Wednesday, and Friday extending to 5:00 P.M. in the winter and ending at about 3:30 P.M. in the summer season. Their class load varied between thirty-two and forty-one contact hours per week. The annual calendar was significantly different from West Germany and Austria. The Swiss school year began in April and extended to the middle of July; then there was a vacation until the middle of August. School then began again and continued until Christmas. After Christmas the program continued until April, with vacations early in February and at Easter. In all, the total school year was some forty weeks long and rather uniformly distributed throughout the year. Basically the year was broken into two semesters: the first from April to October and the second from October to April. All students began their new year during the summer semester commencing in April instead of at the more customary school beginning in the fall. The Kanton of Zurich, following the lead of some of the other districts in Switzerland, was establishing more and more coeducational schools. Until recently

only the private schools had both boys and girls, while the public schools were rigidly segregated. Some of the educators felt that this integration of the sexes would tend to promote better educational opportunities for females than has been the case in the past.

The students were admitted to the Gymnasien after an examination in French, German, and mathematics. Almost all students who applied and took the examination were admitted according to Professor James Hablützel¹ of the Zurich Oberrealschule. It was noted that students must have completed eight years of preparatory education prior to being considered for admission to the Type C schools such as the Oberrealschule, and this in itself was a fairly selective process. The same situation seemed to exist at Freies Gymnasium according to Professor Erich Bernhard², even though the A and B school students were admitted after only six years of preparatory education. Most students who applied for admission to the Swiss Gymnasien were in fact admitted.

There was considerable variation in socio-economic backgrounds between the student populations of the two schools. At the Freies Gymnasium, students came from the

¹Interview, James Hablützel of the physics staff, Oberrealschule, Zurich, Switzerland, on March 4, 1969.

²Interview, Erich Bernhard of the physics staff, Freies Gymnasium, Zurich, Switzerland, on March 6, 1969.

higher socio-economic levels, since only such families could afford the tuition of \$750 per year plus the cost of room and board. This amount was far beyond the means of most middle and lower class families. At the Ober-realschule there were a greater number of students from working class families. Though very few statistics were available, the best estimates seemed to indicate that between 15 and 20 per cent of those students who finished the sixth grade of the primary schools continued into some type of Gymnasium education. This seemed to be lower than in West Germany or Austria, but it should be remembered that in those two countries Gymnasium admission took place at the end of the fourth grade of primary education and not at the sixth to eighth grades as was the case in the Types A, B, and C Gymnasien in Switzerland.

Almost without exception the students at both Gymnasien were looking forward to continuing their education at one of the Swiss universities. This was quite natural since the sole objective of the Swiss Gymnasien appeared to be to prepare students for the universities. At the Oberrealschule the students, all male, were planning to continue in the professions of engineering, medicine, law, and teaching. Those who planned to continue in engineering and science were hoping to continue their education at the Eidgenössische Technische Hochschule in Zurich, known as the Swiss Federal Institute of Technology. This

was one of the most prestigious technical universities of all of Europe and was located approximately 200 yards from the Oberrealschule. Those students who were interested in medicine, law, and non-science teaching areas planned to study at the University of Zurich, which was located immediately adjacent to the Oberrealschule. At the Freies Gymnasium the male students were fairly equally divided among those seeking careers in medicine, law, teaching, except for the very few who were planning to study engineering. The girls were much less vocationally oriented; and of those who had made a career commitment, most were planning careers in teaching or social work.

There was a great deal of consistency between the two schools regarding completion statistics. Professor Hablützel indicated that approximately 65 per cent of all students who were admitted successfully completed the four and one-half year Zurich Oberrealschule program. Professor Bernhard said that some 65 per cent of all students admitted to the Freies Gymnasium successfully completed one of the three available curricula. These percentages were considerably higher than similar success figures for West Germany and Austria. However, one must consider the lower percentage of the age group that entered the Swiss Gymnasien and did so at a higher age, making it entirely possible that a greater part of the selection process had taken place prior to admission.

Students--Swiss University

The two Swiss universities visited were both located in the German speaking city of Zurich. They were the University of Zurich and the Swiss Federal Institute of Technology. Neither university was large by American standards. The University of Zurich had a total enrollment of 8,000 students. Approximately 475 students were taking first-year physics each year; and 65 students took second-year physics, indicating either a major or minor level of specialization. At the Federal Institute there were a total of 6,434 students, of whom 5,735 were at the pre-Diplom level, somewhat comparable to American undergraduate status. All curricula at the Federal Institute included at least one sequence in physics. This meant that even though smaller in enrollment than the University of Zurich, there was a far greater proportion of the student population in physics each year. There were approximately 1,250 students enrolled in the first physics sequences each year, of which approximately 635 students were enrolled in the science, mathematics, and chemistry sections of physics. The rest of the students were in engineering physics sections. It should also be noted that no student at the Federal Institute took physics until his third semester of attendance. There were very few female students enrolled in the physics classes, probably less than 5 per cent. At the University of Zurich, approximately 10 per cent of those students

taking first-year physics were female. According to Dr. Franz Waldner¹ of the University of Zurich, physics students could enroll for as many as forty contact hours of lectures and laboratories each week; however, the average student took approximately twenty-five to twenty-eight contact hours per week. This contrasted somewhat with the students at the Federal Institute. There the students followed a more rigorous schedule and were required to take a class load of between thirty-three to thirty-eight contact hours per week. The classes were held during the week days from Monday through Friday with an occasional evening or Saturday class. The annual calendar was broken up into two semesters, and the summer semester extended from the end of April to the middle of July. The winter semester began at the end of October and concluded in early March. Both universities followed the same annual calendar with the school year beginning in the fall instead of the spring as observed in the Gymnasien.

The admission policies of both institutions stated that any student who had completed a Gymnasium education and successfully passed the Mature had satisfied the entrance requirements and was guaranteed admission. A student no longer needed proficiency in Latin to be admitted to the medical school at the University of Zurich.

¹Interview, Franz Waldner of the physics staff, University of Zurich, Zurich, Switzerland, on March 5, 1969.

This was one indication of how the special requirements for some programs were gradually being phased out. There were a very few exceptions to the Mature admission requirement at the Federal Institute. According to Dr. Urs Schrieber,¹ some students did not have a Mature recognized by the Federal Institute. These students were admitted by successfully passing a special examination.

Naturally, the socio-economic status of the university students reflected the characteristics of the Gymnasium population. Basically it was felt that the university students came from middle and upper class families with a very slight trend toward more of the lower-working classes finding their way through the Gymnasien and on to the universities. The scholarship assistance in Switzerland was well below the level of West Germany, and it seemed to be very difficult for a student to attend the university and work at the same time. In fact, this was rarely done. The physics students at the Federal Institute were divided according to the following vocational interest pattern: 14 per cent were studying architecture, civil engineering--12 per cent, electrical engineering--14 per cent, mechanical engineering--13 per cent, chemistry--8 per cent, pharmacy--2 per cent, forestry--2 per cent, agriculture--10 per cent, physics and

¹Interview, Urs Schrieber of the physics staff, Swiss Federal Institute of Technology, Zurich, Switzerland, on March 5, 1969.

mathematics--13 per cent, biology--9 per cent, military science--2 per cent, and physical education--1 per cent. Most of the students were planning to complete their education with the Diplom degree, but some would probably continue to a doctoral degree. There were no accurate statistics for the University of Zurich physics students; but Dr. Waldner indicated that the students who took physics did so during their first year at the University and were mostly medical and dental students with some science teachers, chemists, physicists, mathematicians, and biologists. Approximately 60 per cent of the 475 first-year physics students were medical and dental students. Approximately 25 per cent were students studying to be physics and mathematics teachers or professional physicists and mathematicians. The remaining 15 per cent were planning to continue in the fields of chemistry or biology.

Since there were no formal examinations or evaluation processes at the conclusion of the first-year physics course at the University of Zurich, it was difficult to determine accurately the number of students who were successful. Even so the attendance dropped off during the course of the first-year physics sequence, and it was estimated that approximately 70 per cent of the students who began the one-year course actually finished it. It was at a later time that their degree

of success was officially determined, since a comprehensive examination was not scheduled until after the end of two or three years at the University. In this over-all test, physics proficiency was examined, along with a number of other subjects. The physics department at the University of Zurich had begun an unofficial project of personal counseling for all students in the science physics course. This involved approximately 200 out of the total of 450 physics students each year. Dr. Waldner felt this had helped to save many students who might otherwise have dropped. The remaining 250 students were in the medical and dental schools, and their examinations and counseling were provided by the medical and dental school staffs, respectively. Dr. Waldner felt that approximately two-thirds of their students were still enrolled at the University after one year.

Students--Swiss Technikum

The next institution to be analyzed was the Technikum located at Winterthur near Zurich, Switzerland. Its full title was the Höhere Technische Lehranstalt des Kantons Zurich. It was generally referred to as the Technikum Winterthur. The institution was a three-year engineering college with an enrollment of 950 students. The program was divided into a total of six semesters with a very heavy schedule of classes spread throughout

a five and one-half day week. Classes met Monday through Friday from 8:00 A.M. to 5:00 P.M. and on Saturday mornings. Each student had a weekly class load of from thirty-five to forty contact hours. The age span of the students ranged from twenty to thirty years. The semesters were arranged to provide a fairly uniform academic exposure throughout the year. The annual calendar followed the universities more closely than the Gymnasien. The first, or winter, semester began in November and ended in May. The second, or summer, semester began in May and ended in October. There were two-week vacations in April and October plus a six-week vacation in July and August. Each semester had approximately twenty weeks of classes. Mr. Hartmann Hirzel¹ discussed the admission criteria for the school and indicated that most of the students had completed six years of primary school plus three years at a secondary school called a Realschule. The young men then enrolled in a three- or four-year apprenticeship program. Following the successful completion of this apprenticeship program, the person was eligible to make application to the Technikum Winterthur. Usually the applicant had completed his four-month military commitment between the time he completed his apprenticeship and the November school beginning. This meant that most

¹Interview, Hartmann Hirzel, Registrar, Technikum Winterthur, Winterthur, Switzerland, on March 4, 1969.

of the newly admitted students were from nineteen to twenty-one years old. Of the 900 students who applied each year for admission, only 350 to 400 successfully passed the entrance examination and were admitted. The examination covered topics in German, mathematics, and technical drafting. It was possible for a Gymnasium graduate to be admitted to the Technikum Winterthur, and approximately 5 per cent of each class had such an educational background prior to admission.

Both Mr. Hirzel and Professor Hanspeter Stump¹ indicated that the majority of the students were from lower class and lower-middle class homes. This was reflected in their non-Gymnasium educational backgrounds and their desire to continue a career in a trade instead of at a university. It was only after completing an apprenticeship program that most of the students even considered entering the Technikum Winterthur. Since the universities were closed to them, the engineering colleges offered the only means of continued education without going back and finishing the Gymnasium

All of the students were looking forward to careers in business, industry, or research-oriented programs. Programs were designed to prepare students for careers in architectural engineering, civil engineering, mechanical

¹Interview, Hanspeter Stump of the physics staff, Technikum Winterthur, Winterthur, Switzerland, on March 3, 1969.

engineering, electrical engineering, and chemistry. All of the programs contained at least two years of physics. Graduation followed successful completion of the curriculum and the passing of a rigorous comprehensive examination. The graduate was awarded a diploma recognized by the Swiss government and all of the Kantons in the country. The school was greatly similar to the West German Polytechnikum in most respects.

Of those students who passed the requirements to be admitted, approximately 70 per cent successfully completed the physics sequences in the first two years, and ultimately 65 per cent of those admitted continued on to successfully complete the full programs plus the final examination and were awarded the diploma, or Diplom as it was called in Switzerland. The Technikum Winterthur did not confer a Matur and so technically its graduates were still not eligible to enter a university. A few, however, were admitted each year to the Swiss Federal Institute to study in specific technical areas.

Students--Jackson Community College

During the academic year 1968-69 there were 3,302 students enrolled at Jackson Community College.¹ Of this group 1,375 were classified as full-time students taking

¹Jackson Community College, Office of the Registrar, Enrollment Information 1968-69, (Jackson, Mich.: Jackson Community College, 1969).

twelve semester hours or more during each semester. The remaining 1,927 students were enrolled for eleven semester hours or less. Of this group 898 were enrolled in collegiate programs, 613 were enrolled in apprenticeship programs, and 416 students were from area high schools and enrolled in the area secondary-vocational program. The total enrollment statistics showed that there were 980 women and 2,322 men enrolled during 1968-69 or approximately 30 per cent and 70 per cent, respectively. During this same academic year there were 187 students enrolled in the various offerings of the Physics Department of Jackson Community College with 26 per cent female and 74 per cent male students. The largest portion of these students, over 90 per cent, were enrolled in more than twelve semester hours and thus were classified as full-time students. The average full-time physics student had a weekly schedule of 15.6 contact hours. This total included laboratory hours as regular contact hours. The student schedules were spread out over a five-day week with classes scheduled from 8:00 A.M. to 5:00 P.M., Monday through Friday. Twenty-two per cent of the physics students had at least one evening class. Evening classes were offered in a variety of subjects including physics during the time interval from 7:00 to 10:00 P.M. on Monday through Thursday. There were no Friday evening or Saturday classes during the academic year 1968-69. The annual calendar of the school was broken into two semesters, which included

a total of thirty-two weeks of instruction and a total of four weeks for registration and examinations throughout the year. The school year began in early September, and the first semester ended near the middle of January with a two-week Christmas vacation. The second semester began at the beginning of February and ended the first week in June with a one-week spring vacation at Easter.

Jackson Community College was an "open-door" institution; that is, a student only needed to have a high school diploma to be admitted. This did not, however, mean that all students were admitted to all curricula or specific courses contained in these curricula. In physics, the students were admitted by the College counseling staff using a combination of criteria. These criteria included the vocational objective of the student, his high school or college progress in allied subjects, aptitude tests, and progress in mathematics. Each of the levels of beginning physics at Jackson Community College had a mathematics pre-requisite. This requirement ranged from one year of high school algebra for the lowest level course to a pre-requisite of one year of calculus for the first-year engineering physics sequence. There was no requirement that students should have had previous high school or college level physics before admission into any of the beginning physics sequences. During 1968-69 there was an advanced sequence in Modern Physics which

was offered during the evening and had a pre-requisite of one year of college-level physics. Only ten students were enrolled in this particular course. It was possible for a student to be admitted to Jackson Community College with little or no previous mathematics and to take remedial courses in mathematics in order to qualify for admission into any of the physics offerings. Seventy-seven per cent of the physics students were between the ages of eighteen and twenty-one at the time they were enrolled in their respective physics classes.

Socio-economic data for Jackson Community College students came from reports supplied by the American College Testing Program based on the result of a survey of full-time students at the time of their admission to Jackson Community College.¹ Ten per cent of the students came from homes with an annual family income of less than \$5,000; 50 per cent came from homes with an annual family income between \$5,000 and \$10,000; 29 per cent came from homes with an annual family income between \$10,000 and \$15,000; and the remaining 11 per cent came from homes with an annual family income greater than \$15,000. While it was difficult to define accurately socio-economic status from income figures alone, it was known that the average annual family income for Jackson County was

¹American College Testing Program, Jackson Community College Class Profiles, Freshmen 1967-68 and 1968-69 (Iowa City, Iowa: American College Testing Program, 1969).

approximately \$8,500.¹ This would mean that the vast majority of Jackson Community College students came from lower-middle to middle income families with relatively few from the upper income levels.

The 1968-69 physics students were surveyed to determine educational and vocational aspirations. Ninety-two per cent of the students aspired to at least the bachelor's degree. Four per cent planned to terminate their education after attendance at Jackson Community College. Four per cent already had a bachelor's or master's degree. Twenty-six per cent of the physics students planned to obtain an engineering degree; 16 per cent planned to obtain a degree in elementary education; 11 per cent planned to teach at the secondary level; 6 per cent planned careers in medicine, dentistry, or veterinary medicine; 8 per cent planned careers in science other than teaching. The majority of the remaining 33 per cent were taking physics to satisfy a general education requirement in science for a senior institution and had not as yet decided on a specific vocational objective.

Completion statistics for physics students were known with a high degree of accuracy as they had been routinely collected for many years. The statistics for

¹Interview, George Williston, Director, Jackson United Community Services, Jackson, Mich., on April 1, 1970.

the academic year 1968-69 were very typical.¹ In this case, completion was defined as finishing the physics course with a grade of C or better. Seventy-two per cent of all students admitted to a physics course completed the course with a grade of C or better. Statistics for the fall semester tended to be somewhat below 72 per cent, whereas second semester figures were usually above 72 per cent.

Students--Summary

There were definite similarities among the student populations of the Gymnasien in the three European countries. Males outnumbered females by more than two to one, and the majority of the students seemed to come from the middle and upper-class of the population. Annual calendars were similar except for Switzerland, where the first semester enrollments took place in the spring instead of the fall. The daily and weekly schedules were such that the students attended classes during the morning and early afternoon hours of a six-day week for a weekly load of from thirty to forty contact hours. The admission processes were such that over 90 per cent of those who applied were admitted to the Gymnasium of their choice. Virtually all students who attended the Gymnasien were

¹Physics Department, Jackson Community College, "Physics Department Grade Distributions, 1968-69" (Jackson, Mich.) (Typewritten.)

interested in continuing their education at some form of university and 90 per cent of the graduates continued their educations. The percentage of students who completed the Gymnasium constituted between 6 and 9 per cent of the total eighteen to twenty-year-old age group or about 30 to 40 per cent of those who were initially enrolled during the fifth to seventh grade.

Universities in West Germany, Austria, and Switzerland were similar in most respects as were the Technische Hochschulen from the three countries. Munich University was by far the largest with its enrollment of 25,000 students. The rest of the universities and Technische Hochschulen had total student populations from 5,000 to 10,000 students, and not all of these students were enrolled in the beginning physics sequences. At the universities approximately 6 per cent of the total student population enrolled in the beginning physics sequences, and males outnumbered females by about ten to one. Approximately 20 to 25 per cent of the total student body at the Technische Hochschulen were enrolled in the beginning physics sequences reflecting the highly technical curricula at these institutions. These students were enrolled in twenty to thirty contact hours of classes during a five-day week. Annual calendars extended for approximately thirty weeks of classes broken into two fifteen-week semesters. All Gymnasium graduates were eligible to enroll in any university or Technische Hochschule in their respective

countries. There were no other admission criteria except the Latin language requirement for medical students, which was fading from the scene as the years progressed. The socio-economic backgrounds of the students were similar to those found in the Gymnasien except that students from the lower-middle and middle class families were more apt to enroll at a Technische Hochschule than at a university. Physics students at the Technische Hochschulen were preparing for careers in engineering, applied mathematics, chemistry, physics, and architecture for the most part. Physics students at the universities were preparing for careers in medicine, dentistry, pharmacy, or some kind of teaching. Because there were few examinations given, it was difficult to get any data on the percentage of students successfully completing the first-year physics sequences. However, several university and Technische Hochschule professors estimated that 70 per cent of all beginning physics students completed the respective sequences.

The engineering colleges of the three European countries varied in size but were usually smaller than the universities and Technische Hochschulen. They varied from several hundred students at the Salzburg Lehranstalt to several thousand at the Oskar-von-Miller Polytechnikum in Munich and the Vienna Lehranstalt. Virtually all of the students were male, and they all were required to

take some physics as a part of their technical training. These students carried extremely heavy class loads extending to forty-five contact hours over a six-day week. Their school year consisted of up to forty weeks of classes, and sometimes participation in summer programs was a requirement. None of these institutions were able to admit all of the students who applied. From 45 to 50 per cent of all who applied were admitted. Of these who were admitted, from 55 to 65 per cent completed the physics sequences and went on to graduate in their respective fields of electrical engineering, mechanical engineering, architecture, and other technical fields. Most of the students at the engineering colleges came from working class and lower-middle class families.

The Kollege were found only in West Germany and enrolled students who were older than the Gymnasium students taking parallel programs. All of these students took physics as did the Gymnasium students. Males outnumbered females by over three to one. There were day schools and evening schools. The students were enrolled in from twenty to thirty-five contact hours per week spread over a five- or six-day week. This wide variation in class load was the result of differences in the length of the total program. Some Kolleg programs were two and one-half years in length, while some evening programs were four years in duration. The annual calendars were

precisely the same as the Gymnasien. The fraction of applicants to the Kollege who were enrolled varied from 10 to 30 per cent. Most of the Kolleg students came from working class or lower-middle class families. These students were interested in passing the Abitur examination to enroll at a university or Technische Hochschule. A high percentage were interested in studying to be engineers, teachers, medical doctors, or other professions where a university education was a requirement. Depending upon the particular Kolleg, the percentage of students enrolled who successfully completed the Abitur varied from 35 to 70 per cent with an overall average of about 50 per cent.

Most of the physics students at Jackson Community College were between eighteen and twenty-one years of age. Men outnumbered women by three to one. The average class load was about fifteen contact hours spread over a five-day week. Most beginning physics courses had specific mathematics requirements for admission. Most of the students came from lower-middle to middle class families. In the beginning physics offerings, the two most frequently cited student vocational objectives were engineering and teaching, followed by medicine, dentistry, applied science, and technical careers. Seventy-two per cent of all students who enrolled in physics sequences completed them successfully.

CHAPTER V

FINDINGS OF THE STUDY--CURRICULUM

There were four major factors analyzed under the general topic of curriculum. The first factor consisted of descriptions of the various physics curricula found at each institution. The second was a determination of the level of sophistication of each physics program based on the inclusion of selected physical principles in the respective physics courses. The third factor related to the level of mathematics studied by students who were enrolled in physics, and the fourth factor dealt with a general description of the total teaching environment including the pedagogical techniques used in the instructional programs. The analyses of the four factors under curriculum are presented in the same order as the student findings in Chapter IV, that is, according to country and institution within that respective country.

Curriculum--West German Gymnasium

Although there were a variety of Gymnasium types in West Germany, only two basic types of physics curricula were observed in the institutions visited. There was a

physics curriculum for the mathematics and science Gymnasien, such as Maria-Theresia in Munich and Christoph Schreiner in Ingolstadt. The modern language, classical, and fine arts Gymnasien had a physics curriculum that was identical for all three types of schools, but significantly different from the mathematics and science Gymnasien in both depth of material introduced and duration of exposure. The basic curricula for all Bavarian Gymnasien were found in an annual publication of the Bavarian Ministry of Culture.¹ In the mathematics and science Gymnasien such as Scheiner and Maria-Theresia, physics was taken during each of the last six years of the nine-year program. Table 2 gives a summary of the physics curriculum and exposure at this type of Gymnasium.

The general approach to physics at the mathematics and science Gymnasien involved two consecutive cycles of instruction, each three years in duration.

The curricula found at the modern language Gymnasien such as Kathatinen in Ingolstadt, at the classical Gymnasien such as Reuchlin in Ingolstadt, and the fine arts Gymnasien such as Gabrielle in Eichstätt were identical and are presented in Table 3. All students were required to take physics during Gymnasium years five, six, and seven. During the last two years of their schooling,

¹Bayerischen Staatsministerium, Schulordnung und Ausführungsbestimmungen, pp. 71-79.

TABLE 2.--Physics Curriculum in the Mathematics and Science
Gymnasien in Bavaria by Year and Topic

<u>Gymnasium</u> Year	Physics Lecture Contact Hours per Week	Topics Covered
1	0	
2	0	
3	0	
4	2 + 1 ^a	Mechanics, statics, hydro- statics, aerostatics
5	2 + 1	Heat, gas laws, geometric optics
6	3	Electricity and magnetism, x-rays
7	3	Kinematics, dynamics, acoustics
8	3	Electro-magnetic waves, physical optics, wave theory
9	3	Atomic physics

^aIn years four and five there was an additional
one-hour laboratory period each week.

TABLE 3.--Physics Curriculum in the Classical Language, Modern Language, and Fine Arts Gymnasien in Bavaria by Year and Topics^a

<u>Gymnasium</u> Year	Physics Lecture Contact Hours per Week	Topics Covered
1	0	
2	0	
3	0	
4	0	
5	2	Mechanics, statics, hydrostatics, aerostatics
6	2	Heat, gas laws, geometric optics
7	2	Electricity and magnetism, wave theory
8	2 ^b	Kinematics, dynamics
9	2	Electromagnetic waves, atomic physics

^aThis was the program recently put into effect but not completely implemented in all schools because of delays due to staffing and physical facilities.

^bIf physics was elected during years eight and nine, the students had two lecture hours per week.

students were given certain options. At the Reuchlin Gymnasium in Ingolstadt,¹ the students had the option of electing physics or chemistry during their last two years. Biology was not offered as an elective. If the student elected physics, he had two class hours of physics and one hour of chemistry per week during his last two years. If he elected chemistry, he had two chemistry hours and one of physics during that same time period. According to Mr. Modesto, the students were quite evenly divided between the physics and chemistry elections during these final two years.

At Katharinen Gymnasium in Ingolstadt, a slightly modified program was presented during these last two years. A student elected to major in either physics or chemistry. If physics were elected, then the student took physics during the eighth and ninth years plus chemistry during the eighth year and biology during the last year. Each of the classes met only twice per week. If the student elected chemistry, then physics was taken during the eighth year and biology during the last year along with the two years of chemistry. There was no option to major in biology provided in the Katharinen curriculum. Approximately 75 per cent of the girls chose to major in chemistry, and the remaining 25 per cent continued with the

¹Interview, Heinz Modesto of the physics staff, Reuchlin Gymnasium, Ingolstadt, West Germany, on February 21, 1969.

physics concentration.¹ At the Gabrielle Gymnasium in Eichstätt, the students followed the same pattern as at Katharinen. Enrollments were also similar with approximately 75 per cent of the students in the chemistry concentration compared to 25 per cent in physics.²

Other general observations were made regarding the relative exposure to the sciences of biology, chemistry, and physics. For example, the mathematics and science Gymnasien students were exposed to sixteen units of physics, fourteen units of biology, and twelve units of chemistry during the total nine-year program.³ At the other types of Gymnasien, a student was required to take six units of physics, ten of biology, and only two of chemistry. He could expand the physics total to ten units by electing the additional options. One also gained the impression that there was a greater emphasis on physics over chemistry in terms of the required curriculum;

¹Interview, Ignatz Kumpf of the physics staff, Katharinen Gymnasium, Ingolstadt, West Germany, on February 4, 1969.

