DOCUMENT RESUME

ED 021 759 SE 004 967

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DEVELOPMENT OF A CORE-COURSE FOR COLLEGE SCIENCE MAJORS COMBINING MATERIAL FROM INTRODUCTORY COURSES IN BIOLOGY, CHEMISTRY, AND PHYSICS. FINAL REPORT.

Portland State Coll., Oreg.
Spons Agency- Office of Education (DHEW), Washington, D.C. Bureau of Research.
Pub Date Oct 67
Grant- OEG-4-7-068468-0060 BN-BR-6-8468
Note- 51p.
EDRS Price MF-$0.25 HC-$2.12
Descriptors- BIOLOGY, CHEMISTRY, *COLLEGE SCIENCE, COURSE CONTENT, COURSE EVALUATION, *CURRICULUM DEVELOPMENT, *INTERDISCIPLINARY APPROACH, PHYSICS
Identifiers- Oregon, Portland, Portland State College

Described is the development of a course that combines subject matter from introductory courses in biology, chemistry, and physics. The syllabus was written by four college science teachers, three of whom taught the course at Portland State College to 32 freshmen and sophomores. To evaluate the course, achievement tests and attitude surveys were administered to the experimental group and a control group of students in regular chemistry, physics, and biology courses. Achievement test results revealed a significant difference favoring the control group in biology at the five per cent level of confidence. No significant difference was noted in physics or chemistry. Results from the attitude survey revealed (1) that students favored the experimental course as often as the conventional courses, and (2) that students in the experimental group were more willing to alter schooling and career plans. Included in the report are the evaluation instruments and the statistical data employed. (BC)

BR-6-8468
PA-24

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Principal Investigator: Arnold D. Pickar

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October 1967

The research reported herein was performed pursuant to a grant with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

Portland State College

Portland, Oregon

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INTRODUCTION

(a) Problem, background, and related research.

It has become increasingly important in recent years for college students of science to obtain a broad background in both the physical and life sciences. Not only are the interdisciplinary research fields such as biophysics and biochemistry of growing significance, but many largely non-research professions such as medicine, dentistry, and secondary school science teaching demand stronger preparation in all the major sciences. In addition, many students find it more expedient to choose their majors after sampling a wide spectrum of disciplines. A vital question, however, is how to achieve this broad training in science in a way which will make efficient use of the student's available time, background, and interests. One answer which has received increasing attention is the integrated course concept. There have been a number of attempts to teach combined physics-chemistry courses, both at the college and high school levels.(2-5, 10) Some studies have been initiated to investigate other interfaces (such as between biology and chemistry) as they relate to teaching (1), but this has apparently not yet led to new curricular developments. Attempts at three-way integration combining material from physics, chemistry, and biology have resulted in courses for non-science majors at the college level (8) and, more recently, for high school students (9), but until the advent of the program described in this report there has been no effort at developing such courses for college science majors.

(b) Purposes and objectives.

The object of the research described in this report has been to develop a course for college science majors which combines in an efficient and consistent way the material from introductory courses in biology, chemistry, and physics. The course is intended for those students who intend to major in any of these three fields, as well as for pre-medical and pre-dental students. A preliminary evaluatory study has been performed which surveys student performance in subject areas as well as student attitudes and reactions towards science learning.

METHOD

(a) Syllabus.

A writing committee of four teachers of college science (a biologist, a chemist, a physicist, and a biophysicist) met during the summer of 1966 to prepare a detailed syllabus for the first year of the two-year introductory course, and an outline syllabus for the second year. The first year of the course was taught during the academic year 1966-67 at Portland State College, during which time the writing committee (three of whom were the instructors in the course) attended all lectures and laboratories, and met regularly in conference for review and reconsideration of the syllabus.

Appendix A contains a general description of the Portland State College course.

(b) Evaluation.

A preliminary study was conducted which was based upon the results of subject matter questions and attitude surveys administered simultaneously to the students in the combined course (treatment group) and to matched students enrolled in the conventional courses in physics, chemistry, and biology (control groups). Students were matched on the basis of sex, year in school, major area of study, SAT verbal score, SAT math score, and high school grade point average. Exceptions with respect to the matching criteria of sex, year in school, and major area of study were caused by limited control populations.

Subject matter achievement was measured by having treatment and control groups complete common test items inserted in regular examinations in the several courses. The paired t-test was used to compare achievement data from the treatment and control groups in each of the three subject areas. Student attitudes towards their particular science course, future plans, and science in general were sampled with a 15 question survey instrument which was completed by treatment and control groups. Point values were assigned to the various answers and then compared using the paired t-test method.

Details of the evaluation study are compiled in Appendix B.

RESULTS

(a) Syllabus.

A day by day outline of lectures, laboratories, and recitations for the first year of the Portland State College two-year 6 credit-hour sequence Science 201-6 is given in Appendix C. Reading assignment refer to texts by the following authors: in biology, Weisz (11); in chemistry, Keenan and Wood (6); and in physics, Morgan (7). A term by term assignment of topics for the second year is also given in Appendix C.

The class-hour distribution is in approximately the same proportion as the three separate courses for which it can be substituted. Four lectures a week are scheduled, and two afternoons are set aside for either laboratory work or recitations, as appropriate. Physics is more heavily emphasized in the earlier stages of the course, whereas proportionately more time is devoted to biology later in the sequence. Although the object was not to develop an interdisciplinary course per se, some attempt was made whenever possible to provide coherence by using some unifying themes. One of these themes is physical, chemical, and biological evolution. Another is the physical and biological aspects of thermodynamics, solutions, and the nature of protoplasm.

(b) Evaluation.

With respect to subject matter achievement it appears that the control students performed somewhat better than the treatment students only in the area of biology. (Comparisons using the paired t-test were made at the 5% level of significance.) The difference in performance was not significant in physics and chemistry though in each case the treatment students recorded a slight advantage. (Refer to page 5 of Appendix B).

The results of the attitude survey (pp. 26,7 of Appendix B) fav[illegible] the combined course approximately as often as the separate courses. (See especially the summary of the t values, page 37 of Appendix B, and the numerical tabulations on page 12.) However, the particular areas in which the different modes of instruction seemed most effective are of interest. In particular, the treatment students indicated a greater willingness to alter their future plans with respect to schooling and career. (See discussion of questions 2, 3, and 6 on pages 8 and 12 of Appendix B.)

DISCUSSION

(a) Syllabus.

In the light of one year's experience in teaching the course, it has become clear that the original syllabus (Appendix C) requires a good deal of revision. The areas in