²Interview, Karl Hetzer of the physics staff, Gabrielle Gymnasium, Eichstätt, West Germany, on February 19, 1969.

³A unit was defined as the number of weekly class meetings extending through an entire school year. Thus the unit was equal to two semester hours or three quarter hours as commonly used in American higher education.

but when the students were given a choice during their last two years, they seemed to prefer the chemistry option.

In order to determine the level of sophistication of the physics taught at the West German Gymnasien, a series of topics in physics were used as criteria. These were topics often covered in the first-year physics courses at United States colleges and universities but not usually covered in the typical United States high school physics course. The topics were:

1. Kinematics and dynamics using the calculus
2. Maxwell's distribution and the kinetic theory of gases
3. Mathematical treatment of the magnetic effects of current flow
4. Fresnel and Fraunhofer diffraction
5. Special theory of relativity
6. Introduction to quantum mechanics

Table 4 shows the relative exposure to each of these topics at the five Gymnasien visited in Bavaria.

It was observed that even though the same topics were covered at the modern language, classical, and fine arts Gymnasien as at the mathematics and science Gymnasien, there was no question that the exposure at the latter institutions was much more rigorous and dealt with all topics at greater depth.

At this point it should be noted that the students in all West German Gymnasien had extremely long exposures to mathematics. In the mathematics and science Gymnasien, the students had four to five contact hours per week in mathematics for all nine years of their Gymnasium

TABLE 4.--Selected Physical Principles and the Year They Were Introduced at Various Bavarian Gymnasien.^a

Topic	<u>Gymnasium Year</u>			
	Scheiner	Maria-Theresia	Reuchlin	Katharinen Gabrielli
1. Kinematics and dynamics with calculus	never	never	never	never
2. Maxwell's distribution	never	never	never	never
3. Magnetic effects of electrical current flow	8	8	8	8
4. Fresnel and Fraunhofer diffraction	8	8	9	9
5. Special relativity	8 ^b	never	never	never
6. Quantum mechanics	9	9	9	9

^aThis used the numbering system of Gymnasium grades one through nine even though the Gymnasium covered total school years five through thirteen. This also assumed that the students elected physics in the eighth and ninth years where an election was possible.

^bSpecial relativity was merely introduced even though it was not a part of the standard lesson plan.

education. This experience included a range of subjects from simple arithmetic through algebra, geometry, trigonometry, modern algebra, and calculus.¹ The calculus included the integration and differentiation of transcendental functions. There was some contact with multiple integrals and partial differentials, and no differential equations. At the other Gymnasien the students had three to four contact hours of mathematics during Gymnasium years one through eight. They had no mathematics in their last year. The general topics covered included arithmetic, algebra, geometry, trigonometry, and calculus. The calculus included the integration and differentiation of algebraic functions but no contact with transcendental functions. While both types of Gymnasien provided fairly intensive mathematics programs, the mathematics and science Gymnasien tended to do more with practical applications and problem solving. It was interesting to note that there was a great deal of transfer provided between the mathematics and physics classes. This interchange was encouraged since the same instructor usually had the students for both their mathematics and their physics. There was limited use of higher mathematics such as calculus in physics, however, since by the time the students

¹Algebra included introductory, intermediate, and college algebra. Geometry included both plane and solid geometry. Trigonometry included plane and spherical trigonometry.

were well into the calculus, they had completed their kinematics and dynamics where the calculus could have most easily been included.

After some fifteen to twenty interviews with West German teachers and administrators plus sitting in some forty-five different physics classes, a rather clear picture of the physics instructional pattern emerged. The basic setting for the physics class was a lecture room with a capacity of from 100 to 200 people but containing a class of from fifteen to twenty-five students. The pedagogical approach was centered around carefully prepared lecture-demonstrations. While there was a good deal of interchange between instructor and students, the instructor adhered to a rigid schedule of what topics to cover and precisely when these were covered. It was possible to look at the standard Bavarian lesson plan and realize that every class planned to study the same topics in physics on any given day with only an exceptional deviation. Most instructors adhered to this pattern so closely that many students followed the lectures with notebooks prepared by students in classes from years gone by. This observation seemed to verify the rigidity and permanence of the lesson plans. While there were textbooks for all of the physics classes, there was great reliance on the instructor's lecture notes and the problems that the instructor assigned independent of the

problems found in the text. Since there were very few if any laboratory experiences for the students, they took data from demonstrations performed by the instructor in the lecture room. The use of films, television, and other audio-visual materials was never observed, although some instructors said they occasionally used slides or the over-head projector. Several instructors stated that they used the same techniques and created the same atmosphere they had experienced in the lectures of their own university days. The only difference between the two situations was that the Gymnasium class was much smaller and hence provided the opportunity for steady interchange between the professor and the students. Since an instructor often stayed with a class from Gymnasium years four through nine for both mathematics and physics, there was an opportunity for a very close relationship between instructor and students. Also, since the students stayed together as a class for virtually all subjects, there was a good deal of comradeship among the students. In many cases they had been in all of the same classes with the same fellow students for the entire nine-year period.

The comment was heard frequently from West German physics teachers that they wished they could expose their students to more laboratory experience. In Bavaria, students at the mathematics and science Gymnasien did get one laboratory hour each week during the first two years of their physics program. There were no other formal

laboratories built into the physics instruction throughout the remaining four years of physics. Most of the laboratory exercises performed during the first two years utilized kits of materials prepared by West German scientific equipment manufacturers. The kits contained apparatus which allowed students to perform simple experiments in mechanics, heat, and optics. The other types of West German Gymnasien visited had no formal laboratory program at all.

When asked why there was no more use of physics laboratory in the curriculum, physics instructors and administrators responded that it was simply a matter of not enough money. Physics laboratories require special rooms with special facilities. A laboratory program requires additional funds for student equipment and materials, frequently in multiple sets. A laboratory program also requires qualified teachers which would have added to the cost of staffing for physics. Thus, the conclusion was reached that the most efficient way to operate was to keep the teachers in the lecture situation, often for twenty to twenty-five contact hours per week. It was felt that at least the lecture-demonstration approach provided some minimal exposure to physics instrumentation for the students.

While a good deal of money was saved by not equipping special laboratories with multiple sets of physics equipment, all of the West German Gymnasien visited had

very impressive collections of lecture-demonstration equipment. Such items as nuclear electronics devices, gas lasers, micro-wave generators, and the full range of mechanics, heat, sound, light, and electrical demonstration equipment were available at all these institutions. Most of the instructors said that advanced students were allowed to perform some experiments with this demonstration equipment on their own time, and that this provided the best substitute for a formal laboratory program. Some of the experimental projects observed included the production of holograms, the building of an analog computer, the building and use of equipment for radio-astronomy, plus a great number of less sophisticated projects. Less than 5 per cent of the physics students at the five Gymnasien visited were involved in such special experimental projects. Thus, the informal program was regarded as less than effective. It was the concensus feeling of teachers and administrators that the physics curriculum should have included associated laboratory experiences for all students throughout the duration of their physics exposure. Many administrators felt that physics laboratories would become a part of the Gymnasien program in the very near future. Several of the chief administrators interviewed were familiar with the laboratory facilities in United States secondary schools, and the American facilities were being used as models in their planning.

One type of instructional facility that was noticeably lacking in the West German Gymnasien was the school library. Only two of the Gymnasien visited even had a room that was called a library. The most extensive book collection was found at the Christoph Scheiner Gymnasium in Ingolstadt. They had approximately 300 volumes, but the room was open only one hour each morning, and students found it much more convenient to use the Ingolstadt City Library which was open in the afternoon when the students were free.

Curriculum--West German University

The physics curriculum at the Pädagogische Hochschule Eichstätt was unique among West German institutions of higher education, and so it will be discussed first. The only physics exposure at the Pädagogische Hochschule Eichstätt was provided during a two-hour per week class elected by the students during any one of their three years at the institution. The class lasted for an entire year and thus was the equivalent of four semester or six quarter hour sequence at an American college or university. The course itself was unique in that it did not go into any physics beyond that to which a student had been exposed during a fine arts, modern language, or classical Gymnasium preparation. The function of the Hochschule course was to provide more of a review and an introduction to the methods and equipment available for the teaching

of elementary school science. Thus the students were being re-acquainted with the basic concepts of mechanics, heat, sound, light, electricity, magnetism, and some atomic physics, in that order, at a rather elementary level. Very little mathematics was utilized in the presentations. The plan of the instruction used a phenomenological approach, that is, it presented the physical concepts almost exclusively through the use of demonstrations and laboratory exercises. The facilities available for the physics program had both a lecture capability and a laboratory capability. The range of demonstration and laboratory equipment available for the limited enrollment of two classes of fifteen students each was most impressive. In fact much of the equipment appeared to be designed to demonstrate phenomena well beyond the level of sophistication of most of the students. A wide variety of teaching techniques were used in this physics sequence. Besides the lecture-demonstration and the laboratory, some of the physics classes used outside experts to lecture on certain topic areas. There was considerably use of sixteen millimeter sound film, eight millimeter silent film loops,¹ network television, closed-circuit television, over-head projection, and the use of a video tape recorder. The

¹These eight millimeter silent film loops were often referred to as "single concept" films, usually only three to five minutes in duration.

last device was used primarily to help the prospective teachers develop confidence in their technique for performing demonstrations. The syllabus for the course was developed by the individual professor, and he had a good deal of flexibility. After conversation with the professors and students and observation of the actual classes, one could not help but conclude that this was a more varied approach to physics teaching than anything observed at other West German educational institutions. Although there was no material beyond a Gymnasium level presented, many of the students commented that this physics course at the Pädagogische Hochschule Eichstätt provided a level of understanding far above that found in their previous experience.¹ The reason for this increased comprehension was not due to the review nature of the course, according to the students, but due primarily to the skill of the professor, the teaching techniques he employed, and the instructional aids available to him.

The other three West German institutions of higher education were at the university level and followed a curriculum similar to that found in American universities. At the University of Munich, there were two basic groups

¹Interviews with staff and students of the Pädagogische Hochschule, Eichstätt, West Germany, on February 12 and February 19, 1969.

of beginning physics students. The largest group was that composed of medical, dental, and pharmacy students. The second group was made up of students from physics, mathematics, chemistry, and those other students majoring in pure science. For the mathematics and physics students, the beginning physics sequence was three semesters in length, and the student entered the program during his first semester of attendance at the University. The first semester covered mechanics and consisted of two lectures per week. The rest of the student's schedule included fourteen contact hours of mathematics and five contact hours of inorganic chemistry. The mathematics was primarily analysis and a review of calculus. During the second semester, physics occupied four lecture hours per week and covered thermodynamics, electricity, magnetism, and acoustics. This term the student had only six contact hours of mathematics. It was during the second semester that the student began his physics laboratory, which took up four contact hours per week. The stated reason for the lag of the laboratory behind the lecture was that the student should encounter basic concepts first in lecture, then test them in the laboratory. However, several professors indicated that the real reason for the delay was that the greatest student attrition took place during the first semester of the student's first year. By delaying the laboratory until the second

semester, it was possible to conserve space, equipment, and staff time since fewer students needed to be accommodated.

The student also had a chemistry laboratory for four hours per week but no chemistry lecture. It was interesting to note that during the entire first year the student completed the equivalent of thirty-nine semester hours in just the three areas of mathematics, physics, and chemistry. This was in line with the assumption that a student's general education had been completed at the Gymnasium and that at the university academic specialization began immediately.

During the third semester the student continued the beginning physics sequence with two hours of lecture per week. He studied optics and quantum physics. He also carried six hours of applied mathematics for physicists and continued to have four hours of physics laboratory per week. In addition, he took six hours of engineering mechanics.

The completion of three semesters ordinarily marked the end of the first phase in a university student's career. It was at this time that he could write his first major examination called the Vordiplomprüfung or pre-diploma examination.

The level of the physics lectures for mathematics and science students was quite sophisticated. Although

several professors stated that they taught their beginning courses as if the students had never had any previous Gymnasium physics, they realized that the student with the stronger background had the greater chance for success. Their arguments for not assuming prior physics experience were based on the fact that even the students in the mathematics and science physics sequence might have had anywhere from three to six years of Gymnasium physics with a great deal of variation due to differences in Gymnasium quality, Abitur ranking, previous instructor quality, and a host of other factors. Thus the university professor assumed nothing from the student except a reasonably good mathematics background. Many of the professors interviewed felt that mathematical proficiency was far more important than previous physics experience for producing success in university physics. This may account for the extremely heavy exposure to mathematics¹ during the first semester of the first-year program.

The physics professors used calculus throughout the beginning physics sequence, and this was also a reason to demand a high level of mathematical maturity. The first sequence covered the kinetic theory of gases using the classical Maxwell's distribution; it dealt rigorously with the magnetic effects of current flow,

¹This was the equivalent of fourteen semester hours at the University of Munich during the first academic year.

physical optics including both Fresnel and Fraunhofer diffraction, the special theory of relativity, and a thorough introduction to quantum mechanics. These were exactly the six topics in physics used to gauge the level of sophistication of the Gymnasium physics program. It was evident that the mathematics and science Gymnasium graduate had a distinct advantage in the university physics over his rival who may have studied at a modern language, classical, or fine arts Gymnasium.

The two semester laboratory sequence bore amazing similarities to its counterpart in the United States. It was usually taught by a graduate student in physics. The students worked in groups of two and were expected to complete an average of two experiments per week. Formal laboratory reports were written and turned in to the graduate student instructor for grading. Each student was expected to perform approximately twenty-five experiments during each of the two semesters. The experiments were selected from the various areas of classical physics such as mechanics, heat, light, sound, electricity, and magnetism.

The second group of beginning students, composed primarily of medical and dental students, had only a two-semester sequence in physics, which they took during their first year at the university. Each semester had five contact hours of lecture per week. The first

covered the topics of mechanics, thermodynamics, and acoustics; and the second semester covered electricity, magnetism, and optics. As was the case for the science students, physics laboratory did not begin until the second semester and concluded during the third semester, even though the students had no physics lecture during the final semester. The general tone of this physics sequence was less rigorous than that for the science section. There was less emphasis on mathematics, although calculus was used freely throughout both semesters of the program. The two-semester sequence did not cover the special theory of relativity or quantum mechanics; however it did handle the other four cited topics with fairly rigorous treatments.¹ The two-semester laboratory sequence was very similar to the one for the science section. Although the students were provided a different lecture course, they performed essentially the same experiments according to the same time schedule as their counterparts in the physics and mathematics sequence.

The heart of the teaching method in physics at the University of Munich and at the other West German universities was the lecture-demonstration. Class sizes for the lectures varied between 250 and 750. The lectures

¹Kinematics and dynamics with calculus, Maxwell's distribution and the kinetic theory of gases, rigorous treatment of the magnetic effects of current flow, and Fresnel and Fraunhofer diffraction.

and the accompanying demonstrations were productions worthy of stage or screen. The professor in charge of the class was usually assisted by at least four junior instructors, several assistants, and technicians. Every lecture had several complex demonstrations which illustrated the significant points in the lecture. The overhead projector, opaque projector, and various types of film projectors were used liberally throughout all of the physics sequences. Assistants spent hours assembling and setting up the demonstrations that were used during these lectures. Because of the size of the lecture sections, there was no opportunity for any class participation. In fact, it was not unusual to see students wandering in and out during the fifty-minute period, and only the few seated near the front of the lecture hall seemed to be intent on what was happening on the podium. Professor Meyer-Berkhout at the University of Munich¹ indicated that this casual attitude of the students was something that all of the professors had learned to live with, and that he felt the only solution was to go to much smaller lecture sections.

There were no textbooks for any of the beginning physics sections at the University of Munich. The material for study consisted of the lecture notes

¹Interview, Ulrich Meyer-Berkhout of the physics staff at the University of Munich, Munich, West Germany, on April 24, 1969.

accumulated during the course. It was interesting to note that all of the references cited as outside reading for the students were popular textbooks used in American colleges and universities.¹ Professor Meyer-Berkhout commented that there were very few good German physics texts; and since all of the students had a good level of English comprehension, he had no qualms about assigning American texts as references. Some provisions were made for assisting students who desired special help. There was a designated two-hour period one evening each week when one of the teaching assistants was available to help students. Student response had been so poor, however, that there was great doubt that the sessions were providing any real assistance.

The beginning sequences in physics at the University of Erlangen were sufficiently different from the University of Munich to warrant some special comment. There were two major beginning physics sequences, one for medical and dental students and the other for science students. Each was two semesters long. Neither of them had an associated physics laboratory. The medical and dental

¹The books cited included all volumes of the Berkeley Physics Course, Modern University Physics by Richards, Sears, Wehr, and Zemansky, Fundamentals of Electricity and Magnetism by Kip, all volumes of The Feynman Lectures on Physics, and Physics by Halliday and Resnick.

physics sequence met for four contact hours of lecture-demonstration each week. In the course of the year this was equivalent to an eight semester or twelve quarter hour sequence. The same topics and the same degree of rigor were exhibited as in the comparable course at the University of Munich. These students did not begin their physics laboratory until the second year; then they spent one afternoon per week for two semesters performing a series of fairly traditional elementary physics experiments.

The science students had a two-semester physics sequence with four hours of lecture each week and two hours of recitation during the first semester. One hour per week was devoted to an orientation laboratory to acquaint the students with various measurement devices. It was not a laboratory experience in the traditional sense. During the second semester, the science students had five lecture hours plus two recitation hours per week. This sequence was equivalent to fourteen semester hours or twenty-one quarter hours using a credit hour equivalent.¹ In addition the science students took a total of ten semester hours of chemistry and twenty-two semester hours of mathematics during the first year. This

¹The University of Erlangen was considering a proposal that would add a two-hour introductory theoretical physics course during the second semester to introduce the students to special relativity and quantum mechanics.

plus the physics yielded a total load equivalent load of forty-six semester hours for the first year.

The science sequence utilized calculus throughout and covered mechanics, thermodynamics, acoustics, electricity, magnetism, and optics to the same degree as at the University of Munich. The significant differences were that the Erlangen students had more contact hours, took two semesters of physics instead of three, and did not cover modern physics and relativity. They also delayed the laboratory experience two full semesters from the beginning of the lecture course instead of one semester as was the case at the University of Munich.

The teaching program at Erlangen was essentially the same as at Munich with large lecture sections and many sophisticated demonstrations. In addition, Erlangen had recitation periods which the students were encouraged to attend. Although these were staffed by graduate assistants, attendance was good and the students participated with questions and comments to a very great extent. Professor Fleischmann,¹ of the physics staff, stated that it was felt there was greater student interest in the lecture classes since they had instituted the recitation classes. He also felt that the students found it easier to keep up and did not have a tendency to be overwhelmed

¹Interview, Rudolf Fleischmann of the physics staff, University of Erlangen, Erlangen, West Germany, on May 7, 1969.

by new lecture material. Professor Fleischmann was regarded by his colleagues as the finest lecturer in the physics department at Erlangen. During a visit to his first-year science physics class, he was observed lecturing to a group of over 350 students in a room that seated 250. The overflow stood or sat in the aisles and on the floor in front of the chairs. Most of the extra students were not even enrolled in physics but merely came to watch the master teacher in action. At the conclusion of each of his physical demonstrations, the students would break into applause. This response seemed to spur Professor Fleischmann on to greater levels of enthusiasm as he lectured on the topics for the day. He interjected anecdotes and displayed a keen sense of humor as he proceeded. While some professors felt that the large lecture class had serious disadvantages, Professor Fleischmann's success seemed to make a case for the large lecture as the only way to expose a great many students to a teacher of high caliber.

The traditional laboratory for the science physics students began during the third semester. This laboratory, or Praktikum as it was called, continued for two semesters. The topics covered in the laboratory were very much the same as found in the traditional first-year physics laboratory in an American college or university. The laboratory plan was almost identical to the program found at the University of Munich.

For the students who continued on in fields where additional physics was required, the second-year program included a two-semester sequence in atomic physics which included concepts of modern physics and special relativity.

There was a departure from the traditional university approach observed at the Munich Technische Hochschule. Although all students at this institution took physics, none of them began their physics sequences until their second semester of enrollment. The reason given was that this allowed the students to take one semester of mathematics at the Hochschule level prior to beginning their physics, and that this produced a higher probability for success in the subject. All students, both physics majors and all types of engineers, took a similar program during their first semester at the Munich Technische Hochschule. This included calculus, linear algebra, chemistry, technical electricity or technical mechanics, and an elective such as glass blowing or machine shop. The total program occupied thirty contact hours per week during the first semester. During the second semester the students continued their calculus and linear algebra; but instead of continuing chemistry, they began their physics. Physics occupied four lecture-recitation hours per week plus a three-hour laboratory per week. The remaining courses during this semester included the continuation of the technical mechanics or electricity and the elective glass blowing or machine shop for a total of thirty

contact hours. For most of the engineers, the physics sequence was completed during their third semester at the Hochschule, that is, after the two-semester sequence in physics and the accompanying laboratory. For students majoring in physics, mathematics, and electrical engineering, the physics sequence was three semesters in duration. In both sequences calculus was used freely and the traditional topics of mechanics, thermodynamics, acoustics, electricity, magnetism, and optics were covered at very sophisticated levels. The two-semester sequences did little in the areas of modern, atomic, or relativistic physics while the three-semester sequence covered these topics with some completeness. The three-semester sequence also included a rather heavy dose of introductory quantum mechanics. During the third semester of enrollment, the students had some fourteen contact hours of mathematics, which included differential equations and applied mathematics in addition to second-semester physics. The students also had an opportunity during this semester to elect one of their three liberal arts courses required during the five-year program. The total contact hour load for the student was reduced to twenty-six hours during this semester. During the fourth semester, the students taking third-semester physics also took mathematical analysis, theoretical mechanics, and the second liberal arts elective in their program. The total weekly contact load carried by the students during this semester was

twenty-two hours, which was a drastic reduction from the much heavier load carried during their first two semesters.

As in the other West German universities, the bulk of the beginning physics teaching at the Munich Technische Hochschule was done in the large lecture halls with class sizes from 250 to 800. There was a somewhat more rigid atmosphere than that observed at the universities. Class attendance was checked, and a student was required to be in the lecture at the assigned time. As in other universities, the lecture classes were very carefully produced and used highly sophisticated demonstrations, over-head projectors, opaque projectors, "single concept" films, sixteen millimeter sound films, and virtually every type of audio-visual aid. Each of the students in beginning physics was required to attend a small recitation or quiz section one hour each week, where junior professors discussed the material presented in the lectures and answered questions that the students might have had.

The physics laboratory began during the same semester as the physics lecture and was not delayed as at the universities at Munich and Erlangen. The laboratory continued concurrently with the lecture throughout each physics sequence. This meant that most of the engineering students had two semesters of physics laboratory with their two-semester physics lecture; and the students majoring in physics, mathematics, or applied science had

a three-semester physics laboratory accompanying their three-semester lecture-recitation sequence. Both laboratory sequences covered experiments of a rather traditional nature during the first two semesters. This included experiments in mechanics, thermodynamics, acoustics, electricity, magnetism, and optics during the first two semesters. During the third semester of the laboratory for science majors, most of the experiments were performed in the areas of atomic and nuclear physics.

Another deviation from the traditional approach to university physics teaching was observed at the Munich Technische Hochschule. While the reading reference list included the typical American physics books, students were required to purchase a textbook for the beginning physics courses; and it was followed more or less by the lecture professor. The text for the first two semesters of both sequences consisted of a series of paperbacks written by Professor Edgar Lüscher.¹ The course for the science majors during the third semester centered on modern atomic and nuclear physics. The professor's lecture notes and references were the primary reading material.

Although the beginning physics students were not called upon to present lengthy written assignments that

¹Edgar Lüscher, Experimental Physik I und II (Mannheim, West Germany: Bibliographisches Institut, 1966).

required large amounts of outside reading, there was a considerable need for the student to use the libraries for reference reading and study. All three West German universities and the Pädagogische Hochschule had excellent library facilities that were used extensively by almost all students, including the beginning physics students. This was in sharp contrast to the students at the Gymnasium level, where there was usually no school library; and if one existed, it was very rarely used by any of the students.

Curriculum--West German Polytechnikum

The Oskar-von-Miller Polytechnikum was located in Munich and had a variety of three-year programs each divided into six semesters. All of the curricula required the students to take some physics, and Table 5 shows the number of lecture hours per week devoted to physics in each of the eight curricula.

According to Dr. Anselm Vogel¹ the basic topic covered in the first semester in all curricula was mechanics, both static and dynamic. The second semester was devoted to thermodynamics, mechanical waves, and optics. The third semester covered electricity, magnetism, and a general treatment of complex wave motion. The civil

¹Interview, Anselm Vogel of the physics staff, Oskar-von-Miller Polytechnikum, Munich, West Germany, on April 11, 1969.

TABLE 5.--Physics Lecture Hours per Week for Each of the Curricula at the Oskar-von-Miller Polytechnikum

Curriculum	Semester					
	1	2	3	4	5	6
Mechanical Engineering	6	4	4	0	0	0
Heat, Water, and Gas Technology	4	4	6	0	0	0
Civil Engineering	2	2	0	0	0	0
Electrical Engineering	4	4	4	0	0	0
Optical Technology	6	6	6	0	0	0
Paper Technology	4	4	4	0	0	0
Architecture	2	2	2	0	0	0
Industrial Engineering	4	4	4	0	0	0

engineering students alone were not introduced to the latter topics as this curriculum had no physics during the third semester. There were great variations among curricula in the depth to which various topics were considered. The number of lecture hours per week was a good measure of the depth of consideration. (See tables.) It was also noted that many curricula included a variety of physical principles in courses beyond the third semester, but these courses did not carry physics as a title. Since all of the students enrolled were either Realschule or Gymnasium graduates, a certain prior knowledge of physics was assumed. This assumption permitted treatment of the various topics in physics at about the mathematics and science Gymnasium level. There was no consideration of the kinetic theory of gases using Maxwell's distribution, and there was very little discussion of the magnetic effects of current flow. Electrical engineering students went into this latter topic in specialized courses but not in a physics course. There was no discussion of Fresnel and Fraunhofer diffraction; but again, the students in optical technology considered these topics in specialized courses during their fourth, fifth, and sixth semesters. No curricula considered special relativity or quantum mechanics, although a nuclear technology program was under consideration that would consider all of the

above physical principles.¹ Since physics was taken during the beginning semesters of all curricula, there was little opportunity to utilize the mathematics that many students were required to take. Some curricula required mathematics through integral and differential calculus, differential equations, vector analysis, and computer programming with applications. This mathematics was woven into the advanced courses required of all students during their fourth, fifth, and sixth semesters.

The physics classes were taught in very modern facilities with excellent demonstration equipment. Classes ranged in size from forty to sixty students. All students were required to take a physics laboratory during their second and third semesters. This was true also for civil engineering students even though they had no physics lecture during this third semester. The laboratory classes were limited to a maximum of twenty students. The emphasis in the lectures was on excellent demonstrations, and there was little opportunity for participation by individual students. The lectures made use of a variety of audio-visual methods including over-head projections, opaque projections, movies, the "single concept" film, closed-circuit television, and a computer terminal located in the lecture hall.

¹Interview, F. W. Stanek of the physics staff, Oskar-von-Miller Polytechnikum, Munich, West Germany, on April 11, 1969.

In this sense the Polytechnikum was very similar to the universities. There were physics textbooks for all courses, and they were followed quite closely. There was no Ministry of Education lesson plan to follow; the plan of study was determined by the Oskar-von-Miller physics staff in consultation with representatives from the various technical departments.

The experiments performed in the laboratory were in the basic areas of statics, dynamics, thermodynamics, optics, electricity, and magnetism. The laboratory met for a two-hour period each week, and the student was expected to complete one experiment during each time period.

The Oskar-von-Miller Polytechnikum had an excellent library which was shared by students and staff. The facility was regarded with great pride by the staff, and its use was encouraged by all departments.

Curriculum--West German Kolleg

The Bayern Kolleg at Augsburg and the Munich Kolleg were day Kollege, and both followed the same curriculum as the last three years of the modern language Gymnasien. This three-year program was compressed into two and one-half years divided into five semesters at the Kollege. During the first three semesters the students were required to take physics for three contact hours per week, about the same as the Gymnasien described in Table 3.

Beginning with the fourth semester of the Kolleg, the modern language student had a choice between three hours of physics and two contact hours of chemistry or three contact hours of chemistry and two of physics for his last two semesters. This degree of emphasis compared to the options in the modern language Gymnasium during their last two years. At the Bayern Kolleg at Augsburg, approximately 60 per cent of the students elected to concentrate on physics during their last two semesters.

The Abendkolleg at Munich allowed three full years instead of two and one-half to duplicate the final three years of the comparable Gymnasium programs. Its modern language section required the students to take physics all of these last three years with three lecture hours per week. There was little chemistry taught; so the students had no option open to them as at the other Kollege or Gymnasien. The mathematics and science branch of the Munich Abendkolleg required five lecture hours of physics per week for the full three years. There was an economics branch of the Abendkolleg, and it had a physics curriculum identical to the modern language section.

There were no laboratories associated with any of the various Kolleg physics programs. The topics covered at all three Kollege and in all curricula included electricity, magnetism, theory of waves, kinematics, dynamics, electromagnetic waves, and atomic physics, in that order.

The mathematics and science section of the Munich Abendkolleg pursued all of these topics to a greater depth than the other Kollege and the other curricula. These were all standard Bavarian physics curricula, and Table 4 gives the level of exposure to the various physics principles. The Bayern Kolleg at Augsburg, the Munich Kolleg, and all three curricula of the Munich Abendkolleg had some introduction to the magnetic effects of current flow, Fresnel and Fraunhofer diffraction, and quantum mechanics. They had no mechanics with calculus, no kinetic theory of gases with Maxwell's distribution, and no special relativity.

There was some variation in the level of mathematics taught among the various curricula encountered at the three schools. The students in the mathematics and science curriculum at the Munich Abendkolleg had integral and differential calculus of both algebraic and transcendental functions. The economics and modern language curricula, along with the Bayern Kolleg at Augsburg and the Munich Kolleg, had integral and differential calculus of algebraic functions only. None of the Kolleg students had any exposure to differential equations.

The physical facilities in use at all three Kollege were far from ideal. The Bayern Kolleg at Augsburg and the Munich Kolleg were using facilities abandoned by other Gymnasien. The Munich Abendkolleg met only in the evening

and used the facilities of a day Gymnasium for girls. In all three cases, however, the basic teaching environment and the pedagogical techniques were identical to those found in West German Gymnasien. The Kollege physics programs were centered around lectures and associated demonstrations. All of the Kollege operated with very meager equipment inventories so that they were able to demonstrate only a few phenomena with low quality apparatus. The physics classes were conducted in lecture halls with capacities of 80 to 100 students. However, the physics classes observed never exceeded an enrollment of twenty students. The atmosphere was similar to the Gymnasium setting with a great deal of interchange between students and instructors. The textbooks used were the same as those used by the West German Gymnasien. The Kollege had very low operating budgets, and no audio-visual equipment or materials were observed at any of the institutions. None of the Kollege had libraries either.

Curriculum--Austrian Gymnasium

As in West Germany there were a variety of Gymnasium types in Austria, although the Austrians seemed more inclined to combine several Gymnasium types under one roof. This was due to a pattern of Gymnasium education that pervaded all of the Austrian institutions. The eight-year Gymnasium program was split into two four-year sections. The first four-year period was called the Unterstufe, or

lower level. The program in the first four years was the same for all students in all Gymnasium types. Any variations in program occurred during the second four-year level called the Oberstufe. The Unterstufe and the combination of Oberstufen were housed in the same building and under the jurisdiction of the same administration and staff. It should be noted also that the eight-year Austrian Gymnasium was in the process of giving way to a new nine-year program. The new program, though established through legislation in 1963, had not yet been put into effect. The new plan maintained the two levels, but the Oberstufe became five years long instead of the previous four years.

The types of Gymnasien visited in Austria included the Realgymnasium, which had two branches, a science branch and a mathematics branch. The only significant difference between the two was that a student in the science branch took descriptive geometry during grades five and six, and a student in the mathematics branch did not. The rest of their respective curricula was virtually identical. All six Austrian Gymnasien visited had a Real section, usually the mathematics branch. Other Oberstufe types included the Humanistisches Gymnasium, or classical curriculum with emphasis on classical languages, the Neusprachliches Gymnasium, or modern language curriculum with emphasis on English, French, and Spanish, and the fine arts Gymnasium, which specialized in the preparation

of students who planned to teach in the Austrian elementary schools. As stated in Chapter IV, the exception to the existing Gymnasium pattern was found at the Werkschulheim Felbertal located at Ebenau near Salzburg. Its nine-year program was quite unique since it combined an academic education with an apprenticeship program.

Table 6 gives the general physics curriculum and topic exposure in the Realgymnasium branches of the various mathematics and science institutions visited. The Werkschulheim in Ebenau was not included and will be separately discussed. There was somewhat of a cyclic approach to the material since several aspects of physics, namely electricity, magnetism, and optics were dealt with at two widely separated times with different levels of sophistication.

Table 7 indicates the structure and content of physics instruction at the other Gymnasium types. When one compared the two basic types of physics curricula, it was obvious that the same general topics were covered, but that there was a greater depth of topic penetration at the mathematics and science Gymnasien.

It is significant to note the exposure these same students had to the other sciences of biology and chemistry. A student at a classical language, modern language, or fine arts Gymnasium had a total of fifteen

TABLE 6.--Physics Curriculum in the Mathematics and Science Gymnasien in Austria by Year and Topic

<u>Gymnasium</u> Year	Physics Lecture Contact Hours per Week ^a	Topics Covered
1	0	
2	2	Measurement, hydrostatics, aerostatics, heat, meteorology, and acoustics
3	2	Mechanics, gas laws, magnetism, electricity
4	1	Geometric optics
5	2	Dynamics, kinematics, kinetic theory of gases, thermodynamic
6	3	Hydrodynamics, aerodynamics, non-linear motion, theory of fields, astronomy, vibration and waves
7	2	Geometric optics, special relativity
8	2	Electricity, magnetism, atomic physics, introduction to quantum mechanics

^aThere were no physics laboratory hours scheduled at any of the Austrian mathematics and science Gymnasien.

TABLE 7.--Physics Curriculum at the Classical Language, Modern Language, and Fine Arts Gymnasien in Austria by Year and Topic

<u>Gymnasium</u> Year	Physics Lecture Contact Hours per Week ^a	Topics Covered
1	0	
2	2	Measurement, hydrostatics, aerostatics, heat, meteorology, and acoustics
3	2	Mechanics, gas laws, magnetism, electricity
4	1	Geometric optics
5	0	
6	2	Dynamics, hydrodynamics, aerodynamics, kinematics, thermodynamics
7	3	Geometric optics, non-linear motion, vibration, waves, electrical charge
8	2	Electricity, magnetism, physics of particles and rays, atomic physics

^aThere were no physics laboratories at any of the three Gymnasien visited.

units¹ of biology and geography compared to twelve units of physics during the eight years at the Gymnasium. This same student had only eight units of chemistry. At a mathematics and science Gymnasium a student had nineteen units of biology and geography and ten units of chemistry, compared to fourteen units of physics. In both Gymnasium categories the bulk of the biology and geography was taught during the first four years of school; and during the last four years, the Oberstufe, all students took more physics than either biology or chemistry by a considerable margin.

Using the topic list from Table 4, the two types of curricula were compared at the Austrian Gymnasien. Since so many of the Austrian institutions were multiple branch schools, it was more meaningful to compare Gymnasium types than actual institutions. Complete consistency between types of Gymnasium and level of sophistication was observed.

Austrian students had no option during the last two years as was the case for many of their West German counterparts. It was interesting to note that the Austrians provided this heavier physics exposure

¹Once again, a unit was defined as one contact hour per week for an entire school year. Thus a Gymnasium unit was equivalent to two university semester hours or three quarter or term hours.

in an eight-year Gymnasium rather than the nine-year institutions of West Germany.

According to the observations indicated in Tables 4 and 8, the general level of sophistication in physics was as high, in fact higher, in the Austrian Gymnasien than that observed in West Germany. This observation was reinforced by many conversations with both Austrian and West German physics students and teachers. This higher level of sophistication was found also in the mathematics that the students were taking along with their physics. The mathematics was much more independent from the physics with less physical application. This lack of articulation between physics and mathematics was easily explained. Where in West Germany, the physics instructor usually taught mathematics to his physics students, this was not always the case in Austria. The certification process for physics teachers in Austria often allowed a professor¹ who qualified to teach all levels of Gymnasium biology to teach just the Unterstufe physics, that is the physics in Gymnasium years one through four. Since the same instructor did not usually teach any mathematics, this seemed to cause some lack of articulation between mathematics and physics at the

¹All Gymnasium teachers in Austria carried the title of professor unless they had received an earned doctorate, in which case their title was Doctor.

TABLE 8.--Selected Physics Principles and the Year They Were Introduced at the Various Types of Austrian Gymnasien^a

Topic	<u>Gymnasium</u> Year Covered	
	Mathematics and Science <u>Gymnasien</u>	Classical Language, Modern Language, and Fine Arts <u>Gymnasien</u>
1. Kinematics and dynamics with calculus	never	never
2. Maxwell's distribution	6	never
3. Magnetic effects of electrical current flow	8	8
4. Fresnel and Fraunhofer diffraction	7	7
5. Special relativity	7	8
6. Quantum mechanics	8	8

^aThis uses a numbering system of Gymnasium grades one through eight even though the Gymnasium constitutes actual school years five through twelve.

lower levels that was not observed in West Germany. The reason that biology professors were pressed into physics teaching was simply that physics professors were scarce and biology professors more plentiful, coupled with the fact that biology teachers had enough physics included in their preparation to handle the lower level physics offerings. During the last four years of Gymnasium, the Oberstufe, the physics was taught by people who had completed their teacher preparation with a major in physics and usually a minor in mathematics.

Physics teachers in the Austrian Gymnasien did not have preparations comparable to the West German physics teachers who had the equivalent of a double major in physics and mathematics. The preparation for mathematics teaching in West Germany was identical to the training to teach physics, since in fact the same people taught both subjects at the Gymnasium level. This was not the case in Austria. The Austrian mathematics professor had a different preparation than a physics professor; and though he often was qualified to teach Gymnasium physics, he was not always so prepared. This qualification was a function of the individual teacher's minor subject during his university training. It did not have to be physics but could have been in languages, biology, or any other academic area in the Gymnasium curriculum.

All Austrian students took mathematics throughout their entire Gymnasium tenure and in general achieved a slightly higher level of exposure in the calculus than their West German counterparts. In West Germany, only students at the mathematics and science Gymnasium had differential and integral calculus through transcendental functions. In Austria, students at all types of Gymnasien had differential and integral calculus through algebraic and transcendental functions. As in West Germany, no Austrian students had had any significant exposure to differential equations.

The teaching techniques used in the Austrian Gymnasien were very similar to those observed in West Germany. The size of the physics classes visited ranged from a maximum of thirty students¹ to a minimum of twelve students. The basic technique used in the classes was a lecture-demonstration approach. There were no physics laboratories in any of the Austrian Gymnasien; so the only contact that students had with equipment was during their lecture periods. Often experiments were set up in the lecture hall, and data were taken by the whole group as the professor, aided by one or two students, performed the manipulations on the measuring devices. Typically,

¹The Austrian federal teachers union had negotiated an agreement with the government that set a mandatory upper limit of thirty-six students in any one class.

physics classes were taught in lecture rooms with capacities of 80 to 120 students. In many ways the rooms resembled the lecture halls found in the universities with ramped seating and facilities for controlled lighting. The small classes that usually occupied such large facilities seemed slightly out of place.

Even though physics classes were conducted in rather formal facilities with a university lecture atmosphere, there was a great deal of student participation. Students asked questions quite freely concerning demonstrations being performed and were frequently called upon to recite, to answer questions posed by the professor, or to solve problems at the chalk board.

All physics classes had textbooks; but because they were considered of poor quality, the lecture notes of the professor were followed rather closely along with the text. The professors used lesson plans developed by the federal education office, but some measure of individual freedom on the part of the instructor was still allowed. This contrasted sharply with the lower level West German physics programs and seemed to follow the procedure more often found at the West German university level.

Some comment must be made concerning the general school environment in Austrian Gymnasien. The buildings were generally worn and in need of repair. The demonstration equipment, even in the large urban Gymnasien,

was usually quite old and extremely limited. The classrooms were bare and drab and rather Spartan in character. Even in newer facilities, the rooms were formal, bare, and lacking in color. In an attempt to preserve what little they had, most Austrian Gymnasien required students to remove their shoes and wear slippers to preserve the floors and keep dirt out of the school facilities. This also cut down on the noise level. The over-all school facilities and equipment were generally of a poorer quality than found even in the Bavarian schools, which were of lower quality than those in other parts of West Germany. The Austrian schools seemed to reflect the lower economic status of the country compared to that found in West Germany. In the Austrian Gymnasien there were no movie projectors, no over-head projectors, and no libraries for student use. The only libraries were maintained for instructor use, although some physics professors did encourage students to use the physics libraries maintained by individual professors and science departments.

Special comment has been reserved for the rather unique Werkschulheim located at Ebenau near Salzburg. Its nine-year Gymnasium curriculum was unique among Austrian Gymnasien. While its curriculum was basically that of the mathematics and science Gymnasium, it also included the completion of an apprenticeship for all boys enrolled at the school. The first four years, the Unterstufe, were

identical to all other Austrian Gymnasien. During the fifth year the students began their apprenticeship programs. There were three possible choices for the boys. They were cabinet making, machine operation and repair, or electronics. This apprenticeship program plus the regular four-year program of the mathematics and science curriculum were combined and finished in a five-year Oberstufe. In order to complete such a program, the student was in classes and laboratories from forty-four to forty-eight contact hours per week spread out over a six-day week. The student had two afternoons per week off, usually Tuesday or Thursday, plus Saturday. The students lived in dormitories; and each group of ten lived in a separate house and was supervised by a staff member, who also served as a head resident and as a counselor.

Because of the rather elaborate procedure that was used to select entering students, the Werkschulheim staff felt that the level of students was far superior to that found in most Austrian Gymnasien. This made it possible for the professors in physics and mathematics to enrich the courses beyond what was normally expected in other Austrian Gymnasien. The students were introduced to differential equations in their last year, and the students found a good deal more calculus being used in their physics. The facilities of the Werkschulheim at Ebenau were far superior to any found at other Austrian Gymnasien. They

had laboratories associated with much of their physics curriculum. These were the only physics laboratories observed in Austrian Gymnasien. The differences in student selection, length of school program, resident dormitories, physical facilities, and percentage of foreign students seemed to be sufficient to remove the Werkschulheim Felbertal from consideration as a typical Austrian Gymnasium.

Curriculum--Austrian University

Although some contact was made with both the University of Salzburg and the University of Vienna, most of the information on Austrian universities came from interviews conducted at the Vienna Technische Hochschule.¹ It should be noted that at the University of Vienna there was less applied physics taught than at the Vienna Technische Hochschule, and a great many more physics teachers were trained than at the engineering oriented Hochschule. The University of Vienna was very comparable to the University of Munich and the University of Erlangen in terms of general physics curriculum.

At the Vienna Technische Hochschule, the beginning physics sequences were broken into three distinct groupings. Group one consisted of the civil engineers,

¹Interview, Horst Ebel of the applied physics staff, Vienna Technische Hochschule, Vienna, Austria, on April 17, 1969.

architects, geologists, and chemical engineers. Their physics program was one year in duration. Group two consisted of physicists and mathematicians. This group took a physics sequence that was two years in duration. The third group consisted of the mechanical engineers and the electrical engineers. This physics sequence was one year in duration and was virtually identical to the program for group one. One of the primary reasons for splitting the engineers into two sections was simply that there was no lecture hall large enough to accommodate all of the first-year engineering students at one time. Unlike the Munich Technische Hochschule, the engineering students at the Vienna Technische Hochschule began their physics during the first year of study. For both groups one and three, this was a classical physics course which had five lecture hours per week with no recitations or concurrent laboratories. It covered the basic areas of classical physics and did little in the areas of special relativity and quantum mechanics. During the second year the engineering students took their physics laboratory. It met for one afternoon per week and only lasted for one semester. Each student was responsible for performing approximately fifteen classical experiments. These experiments were very similar to some of the traditional experiments performed in a first-year American college or university physics laboratory. One could not help but notice the old

and decrepit laboratory equipment at the Vienna Technische Hochschule regarded as the finest technical institution in all of Austria.

The first-year engineering student at the Vienna Technische Hochschule faced a rather formidable curriculum. The typical student had some thirty contact hours of lectures and laboratories per week. It was the equivalent of fifty-nine semester hours during the first year. Physics constituted ten hours of this commitment, mathematics fourteen hours, descriptive geometry ten hours, and statistics twelve hours. A variety of engineering courses unique to the specific type of engineering made up the remaining thirteen hours during the first year.

The students in physics and mathematics had a different curriculum and participated in a different physics program. As stated previously, their basic physics sequence was spread over the first two years. During the first year they had five hours of physics lecture and one hour of laboratory per week. The lecture was a basic classical physics course which covered the same ground as the engineering physics. The short laboratory served only to introduce the basic concepts of measurement, and no actual experiments were performed. In addition to the traditional physics sequence, these students took separate courses in geometric optics, crystallography, and mechanics. The first-year curriculum

included the equivalent of fourteen semester hours of mathematics, twelve semester hours of physics, two semester hours of optics, two semester hours of crystallography, twelve semester hours of mechanics, and six semester hours of chemistry for a total of forty-eight semester hours during the first year. During their second year, the physicists and mathematicians continued physics with some fourteen semester hours of advanced physics lectures in solid state theory, relativity, quantum mechanics, advanced electricity, and advanced magnetism. These students also took a classical physics laboratory one afternoon each week during semester one and two afternoons per week during semester two. The students performed thirty to forty traditional experiments in mechanics, sound, heat, light, electricity and magnetism during the course of this one-year laboratory experience. These experiments seemed to be of a level comparable to those found in the traditional first-year physics course at an American college or university. Similar to the situations in West Germany, several Vienna Technische Hochschule professors felt that the reason physics laboratory was delayed to the second year for economic and not educational reasons. Because they were forced to admit all Mature graduates from all Austrian Gymnasien, they experienced the greatest student attrition during the first year; and by delaying the laboratory to the second year, it was possible to

use more efficiently the meager laboratory equipment available. The rest of the second-year curriculum for physicists and mathematicians consisted of an equivalent of nine semester hours of mathematics, five hours of advanced mechanics, and three hours of strength of materials for a total of forty-three semester hours during the second year. One could not help but notice the engineering orientation of the student in a physics and mathematics curriculum. The student who was interested in a pure physics program was enrolled at the University of Vienna. With few exceptions the programs at the Vienna Technische Hochschule were very similar to the programs found at the Munich Technische Hochschule. General curriculum, length of time to acquire degrees, institutional objectives, and professor attitudes were so much the same that it was difficult to imagine that the two institutions existed in two different countries.

As in West Germany, mathematics was emphasized very strongly during the first-year programs in both engineering and applied physics. Even though all the students who entered the Vienna Technische Hochschule had a reasonably good exposure to integral and differential calculus of both algebraic and transcendental functions, their mathematics at the university level began once again with introductory calculus. There seemed to be an extremely poor quality of articulation between the Austrian

Gymnasien and the Vienna Technische Hochschule. Several professors indicated that this was a carry-over from the days when the Gymnasien did not cover as much in mathematics as was true later, and it was the institutions of higher education which had failed to modify their curricula to accommodate the advances made at the lower levels. This repetition was felt to be important to student success in engineering and physics.

The basic teaching technique in physics during the first two years at the Vienna Technische Hochschule utilized the large lecture with many and varied demonstrations. The use of closed circuit television, overhead projectors, and opaque projectors was not observed; and conversations with staff and students indicated that such devices were not available, and also that few professors had had any experience using them anyway. The lectures were centered about demonstrations using large scale equipment that allowed students to observe the measurement of a variety of basic physical phenomena. As observed in the West German universities, these demonstrations were the result of great planning; and the collection of demonstration equipment was considerably more valuable than the total equipment inventory available to first- and second-year physics students in their laboratory experiences. This seemed to be a tradition in German speaking universities. No provisions were made for

recitation, quiz sections, or study help. The students were almost completely on their own. The lecture notes plus the demonstrations were the bases for any further review and study. There were no textbooks used, and the use of reference material was not encouraged. There seemed to be a general feeling among first- and second-year students and the professors that the course material was intended to be concentrated in the notes that students took while in the lecture classes. Since evaluation in physics was only conducted at the conclusion of the first year for engineers and at the end of the second year for the physics and mathematics students, there was a tendency for students to rely on examinations given in previous years as the basis for preparation for their own infrequent evaluations.

The physics laboratories were run in such a manner that the experiments were in no way correlated to the lecture classes. The laboratory experiments were supposed to reinforce the first-year physics instruction in classical physics. Since this laboratory did not begin until the second year, after the classical physics had been completed, many students and professors expressed some concern over the relevancy of the laboratory experience. There were some professors who defended the laboratory lag on other than economic grounds. They submitted that the students could more fully appreciate the principles

to be demonstrated in the laboratory after first being exposed to the topics in the lecture. One could not help but conclude that the Vienna Technische Hochschule had less money than its counterpart in Munich, and this fact manifested itself in the more limited and older physical plant, a lack of laboratory equipment for undergraduate use, and a smaller collection of lecture demonstration equipment. The over-all observation was that the Austrian economy was lower than West German economy and that this fact showed in the commitment to technical education as well.

Curriculum--Austrian Höhere Lehranstalt

Possibly the most exciting and progressive type of education institution visited was the Höhere Technische Lehranstalt. Although two such institutions were visited, one in Salzburg and one in Vienna, they were basically the same with some slight variations in curriculum. The Salzburg institution had a unique program for textiles with mostly female students, and the Vienna institution had some programs such as aero-technology and communication technology not found at Salzburg. However, the bulk of the curriculum was common to both institutions. This included mechanical technology, electrical technology, civil technology, and architectural technology. Both institutions had continuing education programs for foremen and lead workers in a variety of trades and

crafts such as bricklaying and carpentry. These programs contained no physics, however, and were not the traditional four- or five-year programs elected by most students at both Lehranstalten. The majority of the students at both institutions were engaged in five-year programs which led to the Mature. These were the mechanical, electrical, civil, and architectural technology programs.

For all the possible curricula, there were only three different physics programs. Basically, the physics topics covered corresponded to those found during the last four years, Oberstufe, of the Austrian mathematics and science Gymnasien as in Table 6, though there was some variation in weekly contact hours from the Gymnasium program. Table 9 presents the weekly contact hours for physics instruction as a function of the various types of curriculum available at the Austrian Lehranstalten.

It was interesting to note that although the physics staff members felt that their students were not up to the level of upper division Gymnasium students, the Lehranstalt students were extremely conscientious; and virtually all of the physics students elected a two-hour per week physics laboratory during years three, four, and five of their tenure.¹ The intense exposure was necessary

¹Interview, Elfriede Waldl of the physics staff, Höhere Technische Bundeslehranstalt, Salzburg, Austria, on March 19, 1969.

TABLE 9.--Physics Curricula by Major Program in the Austrian
Höhere Technische Lehranstalten

Weekly Lecture Hours						Topics Covered ^a
Lehranstalt Year	Five-Year Architecture	Five-Year Electrical	Five-Year Civil	Five-Year Mechanical And Aero	Four-Year Electrical	
1	3	3	3	4	2	Dynamics, kinematics, kinetic theory of gases, thermodynamics
2	2	2	2	2	2	Hydrodynamics, aerodynamics, non-linear motion, theory of fields, astronomy, vibration and waves
3	1	2	0	2	1	Geometric optics, special relativity
4	0	0	0	0	0	
5	0	2	0	2		Electricity, magnetism, atomic physics, quantum mechanics

^aThe topics cited were only covered when that curriculum met during the particular year.

since the students were acquiring a fairly thorough technical education in addition to taking those subjects that allowed them to write the Mature successfully, which signified the completion of a university preparatory Gymnasium education.

From Table 9 it can be noted that not all curricula received the same exposure to various topics in the total physics offering. The students in the five-year programs in electrical and mechanical technology received the same or greater exposure to the key physical topics as those students at Austrian mathematics and science Gymnasien. Table 8 gave the breakdown on these topics. It should be noted that kinematics and dynamics were taught with some calculus in the last year of the Lehranstalten in the mathematics classes.¹ In general the Lehranstalt instructors felt that their students had received a more rigorous physics presentation and had studied most topics in greater depth than students in the Gymnasien. These same staff members had all taught in Gymnasien and were basing their opinions on their own experiences. At both Salzburg and Vienna, the respective school directors felt that the mathematics and physics faculties were extremely well integrated and that the level of cooperation

¹Interview, Manuele Gregory of the mathematics staff, Höhere Technische Bundeslehranstalt, Salzburg, Austria, on March 19, 1969.

contributed to the over-all effectiveness of the programs. The level of mathematics was above that found in the mathematics and science Gymnasien. By the time the students reached the fifth and final year in the electrical and mechanical technology programs, the students had received a good exposure to integral and differential calculus of algebraic and transcendental functions plus an introduction to linear differential equations.

In the other three curricula presented in Table 9, the students were given a less vigorous physics program. With the exception of the five-year civil technology program, the students covered dynamics, kinematics, the gas laws, the dynamics of fluids and gases, fields, astronomy, wave motion, and geometric optics. The civil technologists did not have any optics beyond that which they received prior to enrolling at the Lehranstalten. It must be remembered that all students had three years of physics prior to their admission to the Lehranstalt. An outline of this earlier physics program can be found in years two, three, and four of the Unterstufe of the Gymnasien as presented in Tables 6 and 7. The students in the four-year Lehranstalten, non-Mature programs of which the electrical program in Table 9 was an example, did not receive as complete a mathematics program as the five-year students. Their mathematics encompassed the equivalent of advanced algebra, and they received an

introduction to integral and differential calculus of algebraic functions. Generally, members of the physics staff taught some mathematics; and many mathematics teachers taught some physics. This custom was not observed in Austrian Gymnasien or the West German Polytechnikum. However, this was the situation in the West German Gymnasien.

At both the Vienna and Salzburg Lehranstalten, the attitude of staff, students, and administration was most impressive regarding their schools and the various curricula. All of the staff interviewed were most interested in experimenting with teaching methods such as using computer-aided instruction and the use of a variety of audio-visual techniques, and all seemed to have a very pragmatic attitude toward their institution. This was in sharp contrast to the university and Gymnasium physics programs found in Austria. Both Austrian Lehranstalten had optional physics laboratories that were elected by virtually all students in the various physics classes. This contrasted with the Gymnasium students who were taking parallel programs in schools which had no physics laboratory facilities. It was also interesting to note that many of the physics laboratories in both Lehranstalten had been converted from more conventional classroom spaces using student labor almost exclusively. Much of the laboratory equipment was simple, and much of it had

been constructed by students in mechanical and electronic shops right in the institutions. The general philosophy of this type of institution stressed the involvement of the student with the practical aspects and application of basic physical principles.

Most of the physics lecture classes had slightly higher enrollments than at the Gymnasien. Physics class sizes at the Lehranstalten ranged from thirty to forty-five students. The atmosphere was very informal; and although demonstrations were a large part of the lecture program, there was a high degree of student involvement. Students asked questions, answered questions posed by the instructors, and were generally encouraged to participate in the classroom discussion. Both institutions were experimenting with closed-circuit television systems that would allow the presentation of a variety of demonstrations ordinarily impossible to view in a normal lecture situation. The over-head projector was a part of the standard equipment in every classroom, and it was used extensively. This equipment was beyond that found in the Gymnasien or used in the university lectures. The school directors indicated that many extras in terms of equipment and machinery were either given by private business or were financed through private gifts. The Lehranstalt directors were the only Austrian educators interviewed who were active in raising money outside of the normal

Austrian channels for revenue, namely the usual government support. The ability to raise money was indicated as one of the necessary characteristics of a successful Lehranstalt director. Since most graduates of the two schools went directly into the business and industrial world, it was quite natural that close contacts were established with the private sector, which greatly assisted in the solicitation of funds and equipment.

Physics laboratories were set up to allow students to perform experiments in the fundamental principles of mechanics, optics, electricity, and magnetism. There were some experiment packages in mechanics and optics that were purchased from commercial equipment vendors; but many experiments in electricity, magnetism, and electronics used equipment built and assembled by the students. The general sophistication of the experiments was on a par with those observed at the universities.

Although difficult to assess objectively, the level of sophistication in the Austrian Lehranstalten physics seemed to be beyond that in the Austrian Gymnasien. This was regarded as unusual since it was generally concluded by both Gymnasium and Lehranstalt staff members that the students in the Austrian Gymnasien were academically superior to their counterparts in the Lehranstalten. When pushed for an explanation for their success, Lehranstalt staff members and students felt

that because they appealed to the mechanical and practical interests of the male students and taught physics in a practical environment, the student motivation level in the Lehranstalten was much higher than in the Gymnasien. From observation, it was concluded that the morale and motivation levels were very high among students and staff at the Lehranstalten. The fact that this was true in a school situation where the students were in classes up to forty-six contact hours per week was truly significant.

Although the Lehranstalten came under the jurisdiction of the Austrian Federal Ministry of Education as did all other educational institutions, there seemed to be a much less rigid lesson plan in physics; and instructors were encouraged to experiment in their teaching as much as possible. One found physics textbooks of both Austrian and West German origin, and a great deal of interest expressed in expanding the use of programmed physics texts and computer-aided instruction. The Vienna Lehranstalt had pioneered the use of the time shared computer in Austria as a teaching tool.¹ These were but a few indications of the kinds of approaches to education

¹Herbert Ramp, of the mathematics staff, Vienna Lehranstalt, indicated that the Höhere Technische Bundeslehranstalt, Vienna, Austria, had been connected to the General Electric computer in Cologne, West Germany, since 1968, in an interview conducted on April 18, 1969.

that seemed to make the Lehranstalten virtually unique when compared to other Austrian approaches to physics teaching.

Curriculum--Swiss Gymnasium

The Zurich Oberrealschule, being a Type C Gymnasium, had only a four and one-half year curriculum. This was a unique characteristic of all mathematics and science Gymnasien in German speaking Switzerland. The students who were enrolled in such a Gymnasium had spent an additional two years in a special secondary school prior to admission. Thus the combination of the secondary school and Type C Gymnasium totaled six and one-half years, which was equivalent to the total time spent in the Type A, classical, Gymnasium and the Type B, modern language, Gymnasium. These were the same three basic typics of Gymnasium encountered previously in West Germany and Austria. Table 10 indicates the general physics curriculum and topic exposure at the Zurich Oberrealschule and other Type C Gymnasien in German speaking Switzerland.

The second Swiss Gymnasium visited was the Freies Gymnasium in Zurich. It was a private school and was a combination of Type A, B, and C Gymnasien, with different students participating in the various curricula under the same roof and sharing many classes with students from the various programs. Thus, the information presented in

TABLE 10.--Physics Curriculum in the Type C Gymnasien in German Speaking Switzerland by Year and Topic

<u>Gymnasium</u> Year	Physics Lecture Contact Hours per Week	Topics Covered
3	0	
4	3	Mechanics, kinematics, dynamics, hydrostatics, aerostatics
5	3	Molecular physics, heat, gas laws, electricity
4	2 ^a	Magnetism, mechanical and electrical vibrations and waves, acoustics, optics
7	2 ^b	Atomic physics, quantum mechanics, nuclear physics

^aDuring the sixth and seventh year there was a required weekly physics laboratory.

^bThe last year, the seventh, was only one semester in length.

Tables 10 and 11 summarized the total physics offerings found in the various curricula at the Freies Gymnasium.

The physics program in the Type C curriculum at both the Oberrealschule and at Freies were more extensive and rigorous than the corresponding programs in the Type A and B curricula. Though the programs were of varying lengths, the Type A and B schools being six and one-half years in length and the Type C being four and one-half years in length, the basic physics curriculum was presented in the last three and one-half years in both programs. The physics survey that Type A and B students received in their second year was identical to a survey of physics that Type C students received during the last year of their special secondary school preparation. The general level of sophistication in the two types of programs can be contrasted by looking at the exposure to the selected physical principles. This is presented in Table 12.

Again for the purposes of comparison, an hour of class per week for one semester was called a semester hour. Under this system the students at the Type C schools were exposed to eighteen semester hours of physics, not counting their physics laboratory. Students in the Type A and B curricula received twelve semester hours of physics exposure plus their physics laboratory and the survey course during their second year.

TABLE 11.--Physics Curriculum in the Type A and Type B
Gymnasien in German Speaking Switzerland by Year and Topic

<u>Gymnasium</u> Year	Physics Lecture Contact Hours per Week	Topics Covered
1	0	
2	2 ^a	Survey of elementary topics
3	0	
4	2 ^b	Kinematics, dynamics
5	2	Dynamics, geometrical optics
6	2 ^c	Harmonic motion, waves, heat, electrostatics
7	2 ^d	Electrodynamics, magnetism, atomic physics

^aPhysics was taken only during the summer semester.

^bPhysics was taken only during the winter semester.

^cThere was a required physics laboratory during the winter semester.

^dThe last year, the seventh, was only one semester in duration.

TABLE 12.--Selected Physical Principles and the Year They Were Introduced at German Speaking Swiss Gymnasien

Topic	<u>Gymnasium</u> Year		
	Type A ^a	Type B ^b	Type C ^c
1. Kinematics and dynamics with calculus	never	never	7
2. Maxwell's distribution	never	never	5
3. Magnetic effects of electrical current	7	7	6
4. Fresnel and Fraunhofer diffraction	never	never	6
5. Special relativity	never	never	never
6. Quantum mechanics	never	never	7

^aFreies Gymnasium

^bFreies Gymnasium

^cFreies Gymnasium and the Zurich Oberrealschule

Another difference between the two types of basic curricula that was evidenced when the exposure to mathematics was analyzed. The students at the Type C schools received forty-five semester hours of mathematics during their last four and one-half years while the Type A and B students received only thirty-two semester hours of mathematics during this same time period. The type A and B students had mathematics for four contact hours per week every semester, and the Type C students had mathematics five contact hours per week during all semesters. In general, students had about half as many contact hours in chemistry as physics regardless of curriculum type.

It was interesting to note that even with their rather intensive exposure to mathematics, the students in the Type A and B Gymnasium programs were introduced only to integral and differential calculus of algebraic and some transcendental functions. The Type C Gymnasium students went deeper into the calculus and completed both integral and differential calculus of algebraic and transcendental functions. Type C students also had a short introduction to differential equations. In this sense they seemed to be at the level of the Austrian Gymnasium students and ahead of their West German counterparts in the mathematics and science Gymnasien. The teaching staff in Switzerland seemed to be assigned to

their subjects as found in Austria. That is, the teachers who taught physics usually taught only physics, and mathematics teachers taught only mathematics. This was in contrast to the West German Gymnasium teachers who always taught the physics and mathematics combination.

As indicated previously, physics laboratory was a required part of every student's program. At the Zurich Oberrealschule and in the Type C program at Freies Gymnasium, students had this laboratory during both semesters of their sixth year and during the only semester of the seventh year. The laboratory occupied one two-hour period each week for the three semesters. Topics for the experiments came from mechanics, heat, and electricity in the sixth year. During the last semester they investigated topics in magnetism, optics, atomic physics, and went on field trips to various industrial and research facilities in the Zurich area. The experiments were fairly elementary, and a genuine attempt was made to integrate the laboratory with the lecture portion of the physics course.¹ The physics laboratory for the Type A and B programs at Freies Gymnasium was much less extensive than for Type C students. The Type A and B laboratory was conducted during the

¹Interview, Erich Bernhard of the physics staff, Freies Gymnasium, Zurich, Switzerland, on March 6, 1969.

winter semester of the sixth year. During this one semester the students met for one two-hour period each week and were able to complete approximately fifteen elementary experiments in mechanics, heat, optics, and electricity.

As in West Germany and Austria, the primary vehicle for physics instruction was the lecture setting. At the Zurich Oberrealschule, the physics classes were conducted in a lecture room that had a capacity of approximately 100 students. However, the largest physics class at the Gymnasium was thirty students. During the classes visited, there were a variety of demonstrations performed by the instructor usually with some assistance from various students. The demonstrations used equipment of such a size that all students could collect data; and they were required to make certain calculations prior to the next class meeting. Of all the Gymnasien visited, it seemed that the physics classes in Switzerland were conducted in the most informal fashion. Rapport between students and staff appeared to be excellent, and a great deal of humor was exhibited on the part of both students and teachers. Although it was difficult to actually determine their sincerity, the atmosphere seemed to be genuine and not merely a show for the foreign visitor. When questioned about this informality, seemingly so uncharacteristic for a Germanic setting, Professor

Hablützel of the Zurich Oberrealschule staff¹ stated that it was indeed a characteristic of the Swiss Gymnasien and was somehow vaguely related to the time honored democratic heritage of the Swiss people. He stated further that Swiss instructors had a great deal more autonomy than those in West Germany and Austria and felt much more secure in their ability to be themselves in a classroom situation. Although the Gymnasien came under the jurisdiction of the Swiss Kanton, or state, there was very little interference beyond the establishment of a general topic outline for the various courses. The final examination, or Matur, was almost completely within the jurisdiction of the individual Swiss instructors so they did not feel threatened by Kanton educational authorities as the West German instructors had.

Although a private school, the Freies Gymnasium was also under the jurisdiction of the Zurich Kanton. Unlike its private counterparts in West Germany and Austria, no state funds were used at the Freies Gymnasium. All expenses for operation and capital outlay came from tuition and private gifts. The facilities at Freies Gymnasium were rather small, shabby, and in need of maintenance. Its major resource was a valuable downtown location, which was in the process of being sold.

¹Interview, James Hablützel of the physics staff, Oberrealschule, Zurich, Switzerland, on March 4, 1969.

The old facility apparently had a property value sufficient to pay for a large new school in suburban Zurich.

The physics classes at Freies had approximately thirty students in a room designed to hold twenty-four. Boards were placed between desks to gain the additional spaces. The room was very conventional compared to the terraced lecture halls found in almost all other Gymnasien in the three countries. The laboratory and demonstration equipment was extremely limited, and much of it had been hand made by Professor Bernhard. This was in sharp contrast to the facilities of the Oberrealschule, where equipment seemed in ample supply. The Oberrealschule demonstration collection was most impressive. The two lecture halls had over-head projectors and facilities for projecting sixteen millimeter sound movies. The Oberrealschule building was 100 years old, was beginning to show its age, and very little attempt was being made to maintain the facilities in top condition. The University of Zurich, which was just next door, was soon to take over the Gymnasium building; and the Oberrealschule would then occupy a beautiful new facility under construction nearby.

There seemed to be a wealth of adequate to good Gymnasium physics textbooks available for use in the Swiss Gymnasien. All of the instructors interviewed indicated that they followed texts rather closely and asked their

students to rely less on the lecture notes than was the case in West Germany and Austria. This was confirmed by the students. The instructors took pride in modifying courses to some extent to add new concepts and approaches to teaching. They felt their autonomy allowed them the security to do this without fear of sanction from higher authority.

Curriculum--Swiss University

The two institutions of higher education visited were found also in Zurich. They were Zurich University and the Eidgenössische Technische Hochschule, which was usually referred to as the Swiss Federal Institute of Technology. Probably because of their common heritage, Zurich University was very similar to Erlangen and Munich Universities in West Germany. The Federal Institute was an institution comparable to the Munich Technische Hochschule and the Vienna Technische Hochschule. Since many of the University of Zurich students in first-year physics were medical students, dental students, and future teachers, they were expected to take some course work outside of the physical sciences and mathematics during this first year. Even so, the medical and dental students tended to take primarily physics, mathematics, chemistry, and biological science during their first university year. These students took the same physics lecture as future teachers and physical science majors. It was

pointed out that the number of students who planned to major in pure physics or mathematics was small, since most students with those interests continued their education at the more technically oriented institution next door, the Swiss Federal Institute of Technology. The first-year physics sequence at Zurich University had five lecture hours per week, one problem-solving hour per week, and two laboratory hours per week extending through both semesters. It was a classical course with no topics in modern physics except a brief introduction to special relativity. Professor Waldner¹ of the physics staff stated somewhat facetiously that this was in deference to a former student and teacher at the neighboring Swiss Federal Institute, Albert Einstein.

The electricity and magnetism portion of the course covered topics up to, but not including, Maxwell's equations. The course covered kinetic theory of gases with Maxwell's distribution, Fraunhofer but not Fresnel diffraction, and quantum mechanics. Some calculus was used throughout the course but not much differential equations. For those students who required additional physics, such as teachers and pure science majors, there was a second-year atomic physics course. It was two semesters in duration and consisted of three lecture hours and one

¹Interview, Franz Waldner of the physics staff, Zurich University, Zurich, Switzerland, on March 5, 1969.

additional problem class hour per week. The topics covered in this course were advanced mechanics, advanced optics, special relativity, wave mechanics, nuclear physics, and advanced electricity and magnetism. The Bohr-Rutherford theory of the atom was not taught at all because of its questionable theoretical basis, and all atomic theory was taught strictly from a wave mechanics point of view according to physics staff reports.

Students came from a variety of Gymnasium types to the Zurich University physics program, and many of the professors felt there was considerable variation in the mathematics preparations. Accordingly, the first-year physics course assumed little in the way of calculus background, and all students were required to take a first-year mathematics sequence which reviewed beginning calculus and extended to the study of transcendental functions. The course also included an introduction to differential equations. Such a mathematics course should have been somewhat of a review for most Type C Gymnasium graduates. Professor Waldner indicated that the vast majority of the students coming into the Zurich University physics program came from Type A and B Gymnasien, and that the mathematics program was considered vital to these students' success. He stated further that the first-year physics sequence was taught in such a way that Gymnasium physics was not considered a necessary prerequisite for admission to the course.

A unique feature of the Zurich University physics program was the problem-solving class which met one hour each week during the first-year sequence. These were small classes of between twenty and thirty students, where attendance was required for all students and papers were actually collected and graded. The use of these grades will be discussed later under the topic of evaluation.

The physics laboratory met for one two-hour period each week during the two semesters. The experiments were taken from topics in mechanics, heat, optics, electricity, and magnetism and appeared to be very comparable to the experiments performed by students in the Type C Gymnasien. For such Type C students, it was admitted that most of the laboratory was repetitious.

For those students who required second-year physics, there was an additional laboratory experience. In this program students worked individually and were able to perform eleven rather complicated experiments in a variety of topic areas. The students were given very little in the way of formal directions and had to assemble much of their own equipment. Often the Zurich University students did not complete this advanced laboratory experience until their third or even fourth year. It was considered a major hurdle for the physics or mathematics major prior to receiving the Vor-Diplom approval and permission to carry on in advanced work.

The lecture classes at Zurich University were conducted in a lecture hall that had a capacity of 250 students. The room was filled for the first-year physics classes; but during the second-year class, there were only about seventy students. Even with these rather sizable groups, there was a remarkable degree of informality between professor and students. The lecture-demonstrations were still the major vehicles for presenting the basic concepts. They were very elaborate and extremely well executed. The most unusual feature of the Zurich University lectures was that students occasionally interrupted the professor to ask questions. This was the only university where such a phenomenon was observed. The professor commented that this was very common and in fact encouraged as long as it did not hold the lecture up too much. In the second-year class, with only seventy students, the informal atmosphere of the Gymnasium was observed. The most significant impression from Zurich University related to the high degree of informality between staff and students.

The situation at the Federal Institute was markedly different. The atmosphere was much more formal and a great deal more attention seemed to be directed toward basic research and much less interest given to the teaching function than was manifested at Zurich University. The Federal Institute physics program was different also

by virtue of the fact that all students had to have completed two semesters of work prior to being admitted to the beginning physics sequence. This was similar to the Munich Technische Hochschule. The initial two-semester period was filled with mathematics, chemistry, and specialized engineering subjects for those students in the various engineering curricula. Since the students had undergone a rather rigorous selection process, the one-year physics sequence was quite sophisticated. The mechanics utilized calculus and differential equations; and, in fact, calculus and differential equations were used throughout the course. Students had completed vector analysis; and especially in electricity and magnetism, vectors were very commonly used. Topics in electricity and magnetism extended through Maxwell's equations. Special relativity was introduced in this first two-semester sequence. Still the material was essentially classical physics, and modern physics was held over until a second two-semester sequence taken in the third year. This second course was not required in the engineering curricula; so only physics and mathematics majors were required to take it. It was in this second sequence that quantum mechanics, atomic and nuclear physics, and mathematical optics were covered.

The first physics sequence for all students consisted of four lecture hours plus a two-hour laboratory

each week. The laboratory experiments typically performed were similar to those performed in the Swiss mathematics and science Gymnasien and not unlike the experiments found in the traditional American first-year college and university physics laboratory. Topics in mechanics, electricity, magnetism, thermodynamics, and some in elementary optics were sampled in this laboratory experience. There was also a two-hour per week advanced laboratory associated with the second physics sequence taken by mathematics and physics majors. This laboratory dealt with fewer topics and was much more rigorous in nature. The students worked more independently than in their earlier laboratory experience and were called upon to perform experiments in modern physics and optics often utilizing electronic measuring devices. This laboratory was extremely well equipped and often borrowed equipment from various research programs. Students often were able to use this laboratory as a stepping stone to the experimental projects required for their Diplom degrees.

The teaching techniques used at the Federal Institute were very similar to those found in the German universities. The lecture classes were large, and the basic material presented was keyed around the elaborate lecture-demonstrations. Long hours of preparation by technicians and junior professors were spent in creating the proper environment for the senior professor who was the main

lecturer. He was regarded as the star and all of the auxiliary apparatus, including the audio-visual equipment was set up to be operated on his cue. Woe be it to any associate if the demonstration, film, or over-head projection did not function in precisely the planned manner. There was a much more formal atmosphere in the Federal Institute lectures than at the Zurich University lectures. There were no questions by students, and the only person to speak during the entire class hour was the lecturing professor. There were help sessions and recitation hours for all students. The students were broken up into groups of twenty-five to thirty, and problems were assigned depending upon the vocational objectives of the students. Thus chemists, engineers, and physicists had separate problem or recitation sections. This splitting of the total lecture class into separate problem groups had been a fairly recent innovation.¹ Discussions with professors indicated that the basic lecture format had not changed since long before the turn of the century when Albert Einstein had been a student there. In fact they pointed with pride to the fact that some of the same demonstration equipment that had been used when Albert Einstein was a student, almost 100 years ago, was still being used in 1969. The Federal Institute had outstanding

¹Interview, Urs Schrieber of the physics staff, Swiss Federal Institute of Technology, Zurich, Switzerland, on March 5, 1969.

library facilities, but the professors felt that beginning students rarely utilized them. Technical libraries in the various branches of physics were also maintained, but students had no access to these until they became a part of a research group and were assigned to one of the somewhat separate and autonomous institutes. These separate institutes included solid state, nuclear, astronomy, high energy, and many more. Usually students were not assigned to an institute until their fourth or fifth year.

As in Germany, textbooks were not used in the first physics sequences. The lecturing professor's notes constituted the written material in the course. Most of the references cited in the problem sessions were, for the most part, well-known American physics texts. It was conceded generally that the American texts were superior to anything available from Swiss or West German authors at this level. There did seem to be a wealth of physical resources available to the lecturing professor, and a great deal of use was made of such items as the over-head projector, opaque projector, video-tape, sixteen millimeter film, and slides of a variety of types. These were additions to the elaborate demonstrations performed before the students in the large lecture hall. The typical beginning physics lecture was a massive production involving large amounts of equipment and man power for its successful execution. The professor was the authority figure in the

entire enterprise and answered to no one on the content or treatment of his lectures, though the demonstrations available seemed to be the major factor in determining the sequence and topics covered.

Curriculum--Swiss Technikum

The last institution to be analyzed was the engineering college, or Technikum. It was found to be quite similar to the West German Polytechnikum in terms of student age, student preparation for entrance, and in the length and types of curricula offered. There were five basic curricula offered at the Technikum, all of which included physics as an integral part of the total program. These curricula were architectural engineering, civil engineering, mechanical engineering, electrical engineering with two subdivisions in heavy current and telecommunications, and chemistry. There was a department of commerce, or business, which was in the process of being separated from the Technikum, and the few students enrolled in this curriculum took no physics.

All curricula were six semesters in duration, and all included physics during at least the first two semesters. The first-semester physics occupied four contact hours of lecture per week in all curricula, but the topics varied considerably depending on the program involved. Thus students were strictly segregated in their physics classes according to their curriculum.

Table 13 shows the variation of topics covered in the first-semester physics as a function of curriculum.

Table 14 shows the number of lecture hours per week devoted to physics in each of the six curricula at the Technikum.

As indicated in Tables 13 and 14, there appeared to be many similarities among the curricula in terms of a commitment to physics. The notable exception that occurred was the chemistry program, where there was a heavy concentration on physics during four full semesters rather than the two, or at the most three, semesters in the other curricula. While all curricula had a year and at most two years of physics, most curricula covered a range of topics closely related to those in physics in other related courses. For example, the mechanical engineers had three semesters of physics during which they covered no topics in electricity and magnetism; but their curriculum included four semesters during which they had additional courses in electricity and magnetism under the title of electrical engineering. This was true of the other types of engineering and included not only topics in electricity and magnetism, but also heat and thermodynamics. Separate courses for these topics were included in all curricula except chemistry.

The two-semester physics sequence taken by all students was geared to the individual curriculum. This

TABLE 13.--Topics Covered in First-Semester Physics as a Function of Curriculum at the Technikum Winterthur^a

Curriculum	Topics Covered
Architectural Engineering	Equilibrium, vectors, center of gravity, work, power, simple machines, statics of fluids, capillarity, statics of gases, heat, temperature, specific heat, heat and work
Civil Engineering	Scalars, vectors, kinematics, static and kinetic friction, statics of fluids, statics of gases, conservation of energy, gravitational attraction
Mechanical Engineering	Statics of point mass and rigid bodies, dynamics of point masses, circular motion, Newton's laws, mass systems, gravitational laws, work, power, efficiency
Electrical Engineering	Vectors, kinematics, circular motion, dynamics of point masses and rigid bodies, statics of solids, statics of liquids, statics of gases.
Chemistry	Vectors, statics of mass points and solid bodies, introduction to electricity, kinematics, dynamics of point masses

^aIn all curricula, the first-semester physics had four lecture hours per week.

TABLE 14.--Weekly Lecture Hours in Physics for Each of the Curricula at the Technikum Winterthur

Curriculum	Semester					
	1	2	3	4	5	6
Architectural Engineering	4	3	0	0	0	0
Civil Engineering	4	5	0	0	0	0
Mechanical Engineering	4	5	2	0	0	0
Electrical Engineering	4	6	0	0	0	2
Chemistry	4	4	4	6	0	0

was done by adjusting practical examples and applications of the basic physical principles consistent with the particular professional group in that class. However, the list of topics in the first year was fairly similar among the various curricula; and, basically, the first-year sequence covered vectors, kinematics, statics, some dynamics, some geometric optics, mechanical waves, and acoustics. It was noted that such classical physics topics as electricity, magnetism, heat, and thermodynamics were absent, though they were covered in other courses. Only the architectural engineers dealt with heat in their physics program. The only curricula which covered any topics in atomic and nuclear physics were for electrical engineers where these topics were covered during the sixth semester and for chemists during their fourth semester.

Only the chemists had any physics laboratory. During their third, fourth, and fifth semesters, one

afternoon per week was devoted to a laboratory with experiments in the areas of general measurement, work and energy, voltage and current measurement, thermo-electricity, galvanometer, capacity, calorimetry, polarimetry, and measurement of radioactivity. Most of the experiments were those that had applications in the chemical industry and paralleled the procedures found within the industrial community.

The rigor of the physics classes seemed to duplicate that found at the Gymnasien. As to the physical topics used to judge sophistication, there was no calculus used in any physics courses. Maxwell's distribution was not covered in any of the various physics curricula. There was very little discussion of the magnetic effects of current flow included in the physics courses, but this was covered in some depth in the specialized electrical engineering classes taken by all students except the chemists. There was no discussion of Fresnel or Fraunhofer diffraction or special relativity. Only the chemists had some exposure to an introduction to quantum mechanics, and this was of a very qualitative nature. There was a statement that the general level of the physics courses was going to be raised and that physics

laboratory was to be included in every one of the curricula. Both of these changes were expected in the near future.¹

Mathematics was taught in all curricula through the first five semesters. Topics included college algebra, trigonometry, differential and integral calculus, differential equations, Fourier series, Laplace transforms, boundary value problems, and numerical analysis using the computer. Most of the mathematics was covered after completing the physics sequences so that it made little contribution to the sophistication of the physics courses. It was noted, however, that this mathematics program was much more rigorous than the Gymnasium mathematics programs, even those at the mathematics and science Gymnasien. Also it should be noted that the mathematics was very heavily geared toward applications and was not taught from a highly theoretical point of view.

Most of the physics instruction was done in the lecture hall setting with a great emphasis on demonstrations. An average of four to six demonstrations were performed during each lecture hour. Although the classes were conducted in a lecture hall which had a

¹Interview, Hanspeter Stump of the physics staff, Technikum Winterthur, Winterthur, Switzerland, on March 4, 1969.

seating capacity of 180 students, the physics classes varied in size from only fourteen to twenty-five students. The Technikum at Winterthur was one of the few institutions visited that used the eight millimeter, closed loop, "single concept films" to any great degree. They were used both as a part of the lecture program and also as an option for the students to utilize on their own time. The physics lectures used a wide variety of audiovisual aids including closed-circuit television, overhead projectors, opaque projectors, sixteen millimeter sound films, and a number of ingenious projection devices to assist in the viewing of certain demonstrations. The television equipment was often used to allow the physics students to view processes and applications from surrounding industrial plants. There was a great deal of industrial research done in the immediate area of Winterthur, and the Technikum tried to keep the students abreast of this research when possible.

One of the few weaknesses discussed by the Technikum physics staff was the lack of appropriate textbooks for applied physics courses as taught at their institution since there were no German texts and few English texts appropriate to their needs. The main resources consisted of the professor's lecture notes and reference books which were primarily from the United States and were housed in the very excellent library at the Technikum.

This was a profound difference noted between the Technikum and the Swiss Gymnasien. The Technikum used its library while most Gymnasien had no libraries; so obviously the Gymnasien students were not encouraged to develop any skills using the library. The lesson plans used by the professors at the Technikum were largely developed within the institution, and there was no interference from the Kanton or from the federal government. The traditional Swiss autonomy was observed within the Technikum as it had been observed in the other Swiss educational institutions.

Curriculum--Jackson Community College

Since Jackson Community College was a comprehensive institution with a variety of programs, only those curricula that contained physics were analyzed. Even for those students who had physics as a specific requirement, the physics occupied a small part of their total two-year program at the institution. Those who had the greatest commitment to physics were the students who were required or elected to take either of the one-semester physics courses in the Jackson Community College offerings. Table 15 gives an outline of the physics courses at Jackson Community College with some additional descriptive data.

From Table 15 it should be noted that the total physics program broke down into four basic components.

TABLE 15.--Physics Offerings at Jackson Community College

Course Title	Duration in Semesters	Mathematics Pre-requisite	Usual Enrollment Year	Lecture Hours per Week	Laboratory Hours per Week
Physical Science	1	one year high school algebra	1 or 2	3	2
Technical Physics	2	trigonometry	2	3	3
Astronomy	1	plane geometry	1 or 2	3	2
College Physics	2	trigonometry	2	4	3
University Physics	2	one year calculus	2	5	3
Modern Physics		differential equations	3 or more	3	0
Nuclear Reactor Physics		differential equations	3 or more	3	0

One part consisted of the Physical Science and Astronomy courses, which were classified as general education in nature and for the most part were elected by students to satisfy general education requirements in physical science imposed upon them by senior institutions where they planned to transfer. One of these courses was also required in many elementary teacher preparation programs.

The next group of courses included the College Physics and University Physics sequences. These courses were called the college-parallel group since they duplicated the traditional first college physics sequences at most colleges and universities in the United States. The College Physics course was usually taken by students who intended to continue their education in medicine, dentistry, law, and other professions. The University Physics course was for students who intended to continue their educations in engineering, physics, mathematics, chemistry, or other professions related to the physical sciences.

The Technical Physics sequence was taken by those students in the terminal-technical programs. These students completed their education at the end of two years at Jackson Community College and entered business and industry rather than continuing their educations at senior institutions. The technical curricula included electrical technology, industrial or mechanical technology, drafting technology, and x-ray technology.

The continuing education courses included the Modern Physics and Nuclear Reactor Physics sequences. They were not considered as typical in the first two years of an undergraduate curriculum and were taken by people in the Jackson community who had already received at least their bachelor's degree. Most enrollees were engineers from local industries and science teachers from area junior and senior high schools.

Excluding the continuing education courses and the Astronomy course, there were four courses or sequences that could not be regarded as special purpose courses; and these were compared as to their sophistication using the basic physics topics previously cited as criteria. The Astronomy course was not regarded as a general physics survey course and was not included in the table for comparison even though the course included some mechanics and special relativity but none of the other topics used to measure course sophistication. The continuing education courses were excluded because they were well above the sophistication of the first-year sequences.

All four physics programs had weekly laboratories as indicated in Table 15. Basically the topics covered included vectors, kinematics, statics, dynamics, thermodynamics, acoustics, electricity, magnetism, optics, special relativity, and topics in modern physics. The amount of time and the depth of penetration into each

TABLE 16.--Selected Physical Principles as Covered in Four Physics Sequences at Jackson Community College

Topic	Physical Science	Technical Physics	College Physics	University Physics
1. Kinematics and dynamics with calculus	no	no	some	yes
2. Maxwell's distribution	no	yes	yes	yes
3. Magnetic effects of electrical current flow	yes	yes	yes	yes
4. Fresnel and Fraunhofer diffraction	no	some	yes	yes
5. Special relativity	yes	yes	yes	yes
6. Quantum mechanics	some	some	yes	yes

topic varied from course to course and with the instructor who happened to be teaching the course at any given time.

The laboratory programs varied as a function of the course. The Physical Science course, being one semester in duration, allowed the students to perform some fourteen to sixteen experiments ranging over the topics cited in the lecture, plus additional experiments in cryptography, problem solving, and scientific method. The laboratory in the Technical Physics sequence covered the same topics but concentrated more on the techniques of measurement which the student would encounter in an industrial situation.

The laboratory in the College Physics and the University Physics was a less structured experience and oriented more toward problem solving. The first semester of both laboratories was fairly traditional in terms of content and method of operation. Topics covered included mechanics, thermodynamics, and acoustics. The equipment available was more plentiful and sophisticated than observed anywhere in Europe. Such devices as the linear air tracks, Polaroid cameras with stroboscope attachments, falling body systems with electronic timers, ballistic pendula were available in sufficient quantity to allow twelve groups of two to perform experiments simultaneously. During the second semester, students could elect to proceed into experimental areas of their own interest. Thus students were able to perform experiments such as making holograms with the gas laser, nuclear magnetic resonance, electron spin resonance, neutron activation, and a wide variety of experiments in nuclear spectroscopy. Those students who elected a traditional topic sequence performed experiments in electrical and magnetic measurements, geometric and physical optics, and in nuclear and atomic physics.

It was felt rather generally that the laboratory which was in phase with the lecture was an integral part of all physics programs. Even the Modern Physics and the

Nuclear Reactor Physics sequences had laboratory experiences integrated with the lectures. This was possible since both courses had enrollments of no more than fifteen students, which allowed for considerable flexibility in presentation of topics.

The major part of the physics instruction in all classes was done in a lecture-recitation setting. The largest lecture class had an enrollment of thirty-five students established by mutual agreement between the administration and the physics staff. This small class situation allowed for the lecture, demonstrations, problem solving, and recitation in the same class setting. Laboratories had a maximum enrollment of twenty-four students, and the same instructor who lectured also had the laboratories associated with that course. A typical instructor load then was two lectures and three laboratories. This was felt necessary to establish and keep maximum rapport between students and instructor.

In the lecture portion of all courses at Jackson Community College, there was a great emphasis on the use of visual materials such as the over-head projector for problem solving and slide presentations. Also used to a high degree was the eight millimeter, "single concept," closed film loop projector. This device was used in the lecture and then made available to all students in one of the laboratories so that students were able to view films repeatedly at their convenience. The physics department

at Jackson Community College had over 100 different "single concept" films on a wide variety of topics. There was much less emphasis on demonstrations in the lecture classes than found in the European educational institutions. When the Jackson Community College instructors were queried on this, they responded that they had had few demonstrations in their own physics education and relied on the laboratory to carry the demonstration load.¹ They stated further that they used demonstrations far in excess of anything to which they had been exposed in their own undergraduate physics preparation.

It was noted that one of the courses, the Astronomy course, was taught on a team basis with three of the physics teaching staff cooperating in its presentation both in the lecture and the associated laboratory.

In several of the physics courses, all of the students were encouraged to use the time sharing computer in the solution of problems encountered in the lecture and laboratory. Most of the students in the University Physics sequence had taken a course in Fortran IV and could program sufficiently well to use the computer to some advantage. These students were encouraged to share this knowledge with other students who had not had a formal course in computer programming.

¹Interviews, Lawrence Hitchingham and Hilton Abbott of the physics department, Jackson Community College, Jackson, Mich., on June 30, 1969.

Most of the staff felt that there was such a wealth of excellent textbooks available for all courses and that one of the greatest problems the instructor faced was selection of the best one for any course. A particular difficulty was expressed related to the selection of a text for the Astronomy course. The solution was the selection of four different paperbacks. The instructors for the course felt this gave the needed variety and yet kept the textbook cost down to a minimum.¹

Each instructor was given a free hand to develop and present each course in his own way. Consultation came only at the request of the instructor and was available from the department head or other staff members. The staff felt that there was complete autonomy within the department. This autonomy seemed to exceed that observed even in Switzerland and certainly was a contrast to both West Germany and Austria.

Curriculum--Summary

Of the various types of Gymnasien found in the three European countries, there were only two basic physics curricula. There was the mathematics and science physics curriculum which required the students to study physics at a more concentrated level than that

¹Interview, Charles Leonard of the physics department, Jackson Community College, Jackson, Mich., on June 28, 1969.

found at the modern language, classical language, economics, and fine arts Gymnasien. Regardless of curriculum, however, all students took physics for several years. In all Gymnasium curricula in the three countries, the topics studied in physics were virtually the same except that in the mathematics and science curricula they were covered in greater depth. In fact, in the mathematics and science curricula the topics were arranged in two three-year cycles, which meant that the students were exposed to the same topics twice during the last years of their Gymnasium program. The students in the other curricula had only one exposure to the same material spread over a five- or six-year period, and they met for fewer lecture hours per week. There was some variation in the exposure to the six physical principles used as criteria. The Swiss and Austrian Gymnasien students were exposed to more sophisticated topics in physics than their West German counterparts. The levels of Gymnasium mathematics were virtually identical for the same basic curricula. With few exceptions, the mathematics and science students had calculus through transcendental functions, and the students in the other curricula had calculus only through algebraic functions. The Gymnasium classes were small, usually under thirty students, but conducted in a lecture-demonstration atmosphere. There was a good deal of interchange between students and instructors in the

classroom. Few of the Gymnasien had any significant commitment to physics laboratory programs and did not support libraries. All of the Gymnasium physics programs relied in some measure on textbooks.

Since the universities and Technische Hochschulen admitted students from all Gymnasien, they felt it necessary to begin their physics programs beneath the level that might have been expected and reviewed many concepts already covered in the Gymnasium experience. After the brief review, the university and Technische Hochschule beginning physics sequences progressed quickly to much more sophisticated levels than that of the physics found in the Gymnasien. Almost all of the university and Technische Hochschule beginning physics was taught assuming calculus and, in many cases, differential equations as pre-requisites to the courses. This was made possible in some instances by delaying the start of the beginning physics sequence until the student's second or third semester. All of the university and Technische Hochschule beginning physics sequences had associated laboratories. Students at the universities began the physics lecture sequences during their first year, but normally delayed the associated laboratory for one to two semesters. The Technische Hochschulen generally delayed the beginning of the physics sequences one to two semesters. They then usually ran the laboratory in phase with the lecture

portion of the courses. The most dramatic aspect of the beginning physics sequences at both the universities and Technische Hochschulen was the elaborate demonstrations performed in the lectures. These grand productions consumed a great deal of time and effort and utilized large quantities of highly specialized equipment. The demonstrations were a source of great pride to the lecturing professors.

Textbooks were rarely used in these beginning sequences. The professor's notes constituted the basic written material in the course. Rarely were any assignments made to the students, and there was very little interaction between students and the lecturing professor. Lecture classes were large and formally conducted. It was in the laboratory classes that smaller numbers of students were grouped under the direction of junior professors and graduate students. All of the universities and Technische Hochschulen had excellent library facilities, and beginning physics students were encouraged to use these facilities.

The engineering colleges of the three European countries had many characteristics in common. This was particularly true between the West German Polytechnikum and the Swiss Technikum in terms of age group served, entrance requirements, and in the level of sophistication of the physics taught. The Austrian Höhere Lehranstalt

was significantly different in terms of the younger age group that it admitted, its different entrance requirements, its five-year instead of three-year programs, its granting of the Mature at the completion of the program, and the fact that its graduates did not receive an engineering title upon graduation. The Höhere Lehranstalten were similar to their West German and Swiss counterparts in terms of the type of engineering programs offered, the amount of physics required in corresponding curricula, but with slightly less sophistication in the physics taught in the various engineering curricula. The sophistication of the physics taught was generally higher than that found in the mathematics and science Gymnasien of all three countries. The mathematics encountered by the students at the engineering colleges usually included some differential equations, but this was taken after the physics portion of their total curriculum was completed. The physics was taught in lecture classes that did not exceed forty-five students. Considerable use of demonstrations, films, closed-circuit television, and computers was found at all of the engineering colleges. All of the physics programs had associated laboratories. The application of physical principles to the various engineering specialties was an important theme throughout the various physics sequences. While libraries existed in all of the engineering colleges, physics students did not appear to utilize them to any great extent, but rather

used lecture notes, textbooks, and laboratory materials to fulfill their class obligations.

Little was found in the physics programs of the Kollege to distinguish them from the last three years of the West German Gymnasien that they were designed to duplicate. The only noticeable differences were that the Kollege had less in terms of resources and were housed in older buildings than the Gymnasium. Also, the day Kollege compressed the last three years of the Gymnasium program into a two and one-half year time period, which shortened the physics offerings somewhat. Although a few of the West German Gymnasien had physics laboratories and libraries, neither were found at the Kollege.

There were four major divisions within the physics offerings at Jackson Community College. The divisions were the general education courses, college-parallel courses, the terminal-technical course, and the continuing education courses. A student elected the respective physics course depending upon his vocational objective and whether or not the student possessed the mathematics background that the course required for his enrollment. The sophistication of the beginning physics sequences varied significantly among the general education, college-parallel, and terminal-technical courses. Again, this level of sophistication was more dependent upon the mathematical background of the student admitted than whether or not the student had had any physics previously.

These mathematics pre-requisites varied from one year of high school algebra for one of the general education courses to one year of calculus for the University Physics sequence. All of the beginning physics sequences had associated laboratories. Lecture classes varied in size from ten to thirty-five students. There was great emphasis placed upon class recitation, problem solving, use of the textbook, and audio-visual materials in the classes. Demonstrations were performed infrequently. Physical facilities were excellent, and the physics department possessed a great quantity of demonstration and laboratory equipment. Library facilities were good but rarely used by beginning physics students.

CHAPTER VI

FINDINGS OF THE STUDY--EVALUATION

There were three basic types of evaluation processes encountered at all of the types of institutions in each of the respective countries. These evaluation processes were evaluation at entrance, evaluation in physics while matriculating at the particular educational institutions, and the evaluation process experienced at the conclusion of that particular program in physics.

These three types of evaluation processes were analyzed according to country and institution similar to the presentations in Chapters IV and V. The order of the West German institutions was altered slightly, and the Kolleg is discussed immediately after the Gymnasium because of the many similarities in evaluation processes.

Evaluation--West German Gymnasium

In discussions with Land and federal officials plus the observations made and interviews conducted at the five West German Gymnasien, it was obvious that there was a high degree of uniformity in entrance testing at all West German Gymnasien. The two-day entrance

examination was scheduled in the spring of the year, usually in May or June. Students in the fourth grade of the elementary schools who desired entrance at a particular Gymnasium spent one day taking a written and an oral German language test. On the second day the students were given a typical lesson in mathematics; and following this, they were given a short written examination on the material covered in the lesson. When there was a question about a student's ability to enter, that student was scheduled for an interview with some of the Gymnasium instructors; and they made the final determination as to the student's qualifications to be enrolled. As mentioned previously, approximately 90 per cent of the students who applied were admitted. There was no physics required in this entrance examination process, and it was interesting to note that there were only two areas covered in the entrance testing: language and mathematics. There were no psychological, aptitude, personality, or interest tests utilized in the entire process. This concern over mathematical skills pervaded the entire Gymnasium environment and seemed to help set the stage for the significant commitment to physics regardless of the type of Gymnasium enrolling the student.

Within the actual physics classes, there was an informal and a formal evaluation process. Each year was broken into two halves or semesters. At the conclusion

of a semester, a formal examination was administered by the physics instructor. Usually this examination consisted of five to eight problems, and the student was allowed sixty minutes to complete the examination. This final examination plus the instructor's evaluation of the student's recitation, laboratory experiments, if any, and occasional short tests constituted the basis for the student's grade. However, the final examination accounted for well over half of the credit toward the semester grade. At the conclusion of the two-semester school year, a final grade was calculated for the student in each course. The grading system ranged from one to six inclusive, with a one constituting the highest grade and a six indicating failure. If a student received a six in any subject, this not only constituted failure in that subject; but the student was forced to repeat the entire year's work in all subjects. A five in a course was considered a probationary grade; and when a student received fives in two or more subjects, this also was considered a failing year; and the student was forced to repeat the entire year's work. The only official grades that were posted on the student's permanent record and sent home to the parents were the annual grades. This annual grading system was completely under the jurisdiction and control of the instructors at the Gymnasium.

The Abitur in Bavaria was developed and administered completely by the Bavarian Ministry of Culture. The individual instructors had nothing to say about its content. The instructor's only responsibility was to administer the test and submit it to the Ministry of Culture for grading. In other West Germany Länder, there was a committee of instructors who assisted the Ministry of Culture in the preparation of the test. This was not the case in Bavaria, and the system received rather severe criticism from all of the Bavarian physics instructors interviewed. The Abitur in physics was administered during late May or early June and took an entire day to write. Again the grading system ranged from one to six, with six constituting failure. A student could receive a five and still pass the entire Abitur as long as he received four or better in the other test subjects. Two or more five's meant the student had failed the entire Abitur, and he was required to repeat the testing process, usually the following fall. If the student failed again, he was required to repeat his last Gymnasium year and successfully pass the Abitur before being eligible for university admission.

There were some exceptions to the above procedures which are worthy of discussion. First, a student at a mathematics and science Gymnasium wrote a different Abitur than a student at a modern language, classical language,

or fine arts Gymnasium. The usual procedure at the mathematics and science Gymnasium was for the student to write his foreign language portion of the Abitur, usually English, at the conclusion of the twelfth school year. Then at the end of the thirteenth and final year, he would write the German, mathematics, and physics portion of the Abitur. Thus if a student failed his English the first time, he was allowed to repeat it at the end of his final year and not lose any time. Until the year 1967, all Bavarian students were required to write the Abitur in religion. This was discontinued following a trend established earlier in the other West German Länder to discontinue testing religion, although religion was still a required subject in most Gymnasien.

The students in the modern language Gymnasien followed a different procedure. They too were required to write the Abitur in only four subjects, but they wrote their mathematics examination at the conclusion of their twelfth year and the German and their two modern languages at the conclusion of their thirteenth and final year. These students wrote no Abitur in physics.

At the fine arts Gymnasien, the students wrote their mathematics examination at the end of their twelfth year; and they wrote the Abitur in German, English, and Latin at the end of the thirteenth year. Each of these students was also required to take a special final

examination in voice and the musical instrument of his choice. Beginning in the year 1970, each student was required to write the Abitur in music theory or art. None of the students at the fine arts Gymnasien wrote the physics portion of the Abitur. The students at the classical language Gymnasien wrote no physics Abitur either. Even though all students at all Gymnasien were required to take physics sometime during their Gymnasien education, only the mathematics and science Gymnasien students were required to take the physics portion of the Abitur. The physics portion of the Abitur satisfied no specific university admission requirement, not even at the Munich Technische Hochschule. However it was recommended that students who planned to attend the technical universities should secure their Gymnasium education at the science and mathematics institutions where the physics Abitur was a requirement.

Generally the taking of the Abitur was regarded as a very traumatic experience by the Gymnasium students. The examinations were scheduled during a one-week period in late May or June with each subject taking one full day. If a student had successfully completed one of the exams previously at the end of his twelfth year, it meant he looked forward to a minimum of three days of rigorous examinations. All students wrote the same examination questions on the same day. The examination envelope

was opened before the students by the instructor who had also not seen the examination until that moment. The physics examination was similar to the language examinations in that it had an oral as well as a written portion. There was dictation to take down and oral responses to give to certain questions. Usually there were five hours of mathematical problems covering the full range of the student's physics experience plus oral responses to more qualitative questions. It was not always completely new, however; since during the entire thirteenth year, two hours per week had been devoted to the solution of typical Abitur problems under the tutelage of a physics instructor. The practice questions came from previous examinations and nearly always covered the same topics to the same degree as the Abitur prepared by the office of the Ministry of Culture for that particular year. This was a comment from several physics instructors. Although they objected to the fact that they could not help in the preparation of the examination, they did note that the office of the Ministry of Culture was a creature of habit; and the examination looked almost the same year after year. The instructors seemed to team with the students and to look on the Ministry of Culture and the Abitur as the enemy which they had to defeat together. The instructors and students were quite successful when one notes the percentage of examinees who passed the

Abitur. Even though the students were terribly anxious about the Abitur, over 95 per cent passed the total Abitur the first time; and something like 98 per cent passed the physics Abitur the first time.¹ The instructors and the Ministry of Culture regarded the Abitur as somewhat anti-climactic following the conclusion of the thirteenth year. Also since the grades in the various parts of the Abitur had no bearing on university admission, there appeared to be no value placed on a good Abitur ranking versus a poor one. In addition to the written and oral portions of the four major topics in the Abitur, all students were required to take oral examinations in the subjects of geography, history, and social science as a part of their Abitur.

Evaluation--West German Kolleg

The evaluation process in the Kollege was exactly the same as in the various types of Gymnasien. The admission situation was somewhat different as previously explained. The entrance examination was different from the Gymnasium entrance testing to account for the age and prior education of all Kolleg applicants. Also the Kolleg entrance examination included English in addition to the Gymnasium entrance topics of German and mathematics.

¹Interview, Otto Martz of the Bavarian Ministry of Culture, Munich, West Germany, on February 7, 1969.

The examination and grading system within the two and one-half year curriculum was the same as found in the last three years of the various Gymnasien. Examinations in all subjects, including physics, were taken each semester and official grades were assigned each year. Only those students in a mathematics and science curriculum of a Kolleg were required to take the physics portion of the Abitur. Those who did wrote the same examination on the same day as their Gymnasium counterparts, and the tests were all graded together by the Ministry of Culture. At the point when the student successfully completed the Abitur, the Kolleg student was regarded as identical to the Gymnasium graduate by the universities. Kolleg students in the various types of programs such as modern languages and classical languages wrote the Abitur in the same subject areas as if they were enrolled in the respective types of Gymnasien.

The Telekolleg was different in the sense that there was no intermediate evaluation and no evaluation to determine admission. The only examinations administered were the final examinations, which, when completed, entitled the student to the middle school certificate called the Mittlere Reife.

Evaluation--West German University

It was in the Hochschulen and universities that a consistent pattern of evaluation was observed that was

significantly different from the United States college and university system based upon credit-hours.

The situation observed at the University of Munich appeared to be fairly typical of the procedures at Erlangen University as well. As indicated previously, the only criterion for a student to be admitted to a physics curriculum or any curriculum that required physics was successful completion of the Abitur. After the student was admitted to the physics class, there was no formal evaluation in the course; and no grades were assigned. The first examinations were administered after four or five semesters. This battery of tests was called the Vor-Diplom, or pre-diploma, examinations and covered all of the material the student had taken in those specific classes required in his particular curriculum during the two or three years of university work. In the case of the physics or mathematics major, the student was subjected to three days of written and oral examinations in physics, mathematics, and chemistry. The tests covered both lecture and laboratory experiences. These tests were administered by the department of his major curriculum and had to be completed successfully before the student could continue on to more advanced work in an area of specialization for both course work and experimental research. In addition, the tests were used as a counseling device since they indicated areas of strength and weakness. This allowed

the professors and the student to select the most promising areas for concentration as the student proceeded toward the Diplom certificate. If a student indicated a severe weakness in any area, he was required to attend the appropriate lectures and take the tests again. When the weakness was not too severe, it was suggested that the student make the necessary course adjustment to rectify the problem, and it was not necessary to repeat the examination. The system bore a remarkable resemblance to the procedure used by many American university physics departments in developing the program of a doctoral candidate.

An exception to the typical West German university evaluation process was noted for those students who were recipients of federal scholarships. Those students had to successfully pass annual examinations in all subjects to maintain their scholarships. These examinations were administered by the individual departments. This meant that a physics major would take examinations from the departments of mathematics, physics, and chemistry at the end of the first year. This contrasted with the Vor-Diplom, which was administered exclusively by the physics department. For those students who took physics as a service course to their major field of interest such as medical and dental students, there was no formal evaluation in physics except as it was woven into their

examinations in the medical school. Several students interviewed indicated that this meant that there was no physics evaluation until their final examinations for licensing at the conclusion of their entire program. Often this was five to seven years after completing their last physics course.

A frequent comment by the physics professors was that they looked forward to the time when students would be evaluated on a more regular basis, so both students and professors would have an indication of general student progress.

The situation at the Munich Technische Hochschule was somewhat different. Although the only criterion for admission was successful completion of any kind of an Abitur, the school had instituted a comprehensive examination at the end of the first year. It was called the Vor-Diplom I. It was oral and written and covered all subjects taken the first year. It occupied two to three days. There was a similar battery of tests at the end of the second year. It was called the Vor-Diplom II. It was administered and interpreted in exactly the same manner as the Vor-Diplom examinations of the University of Munich and Erlangen. The next step in the evaluation process took place at the end of four or five years and served as the basis for awarding the Diplom certificate or degree. The Vor-Diplom I and II were accepted as

sufficient criteria to maintain scholarship assistance for those students under the federal scholarship program. A special examination was administered to scholarship students at the end of the third year to certify their eligibility for continuing their stipends. Even so, the physics department at the Munich Technische Hochschule felt that the evaluation process needed strengthening. Thus they had instituted a program of periodic examinations, required problems, and laboratory reports for determining progress. While these periodic grades had no official bearing on a student's standing, they were regarded as an accurate measure of individual progress. The only official grades that became a part of the permanent record of the student were those assigned to the various Vor-Diplom and Diplom examinations.

The Pädagogische Hochschule at Eichstätt had yet another system of evaluation. Again the sole criterion for admission was successful completion of any type of Abitur. The basic evaluation technique for graduation at the Pädagogische Hochschule consisted of one large final examination at the end of the three-year program which covered all subjects taken during the entire experience. There were only a few courses which had individual tests and unofficial grades assigned. These included educational psychology, geography, and German. Physics, mathematics, chemistry, biology, and English

had no individual examinations and proficiency was measured only in the final battery of written and oral examinations. This test was administered by the Bavarian Ministry of Culture office, and successful completion entitled the student to receive the elementary school teaching certificate. The physics portion of this examination consisted mainly of testing the student's ability to communicate basic physical principles to children in the five to twelve year age group. This did not sound too difficult, but many students felt that this was the most demanding portion of their five-day final comprehensive examination. The most pervasive factor in the Hochschule and university physics evaluation process was the emphasis on the comprehensive examination as contrasted with the individual course examinations found in the United States in its undergraduate physics courses.

Evaluation--West German Polytechnikum

There was a rather comprehensive set of examinations required of all those who enrolled at the Oskar-von-Miller Polytechnikum in Munich. The students had to pass tests in physics, mathematics, mechanical drawing, English, and German. The sophistication of the physics test was equivalent to the level of physics found in the early Gymnasium years. It was quite elementary, but it did require the use of simple algebra for the solution of the exercises. This examination battery plus evidence

of successful practical work experience had to be presented to be considered for admission. During the physics courses taken by all students, there were periodic examinations, problem sets, and laboratory reports that were evaluated for the purpose of assigning grades. These grades were unofficial, however; and the actual determination of success in all programs was made using the comprehensive engineering examinations administered by the school under the jurisdiction of the Munich Department of Education. These examinations were administered to all students at the conclusion of the third semester and again at the conclusion of the sixth semester. Unofficial comprehensive examinations were administered at the end of the first, second, fourth, and fifth semesters in addition to the examinations given in most individual courses. It appeared as though the evaluation process was much more highly developed in the Polytechnikum than in the Hochschulen or universities. The system resembled that found in American higher education except that the individual course grades had no bearing on the official standing of the student. Progress was marked officially using the comprehensive examinations at the end of the third semester, the Vorprüfung, and the sixth semester final examination called the Städtliche Ingenieurprüfung, or city engineering examination. This final examination was graded on a basis of one to five, with five constituting failure. There were four divisions between one and

four: one to one and one-half was considered unusually outstanding, one and one-half to two and one-half was considered outstanding, two and one-half to three and one-half was considered good, and three and one-half to four was considered fair. These rankings had a bearing on the quality of job offers the graduates received. Physics and the application of physical principles were integral parts of all of the comprehensive examinations.

Evaluation--Austrian Gymnasium

Most of what was observed regarding physics evaluation in West Germany was seen in Austria as well. In fact there were many more similarities than differences. The entrance examination to the Gymnasien consisted of written and oral parts for German and mathematics. There were periodic examinations, problem assignments, recitations, and other written work required in the individual physics courses, but no grades were assigned. Twice a year each physics student received the instructor's written assessment of his progress. This assessment contained an evaluation of the student's class standing plus suggestions for the student's future work in the physics class.

The significant difference between West Germany and Austria was found in the final comprehensive examination. The equivalent of the West German Abitur was called the Mature in Austria. All mathematics and science Gymnasium graduates were required to take written and oral

examinations in German, mathematics, English, and descriptive geometry. In addition each student had to choose three more subjects for inclusion in the written and oral Mature examination. These could come from geography, history, biology, chemistry, physics, modern languages, Latin, religion, or the social sciences. There was no requirement that any student had to take the Mature in physics, although many of the mathematics and science Gymnasium students did. The examinations were prepared with cooperation among the teachers, the school administrators, and the regional educational authorities. These examinations were administered by the Gymnasium staff and graded by the regional educational officials. Then the tests were returned, and each student underwent an oral examination in all subjects before a committee of the teaching staff, school administrators, and the regional educational representatives. Not until the student had successfully completed this process did he receive the Mature.

The situation was similar at the other types of Gymnasien in Austria. The required Mature subjects were German, English, mathematics, and Latin plus the election of three more subjects from among those taken at the respective Gymnasien. It was noted by most of the physics instructors at the modern language and classical language Gymnasien that physics was rarely elected as one of the Mature subjects.

As noted previously, the Werkschulheim at Ebenau, near Salzburg, was a unique institution; and its admission criteria included psychological testing in addition to the standard Gymnasium entrance examination in German and mathematics. The Mature at this institution was exactly the same as at other Austrian mathematics and science Gymnasien. In addition each student took the theoretical and practical examination to qualify as a journeyman in the trade he had chosen to study along with his regular Gymnasium curriculum. Even though this was a private school, the Mature was identical to that found in public institutions and was supervised by the same regional educational officers.

Evaluation--Austrian University

At the Vienna Technische Hochschule, all Mature holders were eligible for admission. The evaluation process within the institution was different from that found in West German institutions of higher education. Final examinations were given in each subject at the conclusion of each course. There were no periodic examinations within the individual physics courses or other subjects, just final examinations. Each student had an academic adviser, and it was the responsibility of the student to present successfully completed examinations in all subjects in his curriculum to his adviser; and the adviser in cooperation with a faculty committee would

then certify the status of the student's progress. There were no comprehensive examinations until the Diplom written and oral tests which were usually completed at the end of the fifth year. The student must have completed a publishable thesis project by this time also.

Evaluation--Austrian Höhere Lehranstalt

The entrance examinations at the two Austrian Höhere Technische Lehranstalten consisted of tests in mathematics, German, and a general intelligence test plus a physical examination. The evaluation in the physics portions of the student programs was conducted on a periodic basis with final examinations written each semester plus intermediate tests, problem sets, laboratory reports, and recitations all counting toward the semester grades. These grades were reported to students and parents and were made a part of the student's permanent record at the school. At the conclusion of the five-year programs, each student took the same Mature that was taken by the students at the science and mathematics Gymnasien. Compulsory written and oral Mature test subjects were mathematics, German, English, and descriptive geometry. The elective test subjects were chosen from the same general list as that used by their Gymnasium counterparts. Physics was one of these elective examination topics and was frequently chosen by the Höhere Lehranstalt students. For those students who chose the

shorter four-year curricula, there was no Mature; but a certificate of completion was awarded if the student had successfully passed all subjects in the chosen curriculum. There were no comprehensive examinations in the four-year curricula.

It was interesting to note that upon completion of the five-year curricula, the students were not granted the title of engineer. The students took jobs; and after five years of practical experience, they applied to the Federal Ministry of Education for the title of engineer. It was routinely granted. This delay in receiving the title disturbed the staffs and administrations of the two Austrian schools because it seemed to imply that their schools were inferior to their counterparts, the Swiss Technikum and the West German Polytechnikum, where the title of engineer was granted upon graduation. Again, it should be remembered that the entrance requirements to the Austrian Lehranstalten were less rigorous and allowed students to enroll five years earlier than students admitted to either the Swiss Technikum or West German Polytechnikum.

Evaluation--Swiss Gymnasium

The entrance examinations at the Swiss Gymnasien required the students to demonstrate proficiency in mathematics, German, and French, with the same test used in all types of Gymnasien. During the course of the Gymnasium

experience, periodic tests and grades were recorded in the same fashion as at the West German Gymnasien. The final comprehensive examination was called the Matur. It was made up by the Gymnasien staffs under the supervision of a university professor chosen by the Kanton office of education. The Matur required every student to be tested in eleven different subject areas. The required test topics for all students were German, French, history, geography, mathematics, physics, chemistry, biology, and free-hand drawing. In addition the Type A classical language Gymnasium students were required to take examinations in Latin and Greek. The Type B modern language Gymnasium students were required to take examinations in Latin and English or Italian. Most of the students elected English. The Type C mathematics and science Gymnasium students were required to take examinations in descriptive geometry and English or Italian. Again most of these students chose to be examined in English. Not all examinations were combined written and oral tests. Some variation in this procedure existed depending on the type of Gymnasium curriculum. However, all students had both written and oral examinations in German, French, and mathematics. In addition the Type A Gymnasium students had written and oral examinations in Greek and a choice between physics and Latin. The Type B Gymnasium students had both types of examinations in English, if elected,

and either Latin or physics. The Type C Gymnasium students had written and oral tests in English, it elected, plus descriptive geometry, and physics. The courses where only written examinations were required were history, geography, and biology.

Each topic was graded on a basis of one to six, where six was the highest score. According to Swiss law, the Matur was not awarded to those candidates who received one mark of one, or two marks of two, or one mark of two and two marks of three, or more than three marks of three, or marks for all eleven subjects that totaled less than forty. Again provisions for unsuccessful candidates were made so that the examinations could be repeated if necessary. Well over 90 per cent of those students who attempted the Matur successfully passed on their first try. All Matur holders were eligible to enroll at either the University of Zurich, the Swiss Federal Institute of Technology at Zurich, or any other university in Switzerland.

Evaluation--Swiss University

There was no formal evaluation during the first-year physics course at the University of Zurich. Also there were no final examinations in any courses elected by the student. The physics department had recently established an unofficial policy under which it called in all physics and mathematics majors and subjected them

to a two-hour oral examination administered by the lecturing professor. This procedure was not officially sanctioned by the University administration, but the physics department felt it was necessary in order to determine the general progress of these students. The process was regarded as a counseling tool. Medical students, chemists, and others who took physics as a required course in their curriculum had no evaluation at all during their exposure to physics. Theoretically any evaluation in physics came later during comprehensive examinations. To test prior to this major examination was regarded by both students and administration as a violation of academic freedom.

At the end of two or three years, the physics and mathematics majors took a comprehensive examination called the Vor-Diplom. In this sense they were handled identically to students at the Universities of Munich and Erlangen in West Germany. The students were counseled following the Vor-Diplom and allowed to select their research area and associated courses, and then allowed to continue toward the Diplom degree, which was awarded following the successful completion of a research project plus another comprehensive written and oral examination. This was usually completed in five to six years from initial admission to the University of Zurich.

The evaluation process at the Swiss Federal Institute was quite similar to that at the University of Zurich. There was no formal evaluation in individual physics courses. The bulk of the evaluation process was conducted by means of a series of comprehensive examinations administered at the conclusions of the fourth, sixth, and eighth semesters. The examination administered at the end of the eighth semester was called the Diplom examination; and this determined whether the student was awarded the Diplom degree. The other two comprehensive examinations were referred to as Vor-Diplom I and II examinations. No sophisticated research topic was required to receive the Diplom at the Swiss Federal Institute. Basic research leading to the doctoral degree began after the Diplom had been conferred. Since most of the students who attended the Swiss Federal Institute were engineers, there was a heavy emphasis on application of physical principles and mathematics in the various comprehensive examinations. The examinations were more sophisticated and theoretical for those students who were majoring in applied physics and mathematics. Still their Vor-Diplom I and II examinations covered all subjects in their curricula taken prior to the particular test. These examinations were prepared and administered by faculty committees whose membership rotated to include at one time or another all those staff members who possessed the academic rank of professor.

Evaluation--Swiss Technikum

The Technikum Winterthur required all candidates for admission to pass an entrance examination in German, mathematics, and technical drafting. The mathematics examination contained exercises in arithmetic, algebra, and geometry. During the physics classes, the students were required to take as many as six short tests in each semester plus problem sets, exercises, and laboratory experiments. There was a final examination at the end of each semester, and grades were assigned and made a part of the student's permanent record. The grading system was one through six, with six being the highest. Grades one, two, and three were considered unsuccessful. In addition to the individual course grades, there were two major comprehensive examinations. These came at the ends of the fourth and sixth semesters. The examinations at the end of the fourth semester contained the final examination for physics. Thus, there were no pure physics questions in the diploma examination taken at the completion of the sixth semester. Upon successful completion of the final examination, the student was awarded the title of engineer or chemist depending on the particular curriculum. It appeared that this evaluation system was a combination of periodic and comprehensive examinations. It should be noted, however, that final certification came only after successful completion of a

comprehensive examination and that all other evaluation appeared to be merely of the progress report variety with no official bearing on the status of the student.

Evaluation--Jackson Community College

The evaluation process at Jackson Community College presented a significant departure from that observed in any of the institutions visited in the three European countries. While all students entering Jackson Community College were subjected to the examination battery prepared by the American College Testing program of Iowa City, Iowa, the results had no bearing on the admission status of applying students. Results in the areas of natural science, mathematics, English, and social science were used as tools by the counseling staff to identify strengths and weaknesses for helping the students make suitable course selections and vocational selections.

Within the individual course offerings, there was a good deal of uniformity in the evaluation process as a tool for the determination of grades and hence credit for the courses. Jackson Community College used the credit hour system to indicate student progress, and there were no comprehensive examinations as found in the three European countries. The grading system used throughout the institution used the grades of A, B, C, D, and E, with A constituting the highest grade. The credit hours were generally equal to the number of contact hours which

the class met each week during the semester. There was some adjustment to this procedure for classes that had laboratories. In addition there was a system for determining general progress that utilized grade points. An A in a course entitled the student to four grade points per semester hour, a B yielded three grade points, a C two grade points, a D one grade point, and an E produced zero grade points per semester hour. To receive an Associate's Degree, which was the highest degree awarded by Jackson Community College, a student needed a minimum of sixty-two semester hours of credit and 124 grade points. This was referred to as a two-point average.

There were three basic types of evaluation experiences that contributed to grades in all physics courses. Students were required to take from three to five one-hour examinations during each semester plus one two-hour final examination. The scores on these tests plus results from shorter tests, quizzes, and problems were combined to yield a total lecture grade. Each laboratory exercise had a written report that contributed to a laboratory grade. There were no laboratory examinations. The lecture grade was combined with the laboratory grade, with the lecture grade weighted three to four times as much as the laboratory grade. This procedure was followed twice each semester. The first grade was unofficial and was determined at the end of eight weeks of classes.

This was called the mid-semester grade. The official grade, which was entered upon the student's permanent record or transcript, was determined at the end of the semester and was reached by totaling all of the evaluation experiences previously cited that occurred during any one semester. In most courses, this meant totaling some ten to fifteen individual lecture grades plus twelve to fifteen laboratory report grades and tests. At Jackson Community College there was a strong commitment to frequent evaluation and a definite aversion to any great emphasis being placed upon the value of one final or comprehensive examination as the criterion for determining student progress. This was a singular departure from the general procedure observed in all three European countries.

Evaluation--Summary

The Gymnasien in the three European countries required written and oral examinations from all prospective students. In West Germany and Austria, their examinations were in the areas of mathematics and German. In German speaking Switzerland, the written and oral examinations were in mathematics, German, and French. As indicated in Chapter IV, over 90 per cent of all students who applied were admitted. All of the physics programs at the various Gymnasien in the three countries had periodic examinations and were assigned grades. These grades were unofficial in the sense that graduation from

the Gymnasium was recognized only after the final comprehensive examination was successfully completed. This comprehensive examination, or maturity examination, was called the Abitur, the Mature, or the Matur in West Germany, Austria, and Switzerland respectively. Although all West German Gymnasium students were required to take physics, not all were required to be examined in physics in their final comprehensive examinations. Only the West German mathematics and science Gymnasium students were required to be examined in physics. The students at the other Gymnasium types could elect physics as one of their optional examination topics, but very few did. Physics was an optional Mature examination topic in Austria. All Swiss Gymnasium students were required to take the written test in physics and could elect the oral part of the physics examination if they desired. Those West German and Austrian students who did not write comprehensive examinations in physics still attended Gymnasien that had systems of grading that required semester and annual grades; and a student had to maintain satisfactory progress in all subjects, including physics, in order to be promoted to the next class and eventually become eligible to write the appropriate final comprehensive examination. The West German Abitur required written tests in four subjects plus oral tests in three more. These written subjects were German, mathematics, and two more subjects consistent with the

student's course of study. The Austrian Mature had written and oral tests in seven subject areas. Those areas were German, mathematics, and five additional subjects depending upon the particular course of study. The Swiss Matur tested all students in eleven different subject areas. All students were tested in the areas of German, French, history, geography, mathematics, physics, chemistry, biology, free-hand drawing, plus two additional topic areas dependent upon curriculum choice. The Matur examined students orally, in writing, or a combination of both according to a complicated pattern which was a function of the student's curriculum and his choice. This was explained previously in this chapter on pages 233 and 234.

The West German Kollege followed the same examination procedures in its physics courses and in the Abitur as the West German Gymnasien. There were some variations in admission testing since the students were admitted assuming more advanced educational backgrounds. Instead of testing in only German and mathematics, the prospective Kolleg student was tested in the areas of German, mathematics, and English.

The only criterion for admission to a university or Hochschule was possession of the Abitur, the Mature, or the Matur. Admission to specific beginning physics sequences was independent of previous success in physics

or mathematics. Very few of the universities and Technische Hochschulen had any evaluation conducted during or at the conclusion of their beginning physics sequences. The institutions relied on comprehensive examinations at the end of two to three years, called Vor-Diplom examinations, which included some physics as a part of their total test battery. The Vor-Diplom was an intermediate examination which was followed by the Diplom examination after an additional three to four years of university or Technische Hochschule study. These institutions were committed to the concept of comprehensive testing as the sole criterion for determining student progress.

The evaluation processes of the engineering colleges operated on a significantly different basis from the Gymnasien, universities, and Technische Hochschulen. The West German Polytechnikum had entrance examinations in the areas of physics, mathematics, mechanical drawing, English, and German. The Austrian Höhere Lehranstalten tested prospective students in the areas of mathematics, German, and general intelligence. The Swiss Technikum tested their prospective students in the areas of German, mathematics, and technical drafting. All of the institutions had periodic examinations, and grades were assigned for the physics courses required of all students. These grades were used for determining general progress but did not constitute the criteria for completion of the

total programs. In all cases, successful completion was determined by comprehensive examination. In the West German Polytechnikum, there was a major intermediate comprehensive examination administered at the end of the student's third semester. The final comprehensive examination called the Ingenieurprüfung was administered at the end of the sixth semester. Both examinations contained physics as one of the examination topics. The situation was very similar at the Swiss Technikum. The intermediate comprehensive examination came at the end of the fourth semester, and the final battery was administered at the conclusion of the student's sixth semester. The Austrian Höhere Lehranstalten followed a pattern that closely paralleled the Gymnasien of the three European countries. There were no intermediate comprehensive examinations, just individual course grades to determine satisfactory progress. At the conclusion of the final year, all students wrote the same Mature that was written by Austrian Gymnasium students. The Höhere Lehranstalt students took oral and written tests in mathematics, German, English, descriptive geometry, plus three more elective subjects. Physics was one of these subjects and was often elected by Höhere Lehranstalt students.

There were no entrance examinations at Jackson Community College. A test battery was administered to all entering freshmen which was used by the counseling

staff to assist the students in course and vocational selection. It tested students in the areas of natural science, mathematics, English, and social science. In all physics courses and sequences, there were a variety of evaluation processes. Periodic examinations, laboratory reports, problem sets, and short quizzes were combined to yield a final semester grade for each student. This grade became a part of the student's permanent record. There were no comprehensive examinations comparable to those found in all European educational institutions. The credit hour system was the sole basis for determining student progress in a course of study.

CHAPTER VII

SUMMARY OF THE FINDINGS, CONCLUSIONS, AND SUGGESTIONS FOR FUTURE RESEARCH

Summary of the Findings

Students

There were many similarities among the populations of the Gymnasien of the three European countries. Male students outnumbered females by more than two to one. The majority of the European Gymnasium students came from middle to upper-middle class families. Students attended classes in the mornings and early afternoon hours over a six-day week, with weekly class loads of from thirty to forty contact hours. Over 90 per cent of all students who applied to the various Gymnasien were admitted. Most Gymnasium students planned to continue their educations at universities or Hochschulen. Approximately 30 to 40 per cent of all students who enrolled in Gymnasien successfully completed. Those who completed constituted only 6 to 9 per cent of the total eighteen to twenty-year-old age group.

The European universities and Technische Hochschulen studied were small by United States standards,

ranging in size from 5,000 to 10,000 students. The only exception was Munich University with 25,000 students. It was the largest university in West Germany, Austria, or Switzerland. Approximately 6 per cent of the total university student populations were enrolled in the beginning physics sequences. Twenty to 25 per cent of the total Technische Hochschule student bodies were enrolled in the beginning physics sequences. All Gymnasium graduates were eligible to enroll in any university of Hochschule. The socio-economic backgrounds of the university and Hochschule students were similar to the Gymnasium students, with very few students coming from working class and lower-middle class families. Approximately 70 per cent of all students enrolled in beginning physics sequences successfully completed them. University and Hochschule students carried weekly class loads of from twenty to thirty contact hours.

Virtually all of the students at the engineering colleges were male, and all took some physics as a part of their various technical curricula. Students carried class loads of from thirty to forty-five contact hours spread over a six-day week. Only 50 per cent of all students who applied were admitted. In West Germany and Switzerland, a student must have completed some secondary education plus some work experience or apprenticeship to apply for admission. Applying students ranged from

eighteen to twenty-four years of age. Students who applied to the Austrian Höhere Lehranstalten were admitted after a total of eight years of elementary and secondary education. Thus, they were admitted at fourteen to sixteen years of age. Most of the students at all of the engineering colleges came from working class and lower-middle class families. Approximately 60 per cent of all students who were enrolled successfully completed their respective programs.

The Kollege were found only in West Germany and enrolled students who were older than the Gymnasium students in comparable programs. All Kolleg students took physics as a part of their respective curricula. Male students outnumbered female students by more than three to one. Students were enrolled for twenty contact hours per week in the evening programs and up to thirty-five contact hours in the day programs. The evening Kollege had three-year programs and paralleled the last three years of the Gymnasium. The day Kollege compressed the three-year Gymnasium programs into two and one-half years. Only 10 to 30 per cent of the students who applied to the Kollege were admitted. Over half of the students were interested in pursuing the vocations of engineering and teaching. Approximately 50 per cent of the students who began the Kollege completed the Abitur successfully.

Most of the physics students at Jackson Community College were between the ages of eighteen and twenty-one. Men outnumbered women three to one. Students who were enrolled in beginning physics sequences had class loads averaging fifteen contact hours per week spread over a five-day week. Most of the students came from lower-middle to middle class families. Over 70 per cent of all students enrolled in physics classes completed them successfully.

Curriculum

There were only two basic types of physics curricula for all of the types of Gymnasien in West Germany, Austria, and Switzerland. There was the mathematics and science curriculum; and there was a common physics curriculum for the modern language, classical language, economics, and fine arts Gymnasien. Regardless of curriculum, all students took physics for several years. The mathematics and science students had physics for a greater number of class meetings per week, for more years than the students at the other Gymnasien, and pursued topics to greater depth. All of the Gymnasium students were required to take mathematics through calculus. The mathematics and science students had calculus through transcendental functions while the other Gymnasium students had calculus only through algebraic functions. None of the students were exposed to differential equations. The Gymnasium

physics classes were small, usually under thirty students but conducted as lecture-demonstrations. Most of the Gymnasien followed fairly rigid course outlines with little room for flexibility on the part of the instructor. There was a good deal of interchange between students and teaching staffs in the classroom. Few of the Gymnasien had libraries, and those which did rarely had physics students using them. The West German Kollege offered the same basic curricula as did the West German Gymnasien.

The universities and Technische Hochschulen started their physics courses below the level of the final Gymnasium physics but quickly accelerated to a more sophisticated level. The university and Technische Hochschule physics usually required calculus and differential equations as pre-requisites. This was accomplished in some cases by delaying the start of the beginning physics sequence until the student's second or third semester. All of the beginning physics lecture sequences had associated laboratories. When students at the universities began the physics lecture courses during their first semester, the beginning of the laboratory was often delayed at least one semester. The Technische Hochschulen did not allow students to begin their physics until the second or third semester and then ran the laboratories in phase with the lecture portion of the course. The

demonstrations performed in the lecture classes at the universities and Technische Hochschulen were very dramatic and required vast quantities of time and effort to set up. These demonstrations utilized great quantities of highly specialized equipment. Lecture classes were large and very formally conducted. Textbooks were rarely used, and the lecturing professor's notes constituted the basic written material for the course. Physics laboratories had enrollments of under twenty students and were conducted by junior professors and graduate students.

There were many similarities among all of the engineering colleges in the three European countries, especially between the West German Polytechnikum and the Swiss Technikum. The Polytechnikum and Technikum served the same age group, had the same entrance requirements, offered the same technical curricula, and required the same amount and level of physics in these curricula. The Austrian Höhere Lehranstalt was different in terms of the younger age group it served, its five-year rather than three-year programs, its different entrance requirements, its granting of the Mature, and the fact that its graduates did not receive an engineering title upon graduation. The Höhere Lehranstalten were similar to their West German and Swiss counterparts in terms of the type of engineering programs offered, the amount of physics

required in corresponding curricula, and the sophistication of the physics taught in various engineering curricula. The sophistication of the physics taught approximated that found in the mathematics and science Gymnasien of all three countries. The mathematics encountered by the students at the engineering colleges usually included some differential equations; but this was taken after completing the physics portion of their total curriculum, so it provided little help. The physics was taught in lecture classes that did not exceed forty-five students. Considerable use of demonstrations, films, closed-circuit television, and computers was found at all of the engineering colleges. All of the physics programs had associated laboratories. The application of physical principles to the various engineering specialties was an important theme throughout the various engineering specialties was an important theme throughout the various physics sequences. While libraries existed in all of the engineering colleges, physics students did not utilize them to any great extent but rather used lecture notes, textbooks, and laboratory materials to fulfill their class obligations.

There were four major divisions within the physics offerings at Jackson Community College. The divisions were the general education courses, college-parallel courses, the terminal-technical course, and the

continuing education courses. A student elected the respective course depending upon his vocational objectives and whether or not the student possessed the mathematics background that the course required for his enrollment. The sophistication of the beginning physics sequences varied significantly among the general education, college parallel, and terminal-technical courses. Again, this level of sophistication was more dependent upon the mathematical background of the students admitted than whether or not the student had had any physics previously. These mathematics pre-requisites varied from one year of high school algebra for one of the general education courses to one year of calculus for the University Physics sequence. All of the beginning physics sequences had associated laboratories. Lecture classes varied in size from ten to thirty-five students. There was great emphasis placed upon class recitation, problem solving, use of the textbook, and audio-visual materials in the classes. Demonstrations were performed infrequently. Physical facilities were excellent, and the physics department possessed a great quantity of demonstration and laboratory equipment. Library facilities were good but rarely used by beginning physics students.

Evaluation

The Gymnasien in the three European countries required written and oral examinations from all prospective

students. In West Germany and Austria, these examinations were in the areas of mathematics and German. In German speaking Switzerland, the written and oral examinations were in mathematics, German, and French. As indicated in Chapter IV, over 90 per cent of all students who applied were admitted. All of the physics programs at the various Gymnasien in the three countries had periodic examinations and were assigned grades. These grades were unofficial in the sense that graduation from the Gymnasium was recognized only after the final comprehensive examination was successfully completed. This comprehensive examination or maturity examination was called the Abitur, the Mature, or the Matur in West Germany, Austria, and Switzerland respectively. Although all West German Gymnasium students were required to take physics, not all were required to be examined in physics in their final examinations. Only the West German mathematics and science Gymnasium students were required to be examined in physics. The students at the other types of Gymnasien could elect physics as one of their optional examination topics, but very few did. Physics was an optional Mature examination topic in Austria. All Swiss Gymnasium students were required to take the written test in physics and could elect the oral part of the physics examination if they desired. Those West German and Austrian students who did not write a comprehensive examination in physics

still attended Gymnasien that had systems of grading that required semester and annual grades, and a student had to maintain satisfactory progress in all subjects, including physics, in order to be promoted to the next class and eventually become eligible to graduate. The West German Abitur required written tests in four subjects plus oral tests in three more. The written subjects were German, mathematics, and two more subjects consistent with the student's course of study. The Austrian Mature had written and oral tests in seven subject areas. These areas were German, mathematics, and five additional subjects depending upon the particular course of study. The Swiss Matur tested all students in eleven different subject areas. All students were tested in the areas of German, French, history, geography, mathematics, physics, chemistry, biology, free-hand drawing, plus two additional topic areas dependent upon curriculum choice. The Matur examined students orally, in writing, or a combination of both according to a complicated pattern which was a function of the student's curriculum and student choice of test subjects.

The West German Kollege followed the same examination procedures in its physics courses and in the Abitur as the West German Gymnasien. There were some variations in admission testing since the students were admitted assuming more advanced educational backgrounds. Instead

of testing in only German and mathematics, the prospective Kolleg student was tested in the areas of German, mathematics, and English.

The major requirement for admission to a university or Hochschule was possession of the Abitur, the Mature, or the Matur. Admission to specific beginning physics sequences was independent of previous success in physics or mathematics. Very few of the universities and Technische Hochschulen had any evaluation conducted during or at the conclusion of their beginning physics sequences. The institutions relied on comprehensive examinations at the end of two to three years called Vor-Diplom examinations which included some physics as a part of the total test battery. The Vor-Diplom was an intermediate examination which was followed by the Diplom examination after an additional three to four years of university or Technische Hochschule study. These institutions were committed to the concept of comprehensive testing as the sole criterion for determining student progress.

The engineering colleges operated on a significantly different basis from the Gymnasien, universities, and Technische Hochschulen. The West German Polytechnikum had entrance examinations in the areas of physics, mathematics, mechanical drawing, English, and German. The Austrian Höhere Lehranstalten tested prospective students in the areas of mathematics, German, and general intelligence. The Swiss Technikum tested their prospective

students in the areas of German, mathematics, and technical drafting. All of the institutions had periodic examinations, and grades were assigned for the physics courses required of all students. These grades were used for determining general progress but did not constitute the criteria for completion of the total programs. In all cases successful completion was determined by comprehensive examination. In the West German Polytechnikum, there was a major intermediate comprehensive examination administered at the end of the student's third semester. The final comprehensive examination, called the Ingenieurprüfung, was administered at the end of the sixth semester. Both examinations contained physics as one of the examination topics. The situation was very similar at the Swiss Technikum. The intermediate comprehensive examinations came at the end of the fourth semester, and the final battery was administered at the conclusion of the student's sixth semester. The Austrian Höhere Lehranstalten followed a pattern that closely paralleled the Gymnasien of the three European countries. There were no intermediate comprehensive examinations, just individual course grades to determine satisfactory progress. At the conclusion of the final year, all students wrote the same Mature that was written by Austrian Gymnasium students. The Höhere Lehranstalt students took oral and written tests in mathematics, German, English,

descriptive geometry, plus three more elective subjects. Physics was one of these subjects and was often chosen by Höhere Lehranstalt students.

There were no entrance examinations at Jackson Community College. A test battery was administered to all entering freshmen which was used by the counseling staff to assist the students in course and vocational selection. It tested students in the areas of natural science, mathematics, English, and social science. In all physics courses and sequences, there were a variety of evaluation processes. Periodic examinations, laboratory reports, problem sets, and short quizzes were combined to yield a final semester grade for each student. This grade became a part of the student's permanent record. There were no comprehensive examinations comparable to those found in all European educational institutions. The credit hour system was the sole basis for determining student progress in a course of study.

Conclusions

Probably the most significant implication of this total study was that it provided a comparison of physics instruction in corresponding European educational institutions, a comparison that had not as yet appeared in any of the German or English language literature. In fact, there was very little descriptive writing about any

of the instruction in the types of institutions studied. Jackson Community College served only as a familiar and convenient reference point to anchor the entire study.

There was a great deal of similarity among comparable institutions in the three European countries, more than could be attributed to the common language utilized throughout. With some notable exceptions, the various institutions served the same socio-economic classes with the same curricula and did this in the same general physical settings with approximately the same dogmatic attitudes from the teaching staffs and the rigid bureaucracy found in the state and federal ministries of education. The notable exceptions to the above generalizations were cited previously and included the degree of flexibility found in some Swiss institutions with their less rigid teaching staffs. Another exception to this rigid pattern was found in the engineering colleges of the three European countries. Their pragmatism was in sharp contrast to the authoritarian attitude of the other institutions and more closely paralleled the general situation observed at Jackson Community College.

Students

One of the most significant conclusions related to the fact that all Gymnasium students took several years of physics and that physics occupied a greater part of the student programs than either biology or chemistry. This

was true in all three European countries. As expected, all students at the engineering colleges and Technische Hochschulen took physics, while only some of the general university students found physics in their curricula. In that sense the latter students were similar to the students at Jackson Community College.

It was noted that the Gymnasien in all three European countries were fairly exclusive institutions since only some 20 per cent of the potential entering students found themselves enrolling. The fact that only 6 to 8 per cent of that total age group successfully completed the Gymnasien meant that a very small percentage of the youth was qualified to continue its education at the universities. This was in sharp contrast to the percentage of students who graduated from high school and were eligible to enroll at Jackson Community College. A percentage many times in excess of 6 to 8 per cent of the age group graduated from Jackson County high schools and was eligible to enroll at Jackson Community College with its "open-door" policy.

It has been pointed out that most of the students at these European Gymnasien and universities appeared to come from middle to upper-middle class families while the students at Jackson Community College came mostly from lower-middle to middle class families. This appeared to reflect the fact that higher education was somewhat more available in the Jackson area and desired by a wider

range of the population spectrum. The students at the engineering colleges came from the lower-middle classes; and although they were virtually all male students, they appeared to be very comparable to the socio-economic level of the male student population at Jackson Community College. Similarities between the West German Kolleg students and Jackson Community College students were very noticeable also. They were similar in socio-economic background and vocational interests. The student populations at the Technische Hochschulen and universities were virtually the same as found at the Gymnasien since they provided the only route to higher education and in fact appeared to be the sole reason for their existence.

Curriculum

Some of the most impressive characteristics of the total European physics programs included the strong commitment to physics as the most significant part of the required natural science programs. This showed up in enrollment statistics, especially at the Gymnasium level. More students were enrolled each year in physics than in biology or chemistry. This was not true in American high schools or institutions of higher education. An exception was noted at Jackson Community College. There were more students enrolled in physics each year than in chemistry, but biology had a higher enrollment than physics and chemistry combined.

At this point something must be said about the equivalency of the Gymnasium education to American education. Certainly, the Gymnasium graduates from West Germany, Austria, and Switzerland were well above the level of most American high school graduates in terms of exposure to languages, science, mathematics, social sciences, and humanities. The fact that most West German universities did not admit American transfer students to enter as first-year students until they had completed two years of American higher education did not appear to be unreasonable.

Based upon the observations and the results of the interviews, some conclusions can be drawn regarding the level of physics instruction among the various institutions in the three European countries compared to Jackson Community College. The general level of Gymnasium physics instruction was higher in Austria than in either West Germany or Switzerland when similar Gymnasium types were compared. This was not anticipated since the Austrian Gymnasium was only eight years in length compared to nine years in West Germany and eight and one-half years in Switzerland. In all three countries the science and mathematics Gymnasien had more rigorous physics programs than at the other Gymnasium types. The most sophisticated Gymnasium physics closely paralleled the College Physics sequence at Jackson Community College, which was taken

by non-science majors and had a mathematics prerequisite of trigonometry. The University Physics sequence at Jackson Community College was above the level of any Gymnasium physics encountered. This was unusual when one considered the number of years these Gymnasium students were exposed to physics. It was felt also that with the selection process that took place, the general intellectual sophistication of the Gymnasium students was higher than the University Physics students at Jackson Community College. It was felt that there was no reason why the Gymnasium students could not have progressed further except that the advanced topics were simply not in their prescribed curricula. Were these advanced topics included, it would have meant that the Gymnasium students would have been exposed to a level of physics equivalent or beyond the level of beginning physics found at the universities and Technische Hochschulen. It was felt that the Gymnasium physics programs suffered also because of the general lack of laboratory experiences.

The level of sophistication of the first-year physics programs at the universities and Technische Hochschulen was slightly below or equivalent to the level of physics presented in the University Physics at Jackson Community College. It was felt that the students were handicapped to some degree in those institutions where their physics laboratory was delayed one to two

semesters after the lecture presentations. This lack of articulation was a cause for concern to many professors and students.

The physics at the European engineering colleges, while presented in a most attractive way, did not match the level of sophistication of the University Physics at Jackson Community College and more closely paralleled the physics found in the College Physics sequence.

Many of the Gymnasium physics teachers felt that state and federal curriculum requirements kept the students from realizing their full potential in physics during the long exposure at the science and mathematics Gymnasien. The students had undergone a fairly rigorous selection process, worked extremely hard; and in six to eight years of physics classes it was felt that the students should have been able to progress far beyond the level the respective ministries of education required, or allowed, and tested.

The similarities in physics curricula among the three European countries at the Gymnasien, engineering colleges, universities, and Technische Hochschule were amazing. Differences existed only in matters of emphasis and somewhat in the physical facilities the particular economy was able to support. The similarities at the Gymnasium level that appeared most significant included the emphases on the demonstrations in the lecture classes,

the lack of physics laboratories, the small class sizes, the inflexibility of the physics offerings, the general formality of the class meetings, the fact that all of the physics was taught as though all students were majoring in the subject instead of using a general education approach, the chafing of the physics teachers because they wished to have more autonomy in the design and execution of the physics curriculum, and the restrictions placed on the teachers because they all had to teach toward one final comprehensive examination at the conclusion of the school experience. There was a decided enrollment trend away from the classical language Gymnasien to the modern language institutions, with the science and mathematics Gymnasien maintaining their same percentage of total students. In all countries a greater percentage of students were enrolling in the Gymnasien, predicting problems for the universities in years to come unless university admission policies changed.

The general environment, philosophy, and approach to teaching found at the universities of the three countries were very comparable. The physics programs seemed very professor-centered and rarely considered student needs and interests. There was some evidence that this lack of interest for the student concerns was changing. The Universities of Munich, Erlangen, and Zurich were instituting counseling programs to help students make

course and career selections. Students were being allowed to have some voice in the design of curricula. All three institutions were in the process of developing curricula for physics majors that included required courses from the areas of the social sciences and humanities. These courses were not to be included in the comprehensive testing program in the near future; so many professors had doubts regarding the effectiveness of the programs. Students were primarily responsible for instituting these new non-science requirements, and they felt that their inclusion would be welcomed as long as there was some corresponding reduction in physics and mathematics course and test requirements.

The Technische Hochschulen were different from the universities beyond the difference in vocational choices of their students. There was a more rigid attitude on the part of the physics departments and the school officials requiring attendance of students at class lectures. They usually required a heavier schedule of contact hours per week and seemed to be more successful in graduating their students in a shorter time period than the corresponding students in similar programs at the universities. An observation was made for both the universities and the Technische Hochschulen, and that was that the Herr Doktor Professors had firm control of the institutions. This was a product of tradition and

the intricacies of governmental funding of research and teaching activities controlled by the professors.

The similarities found at the engineering colleges of the three countries were significantly different from those found at the Gymnasien and the institutions of higher education. The engineering colleges were less bound by tradition and less under the domination of the teaching staffs. The institutions were much more student oriented and maintained a consistent philosophy of doing whatever was necessary to produce a desirable final product. Thus, these institutions were quite susceptible to change. This general attitude pervaded their approach to teaching, the use of audio-visual aids, and a willingness to experiment in all phases of their program. This was true even in Austria, where the students enrolled at an earlier age than in West Germany or Switzerland; and the Austrian students were required to write the Mature the same as their Gymnasium counterparts. It was at the engineering colleges that the greatest similarities between European education and Jackson Community College were observed. The most significant characteristic shared by the physics staffs at the engineering colleges and at Jackson Community College was their commitment to attempt to satisfy community and hence student needs with their respective curricula.

One of the most significant aspects of the Jackson Community College curriculum was the many tracks of beginning physics available, five in all, that took a heterogeneous student population and attempted to provide a physics program for each of the students regardless of academic background or vocational preference. Another aspect was the firm commitment to the physics laboratory as a significant part of all five physics programs. Along with this laboratory commitment was an abundance of laboratory equipment and supplies. It was obvious that a significant financial commitment had been made for the acquisition of equipment and supplies.¹

Evaluation

The greatest single difference in educational philosophy between the European countries and Jackson Community College was found in the attitude toward comprehensive testing. It was safe to say that even minor steps in the European educational process were documented with some type of comprehensive testing. There was no comprehensive testing at Jackson Community College. Instead it had the standard credit hour system commonly found at American institutions of higher education. Although there was some discussion at the European

¹Interview, Donald Troyer, Comptroller of Jackson Community College, Jackson, Mich., on May 14, 1970.

universities about adding intermediate levels of testing, there was little mention of doing away with the comprehensive testing at any of the current levels.

The admission examinations at all Gymnasien did not appear to be particularly rigorous since such a high percentage of those who applied were successfully admitted. Thus, if the Gymnasien were enrolling a selected portion of the total population, this was not a result that could be credited to the testing procedures. The most significant part of the evaluation process at the Gymnasium level was the final comprehensive examination. Such examinations as the Abitur, Mature, and Matur are not commonly found in American education. The New York Regency examinations and examinations for graduates of unaccredited high schools to determine university admission are two of a very few such comprehensive examinations and are not found generally as the sole criteria for admission to higher educational institutions, although many institutions require testing as one of several criteria considered during the admission process. Rarely are these same tests used as a part of the high school completion process. The significant differences among the Abitur, Mature, and Matur were in the fewer number of subjects that were tested in West Germany compared to Austria and Switzerland. Another difference was that the Bavarian physics teachers had absolutely no part in the

preparation of the examinations, which contrasted with their Austrian and Swiss counterparts with their respective degrees of participation.

The universities and Hochschulen were committed to the Abitur, Mature, and Matur as the sole criterion for admission although many individual professors were concerned about the fact that too many students were enrolled in the Gymnasien and heading inevitably toward the universities. Many university professors felt that more than successful completion of the Abitur, Mature, or Matur would be required for university admission in the near future. In any case, growth of the universities and associated changes seemed certain. The commitment to comprehensive examinations such as the Vor-Diplom and Diplom plus the lack of individual physics course evaluations was significantly different from the situation at Jackson Community College. No individual course grades were assigned at any of the European universities and Hochschulen.

Suggestions for Future Research

There were a number of problems and trends observed in the European educational institutions that could provide material for future study. One of these topics concerns the preparation, status, and salary of Gymnasium teachers compared to American high school and junior college teachers. There are several questions that should

be answered. Is the European teacher currently compensated better than his American counterpart? What are the relative educational backgrounds, and how do these relate to salary levels? Does the European teacher really enjoy a higher status than the American teacher?

There seemed to be a paradox which related to the fact that such a small number of students applied to the Gymnasium and yet over 90 per cent were admitted. Why do more students not elect to enter a Gymnasium since it appears so easy to enroll? There were many responses to this question when it was asked, but none seemed conclusive.

Another trend that was observed in West Germany concerned the emergence of the Realschule. It was stated by many educators that the Realschule was being developed to parallel the American comprehensive high school. The question is: What effect will this have on Gymnasium and university enrollments in the coming years?

West German, Austrian, and Swiss educators were predicting that the classical language Gymnasien were fading from the scene. West German educators were predicting also that the life of the Kollege was limited. It would be of interest to see if these predictions hold true and if so, to analyze fully what factors are bringing about the demise of these two types of institutions.

Another series of problems relate to the university. Many professors felt that their control of the institutions was being threatened by student demands for an increased voice in university affairs. Will the universities institute reforms giving the students more control over their curricula, providing counseling services to students, increasing the number of elective courses in student curricula, and allowing the students closer personal contact with the professors? The value of such reforms is currently being debated within the university structure. The various political parties, professors, students, and governmental officials were all involved in this sometimes violent debate.

Another matter of interest in the universities and Hochschulen includes the fact that individual professors were requesting to be grouped in physics departments and not independent institutes, with the physics departments having more authority than the Land, federal, or Kanton ministries of education. A physics department as known in the United States existed only at the Munich Technische Hochschule, and there only because Nobel Laureate Rudolph L. Mössbauer had threatened to leave the Munich Technische Hochschule and come to the United States unless a physics department were established.¹

¹Interview, Edgar Lüscher of the physics department, Munich Technische Hochschule, Munich, West Germany, on April 25, 1969.

Will more West German, Austrian, and Swiss universities and Hochschulen be granted this increased departmental autonomy, and what effect would this have on the total physics program?

Still another topic that was partially investigated and deserves further consideration is the method of selecting professors at the universities and Technische Hochschulen in German-speaking Europe. The politics and intrigue involved in this process would make for interesting reading, especially when compared to the process in American colleges and universities.

Another very pervasive feeling, which should be studied, was detected in Austria, Switzerland, and particularly in West Germany. This was the desire of the individual Gymnasium teachers to have greater freedom in what they taught and how their students were evaluated. They longed for some of the autonomy of the university professor. This desire was expressed most strongly in West Germany and to a lesser degree in Austria and Switzerland, where the Gymnasium teachers already had some greater flexibility. It would be of interest to see if the Gymnasium teachers are granted greater autonomy and how such a process might evolve.

During the survey of the existing literature related to this investigation, it became apparent that very little had been done in analyzing and comparing

the various curricula in comparable European institutions among themselves or to any educational programs in the United States. It is felt that the current literature would be enhanced if such studies as suggested were undertaken and the results published. A number of journal articles are expected to be written using the material contained in this study plus additional data obtained in the observation and interview process that were not included in this report.

As the direct result of a preliminary report on this study, one investigator has undertaken a comparable study of physics instruction in Great Britain, France, and northern West Germany. Dr. Ralph Miller, Chairman of the Physics Department at Greenville College, Greenville, Illinois, is spending the first semester of the academic year 1970-71 conducting this study. He is using the same basic questionnaire that was used in this investigation. Since this study contained little information on physics instruction at Gymnasien in West German Länder other than Bavaria, it is hoped that Dr. Miller's research can complement the investigation contained in this paper.

BIBLIOGRAPHY

BIBLIOGRAPHY

Books Cited

- American College Testing Program. Jackson Community College Class Profiles, Freshmen 1967-68 and 1968-69. Iowa City, Iowa: American College Testing Program, 1969.
- Arlt, Fritz. Der Zweite Bildungsweg. Munich, West Germany: Isar Verlag, 1958.
- Bauer, Hans. All About Switzerland. Zurich, Switzerland: Swiss National Tourist Office, 1968.
- Bayerischen Staatsministerium für Unterricht und Kultur. Schulordnung und Ausführungsbestimmungen für die Gymnasien in Bayern 1968. Munich, West Germany: Franz X. Seitz und Val. Hofling, 1969.
- Bericht 1967. Stiftung Volkswagen zur Förderung von Wissenschaft und Technik in Forschung und Lehre. Göttingen, West Germany: Vandenhoeck und Reprecht, 1968.
- Bildungswege an den Schulen des Landes Nordrhein-Westfalen. Röttingen, West Germany: A. Henn Verlag, 1964.
- Blättner, Fritz. Das Gymnasium; Ausgaben der Höheren Schule in Geschichte und Gegenwart. Heidelberg, West Germany: Quelle und Meyer, 1960.
- Bolton, Frederick Elmer. The Secondary School System of Germany. New York: D. Appleton and Co., 1900.
- Bundesgesetzblatt für die Republik Österreich. Vienna, Austria: Österreichische Staatsdruckerei, August 24, 1967.
- Bundesministerium für Unterricht. Die Wichtigsten Daten des Schullewesens in Österreich 1967/68. Vienna, Austria: Bundesministerium, 1968.

Central Office of the Swiss Universities. Swiss Universities. Berne, Switzerland: Swiss National Tourist Office, 1967.

Deutsche Forschungs Gemeinschaft: Aufbau und Aufgaben. Wiesbaden, West Germany: Franz Verlag GmbH, 1959.

Dottrens, Robert. The New Education in Austria. New York: John Day Company, 1930.

Egger, Eugene. Education in Switzerland. Zurich, Switzerland: Pro-Helvetia, 1968.

_____. Swiss Schools. Zurich, Switzerland: Pro-Helvetia, 1967.

Federal Ministry of Education, Austria. School Organization Act 1962. Vienna, Austria: Austrian Federal Press, 1965.

Hirlekar, Yamunabai. Education in Germany; Personal Impressions and Experiences. Bombay, India: Popular Book Depot, 1955.

Holme, E. R. The American University: An Australian View. Sydney, Australia: Angus and Robertson Ltd., 1920.

Huebner, Theodore. The Schools of West Germany: A Study of German Elementary and Secondary Schools. New York: New York University Press, 1962.

Hylla, Erich J. and Kegel, Friedrich O. Education in Germany; an Introduction for Foreigners. 2nd ed. Frankfurt on Main, West Germany: Hochschule for Internationale Padagogische Forschung, 1958.

Jackson Community College Catalog, 1968-1970. Jackson, Mich.: Jackson Printing Co., 1968.

Jackson Community College, Office of the Registrar. Enrollment Information 1968-69. Jackson, Mich.: Jackson Community College, 1969.

Klemperer, Lily von. A Survey of Austrian Education and Guide to the Academic Placement of Students from Austria in Educational Institutions in the United States of America. New York: World Education Series, 1961.

- Knoll, Joachim H. The German Educational System. Bad Godesberg, West Germany: Inter Nationes, 1967.
- Lüscher, Edgar. Experimental Physik I und II. Mannheim, West Germany: Bibliographisches Institut, 1966.
- Pilgert, Henry P. The West German Educational System. Historical Division, Office of the Executive Secretary, Office of the U.S. High Commissioner for Germany, 1953.
- Rickover, Hyman George. Swiss Schools and Ours; Why Theirs Are Better. Boston: Little, Brown, and Co., 1962.
- Schneebeli, Robert. Adult Education in Switzerland. Zurich, Switzerland: Pro-Helvetia, 1968.
- School Systems, A Guide: Austria. Strasbourg, France: Council for Cultural Cooperation, 1965.
- School Systems, A Guide: Federal Republic of Germany. Strasbourg, France: Council for Cultural Cooperation, 1965.
- School Systems, A Guide: Switzerland. Strasbourg, France: Council for Cultural Cooperation, 1965.
- Schultze, Walter and Führ, Christoph. Schools in the Federal Republic of Germany. Weinheim, West Germany: Verlag Julius Beltz, 1967.
- Statistisches Bundesamt, Wiesbaden. Bevölkerung und Kultur, Fach-Serie A, Allgemeinbildene Schulen 1967. Stuttgart und Mainz, West Germany: W. K. Kohlhammer GmbH, 1969.
- The National Beta Club. 1969-1970 College Facts Chart. Spartanburg, S.C.: The National Beta Club, 1969.
- United Nations. Educational, Scientific, and Cultural Organization. World Survey of Education: IV, Higher Education. Paris: UNESCO, 1966.
- U.S. Department of Health, Education, and Welfare, Office of Education, Division of International Education. "Education in the German Federal Republic," Studies in Comparative Education. Washington, D.C.: Government Printing Office, November, 1954.

U.S. Department of Health, Education, and Welfare, Office of Education. Educational Data: Federal Republic of Germany. Information on Education Around the World, Pubn. 35, November, 1959.

U.S. Department of Health, Education, and Welfare. Germany Revisited; Education in the Federal Republic. Washington, D.C.: Government Printing Office, 1958.

Warren, Hugh. Vocational and Technical Education: A Comparative Study of Present Practice and Future Trends in Ten Countries. Paris: United Nations Educational, Scientific, and Cultural Organization, 1967.

Wenke, Hans. Education in Western Germany; a Post-War Survey. Washington, D.C.: Library of Congress, Reference Department, European Affairs Division, 1953.

Periodicals

Abelson, Philip H. "German Technological Resurgence." Science, CLXV (July 25, 1969), 339.

Buchta, J. W. "Physics Education: An Account of the Paris Conference." Physics Today, XIV (January, 1961), 28-29.

Clarke, Norman. "The Teaching of Physics in Schools." Physics Today, XIV (January, 1961), 30-38.

Fox, F. W. "Physics for European Secondary Schools." Science Teacher, XXVIII (September, 1961), 15-19.

Gleazer, Edmund. "The Junior College Picture." Junior College Journal, XXIX (March, 1969), 24.

Goldfarb, Albert M. "On the Education of Physicists in Austria and Israel." American Journal of Physics, XXIX (March, 1961), 161-67.

Lambert, John. "Power and Politics." Science News, XCIV (November 2, 1968), 454.

Lüscher, Edgar. "Physics in West Germany." Physics Today, XIX (August, 1966), 46-54.

McKay, Llewelyn R. "The 'New Look' in West German Schools." History of Education Journal, VII (Summer, 1956), 144-56.

Sears, Francis W. "International Conference in Physics Education." American Journal of Physics, XXIX (March, 1961), 151-60.

Smart, K. F. "Education in East Germany." Educational Forum, XXV (May, 1961), 463-71.

"The Vocational Desires of Grammar School Learning." Education in Germany, IV d (February, 1964), 2-6.

Welch, Wayne W. and Walberg, Herbert J. "Are the Attitudes of Teachers Related to Decreasing Percentage Enrollments in Physics?" Science Education, LI (December, 1967), 436-42.

"West German School Statistics." Education in Germany IV (April, 1965), 21.

Whiting, Charles H. "Religion and Politics in German Schools." Educational Forum, XXXII (November, 1967), 93-96.

Wilkinson, Paul A. "Science Education in Europe." Science Education, XLVIII (October, 1964), 340.

Unpublished Report

Physics Department, Jackson Community College. "Physics Department Grade Distributions, 1968-69." Jackson, Mich. (Typewritten.)

Interviews

Abbott, Hilton. Physics Department, Jackson Community College, Jackson, Mich., June 30, 1969.

Bernhard, Erich. Physics staff, Freies Gymnasium, Zurich, Switzerland, March 6, 1969.

Christmann, Hans. Director, Munich Abendkolleg, Munich, West Germany, April 25, 1969.

Ebel, Horst. Physics staff, Vienna Technische Hochschule, Vienna, Austria, April 17, 1969.

- Eschig, A. Director, District Ten Bundesgymnasium und Realgymnasium, Vienna, Austria, April 16, 1969.
- Fleischmann, Rudolf. Physics staff, University of Erlangen, Erlangen, West Germany, May 7, 1969.
- Friedberger, Heinz. Director, Katharinen Gymnasium, Ingolstadt, West Germany, February 4, 1969.
- Frisch, Anton. Director, Höhere Technische Bundeslehranstalt, Salzburg, Austria, March 19, 1969.
- Geier, Andreas. Physics staff, Scheiner Gymnasium, Ingolstadt, West Germany, January 31, 1969.
- Gregory, Manuele. Mathematics staff, Höhere Technische Bundeslehranstalt, Salzburg, Austria, March 19, 1969.
- Hablützel, James. Physics staff, Oberrealschule, Zurich, Switzerland, March 4, 1969.
- Hammer, K. Director, Oskar-von-Miller Polytechnikum, Munich, West Germany, April 11, 1969.
- Hechenblaichner, H. Director, Salzburg Office of Education, Salzburg, Austria, March 17, 1969.
- Hetzer, Karl. Physics staff, Gabrielle Gymnasium, Eichstätt, West Germany, February 19, 1969.
- Hirzel, Hartmann. Registrar, Technikum Winterthur, Winterthur, Switzerland, March 4, 1969.
- Hitchingham, Lawrence. Physics Department, Jackson Community College, Jackson, Michigan, June 30, 1969.
- Kacowsky, Walter. English staff, University of Salzburg, Salzburg, Austria, March 18, 19, and 20, 1969.
- Kaforka, Erich. Director, Salzburg Bundesgymnasium, Salzburg, Austria, March 20, 1969.
- Kargl, H. Physics staff, Vienna District Ten Bundesgymnasium und Realgymnasium, Vienna, Austria, April 16, 1969.
- Kranz, Jakob. Physics staff, University of Munich, Munich, West Germany, March 13, 1969.

- Kumpf, Ignatz. Physics staff, Katharinen Gymnasium, Ingolstadt, West Germany, March 4, 1969.
- Leonard, Charles. Physics Department, Jackson Community College, Jackson, Michigan, June 28, 1969.
- Lüscher, Edgar. Physics Department, Munich Technische Hochschule, Munich, West Germany, April 25, 1969.
- Maisch, Josef. Director, Munich Kolleg, Munich, West Germany, May 5, 1969.
- Marz, Otto. Bavarian Ministry of Culture, Munich, West Germany, February 7, 1969.
- Mayr, Albert. Physics staff, Salzburg Bundesrealgymnasium, Salzburg, Austria, March 17, 1969.
- Meyer-Berkhout, Ulrich. Physics staff, University of Munich, Munich, West Germany, April 24, 1969.
- Modesto, Heinz. Physics staff, Reuchlin Gymnasium, Ingolstadt, West Germany, February 21, 1969.
- Ramp, Herbert. Engineering staff, Höhere Bundes-Lehr und Versuchsanstalt, Vienna, Austria, April 18, 1969.
- Riedl, P. Electrical Engineering staff, Höhere Technische Bundes-Lehr und Versuchsanstalt, Vienna, Austria, April 18, 1969.
- Rolle, Theodor. Director, Augsburg Kolleg, Augsburg, West Germany, March 26, 1969.
- Schanzenback, H. Technical staff, Ingolstadt Telekolleg, Ingolstadt, West Germany, February 10, 1969.
- Schlinder, Josef. Director, Vienna District Five Bundesgymnasium und Realgymnasium, Vienna, Austria, April 15, 1969.
- Schön, Otto. Assistant Director, Pädagogische Hochschule, Eichstätt, West Germany, February 12, 1969.
- Schrieber, Urs. Physics staff, Swiss Federal Institute of Technology, Zurich, Switzerland, March 5, 1969.
- Schuster, Margarete. Director, Vienna District Twelve Bundesgymnasium für Mädchen, Vienna, Austria, April 17, 1969.

- Sickinger, Richard. Federal Ministry of Education,
Vienna, Austria, April 14, 15, and 17, 1969.
- Stanek, F. W. Physics staff, Oskar-von-Miller Polytechni-
kum, Munich, West Germany, April 11, 1969.
- Stump, Hanspeter. Physics staff, Technikum Winterthur,
Winterthur, Switzerland, March 3, 1969.
- Treml, Richard. Headmaster, Werkschulheim, Ebenau,
Austria, March 18, 1969.
- Troyer, Donald. Comptroller, Jackson Community College,
Jackson, Mich., May 14, 1970.
- Vogel, Anselm. Physics staff, Oskar-von-Miller Polytech-
nikum, Munich, West Germany, April 11, 1969.
- Waldl, Elfriede. Physics staff, Höhere Technische Bun-
deslehranstalt, Salzburg, Austria, March 19, 1969.
- Waldner, Franz. Physics staff, University of Zurich,
Zurich, Switzerland, March 5, 1969.
- Williston, George. Director, Jackson United Community
Services, Jackson, Mich., April 1, 1979.

Books Not Cited

- Eidgenössische Technische Hochschule Zürich. Program und
Studenplan für das Wintersemester, 1968-69.
Zurich, Switzerland: Polygraphischer, 1968.
- Friedrich Alexander Universität, Erlangen-Nürnberg. Per-
sonen-und Vorlesungsverzeichnis: Sommerse-
mester, 1969. Erlangen, West Germany: Hofer
und Lummert, Inh., 1969.
- Höhere Technische Bundes-Lehr-und Versuchsanstalt Wien.
Bericht über das Schuljahr, 1967-1968. Vienna,
Austria: Bietak und Bernhardt Druck, 1967.
- Ludwig-Maximilians-Universität München. Personen-und
Vorlesungsverzeichnis: Sommersemester, 1969.
Munich, West Germany: Verlag Uni-Druck, 1969.
- Pädagogische Hochschule Eichstätt. Vorlesungs-Verzeichnis:
Wintersemester, 1968/69. Eichstätt, West Ger-
many: Bronner und Daentler KG, 1968.

Paris Lodron-Universität Salzburg. Vorlesungsverzeichnis
Personalstand: Sommersemester, 1969. Salzburg,
Austria: Universität Salzburg, 1969.

Technikum Winterthur Program: Ausgabe 1968. Zurich,
Switzerland: G.Z. und Co., 1968.

Technische Hochschule Wien. Vorlesungs-und Personalver-
zeichnis, 1968/69. Vienna, Austria: Adolf
Holzhausens Nfg., 1968.

Universität Zürich. Verzeichnis der Vorlesungen: Sommer-
semester, 1969. Zurich, Switzerland: Univer-
sität Zürich, 1969.

APPENDICES

APPENDIX A

DEFINITION OF TERMS

APPENDIX A

DEFINITION OF TERMS

Since this study was primarily concerned with the study of education in German speaking Europe, there are a number of terms related to education that will be defined as they have appeared in the text of this study. The best source book available for the definition and explanation of the German terms was found to be Schultze and Führ.¹

1. Comprehensive junior college.--A two-year, post-high school institution in the United States that had as its objectives the six cited on page 1.

2. Gymnasium.--A school which led to the qualifications needed for entry to universities, technical universities, teacher training colleges, and other institutions of higher education. The plural of Gymnasium is Gymnasien. The Gymnasium was found in West Germany, Austria, and Switzerland. In West Germany it encompassed grades five through twelve. In Switzerland it contained

¹Walter Schultze and Christopher Führ, Schools in the Federal Republic of Germany (Weinheim, West Germany: Verlag Julius Beltz, 1967).

grades seven through twelve and one-half; however, this varied somewhat from Kanton to Kanton. In addition to the three traditional West German school types, the Gymnasium for classical languages, the Gymnasium for mathematics and science, and the Gymnasium for modern languages, new ones had recently been added so that there were now a commercial Gymnasium, a Gymnasium for social subjects, and the Gymnasium for the fine arts. In prior years, this last had been called the Deutsches Gymnasium, which served as the institution for training elementary school teachers. All of these schools had since been converted to one of the other newer types of Gymnasium, and the requirements for teaching in the elementary schools had been raised to require three years of preparation beyond Gymnasium completion. In Austria there were many more types of Gymnasien established by the Education Act of 1962¹, but the most common types corresponded to those found in West Germany. There was some slight difference between a Gymnasium of mathematics and a Gymnasium of science and mathematics.

3. University.--Similar in all three German speaking countries and corresponded to the university in

¹Federal Ministry of Education, Austria, School Organization Act 1962 (Vienna, Austria: Österreichischer Bundesverlag, 1965).

the United States. In all countries, admission to the university was attained only after successfully passing the comprehensive maturity examination required for completion of any type of Gymnasium. Most of the universities had the classical faculties of law, medicine, theology, and philosophy. Only recently had some of the philosophy faculties split into science faculties, where the physics program was found. Very few universities had colleges of engineering or technology.

4. Technische Hochschule.--Literally translates as technical high school, but in reality was a technical university with colleges of engineering, technology, and applied sciences. The plural of Hochschule is Hochschulen. Entrance regulations required the applicant to have received the maturity certificate from a Gymnasium.

5. Kolleg.--Institutions established since World War II for older students who had not completed the Gymnasium yet who desired to enter the university. The plural of Kolleg is Kollege. There are both day and night Kollege; but in any case, they take the final three years of the Gymnasium and compress this into a two and one-half year program leading to the maturity certificate. The Kolleg was found only in West Germany. The governments of Austria and Switzerland assisted a number of private educational institutions that offered remedial Gymnasium

programs to serve the same purpose as the West German Kolleg.

6. Abitur.--The West German maturity certificate necessary for university entrance. It was a comprehensive examination supervised by the individual states written at the end of the Gymnasium program and was a requirement for university admission.

7. Mature.--The Austrian equivalent of the West German Abitur.

8. Matur.--The Swiss equivalent of the Abitur and Mature.

9. Polytechnikum.--The West German college of engineering or engineering school. It had a shorter and a less rigorous program than at a Technische Hochschule.

10. Höhere Technische Lehranstalt.--The Austrian equivalent of the West German Polytechnikum.

11. Technikum.--The Swiss version of the engineering college and nearly comparable to the West German Polytechnikum.

12. Volksschule.--Elementary school found in all three countries of West Germany, Austria, and Switzerland. In West Germany the elementary school was divided into two major parts. The first was four years in duration;

and following this some of the students transferred to various types of secondary education, the Gymnasium being one of the types. The second part of the Volksschule consisted of a five-year program, and the completion constituted the end of compulsory full-time education. Only the city-state of Berlin required six years in this second phase of elementary education. Austria had an eight-year elementary program divided into two four-year segments. After the first four years, many students switched into various types of secondary education as was the case in West Germany. Compulsory full-time education concluded with the completion of eight years of any type of schooling. Switzerland had an elementary education program which varied slightly depending upon the particular governmental province in which the student lived. In Zurich, compulsory elementary education was eight years in duration. Some students continued on to secondary schools, and others went into various types of vocational training at the conclusion of this elementary sequence.

13. Mittel or Realschule.--A type of general secondary education found only in West Germany. Students enrolled after the conclusion of four, five, or six years of elementary education. The Realschule program was six years in duration and concluded at grade ten, one year beyond the compulsory full-time school attendance requirement.

14. Mittlere Reife.--The certificate of completion received at the conclusion of the Realschule in West Germany. The literal translation is "middle examination."

15. Berufsschule.--A part-time vocational school found in West Germany, Austria, and Switzerland usually financially supported by the local community. Students were required to attend the Berufsschule one or two days per week between the ages of fifteen and eighteen, taking some general education and some vocational subjects closely related to the type or work they were performing at their job in the local community. An extremely close relationship existed among this type of school, the employers, and the local community. A student who finished the elementary school or Realschule before age eighteen was required to attend the Berufsschule until his eighteenth birthday in all West German Länder.

16. Telekolleg.--An educational television effort found in West Germany, where older students who had not completed the Realschule watched a five-night per week schedule of television programming in five subjects and then attended classes on Saturday morning at an education center to review and evaluate their progress. The total program was three years in duration, and the Mittlere Reife was conferred upon those who successfully completed the three-year sequence.

17. Abendgymnasium.--The night Gymnasium, an institution most commonly found in Austria and Switzerland, existing in either a public or private form, where a large number of the older students and "late bloomers" went back to secure the Mature or Matur in order to enter a university program. In these two countries the Abendgymnasium served the same purpose as the Kolleg in West Germany.

18. Volkshochschule.--Literally translates as "people's high school." The institution was found in West Germany, Austria, and Switzerland and contained most of what is known in the United States as adult education. Most of the programming in the Volkshochschule served a general education function and was not designed to lead a person to advanced or higher education. One notable exception was found in Austria, where the Abendgymnasium program was a part of the more general adult program found in the Volkshochschule. Although the Volkshochschule was usually locally administered and locally funded, the federal government did subsidize the Abendgymnasium portion of the Volkshochschule program.

19. Kanton.--The Swiss equivalent of our American state. There are twenty-five Kantons and half-Kantons in the Swiss Republic. Virtually all educational programs in Switzerland were administered on the Kanton level rather than at the federal level.

20. Land.--The equivalent of state in West Germany and Austria. The plural of this word is Länder. There are eight states in West Germany and the three city-states of Berlin, Bremen, and Hamburg, making a total of eleven major political and educational subdivisions in all West Germany. In West Germany the Land was the basic educational subdivision and assumed jurisdiction in almost all school matters. It was comparable to the Swiss Kanton in this regard. In Austria, while the Land or state also existed, most school programs were administered on a national level from the Federal Ministry of Education in Vienna. There are a total of nine Länder in Austria including the city-state of Vienna.

21. Ministry of Culture.--The governmental branch that housed the office of education in all of the West German Länder. Each of the eleven West German Länder had a Minister of Culture who was also the chief executive of all educational programs in that particular state.

22. Oberstudiendirektor.--The title of the chief official or principal at a West German Gymnasium. In Austria the equivalent title was Direktor. In Switzerland the chief official was called the Rektor.

23. Oberstudienrat.--The title of a senior instructor at a West German Gymnasium, usually conferred by the Ministry of Culture after five or six years of

successful teaching experience. In Austria, all Gymnasium teachers had the title of professor unless they possessed the doctorate, in which case their title was Doctor. In Switzerland, there were no titles used for instructors unless they possessed doctorates, in which case the title Doctor was also used.

24. Referendar.--The title used in West Germany for the teacher trainee while still in a student-teaching program at the Gymnasium level. The teacher candidate retained this title for one year or until he successfully passed the comprehensive teacher certification examinations administered by the Land.

APPENDIX B

QUESTIONNAIRE FORM AT ALL EDUCATIONAL INSTITUTIONS

APPENDIX B

QUESTIONNAIRE FORM AT ALL EDUCATIONAL INSTITUTIONS

A. Institution

1. Location
2. Type
3. Size
4. Founded

B. Names and Positions of Interviewees

C. Other Descriptive Data

1. Sex of Students
2. Daily Schedule
3. Annual Calendar
4. Education of Girls

D. Institutional Objectives and Criteria for Evaluating Institutional Effectiveness

E. Relationship of School to Environment

1. Relationship to Labor Force
2. Relationship to Local Community
3. Relationship to Church
4. Method of Financial Support for School

F. Teaching Staff

1. Sources and Preparation of Teaching Staff
2. Selection and Hiring
3. Teacher Compensation
4. Teaching Load
5. Relationship of Mathematics Staff to Physics Staff

G. Student Input

1. Admission Criteria
2. Socio-Economic Status of Students

3. Educational and Vocational Aspirations
4. Part of the Total Age Group Served by Respective Institution
5. Number of Students Who Work
6. Student Fees
7. Cost for Room and Board
8. Cost and Availability of Transportation
9. Any Other Demography

H. Completion Data

1. Percentage of Beginning Students Who Complete
2. Criteria for Completion
3. What Do Completers Do and Where Do They Go?
4. What Do Drop-Outs Do?
5. When Do Drop-Outs Drop Out?
6. Determination of Value of Gymnasium Completion for Students Who Do Not Enter University

I. Curriculum

1. Typical Curriculum for Students
2. Subjects Taken, When, and How Long
3. Contact Hours by Years
4. Curricula Where Physics Is Taken
5. Physics Cycle
6. Existence of Specialized Physics Program Such As Physical Science or Technical Physics

J. Pedagogical Techniques in Physics

1. Audio-Visual, Programmed Instruction, Computer Aided Instruction
2. Team Teaching
3. Lecture, Recitation
4. Class Size
5. Use of Laboratory
6. Textbooks
7. Lesson Plans (Source and Nature)
8. Library
9. Any Other Techniques or Aids

K. Evaluation

1. Evaluation for School Completion
2. Discussion of Abitur, Mature, or Matur, Where Appropriate
3. Differences in Final Evaluation in Different States
4. Any Major Testing Programs Prior to Final Evaluation

- L. Mathematics Related to the Physics Programs
- M. Key Physical Principles--When and Where Introduced
 - 1. Newton's Laws with Calculus
 - 2. Maxwell's Distribution--Kinetic Theory of Gases
 - 3. Magnetic Effects of Electrical Current Flow
 - 4. Fresnel and Fraunhofer Diffraction
 - 5. Special Relativity
 - 6. Bohr-Rutherford Theory of the Atom
 - 7. deBroglie Waves
- N. Look to the Future
 - 1. Curriculum Development
 - 2. Buildings and Equipment
 - 3. Enrollment Projections
 - 4. Any Trends in Physics Instruction
- O. General Comments Based upon Observations

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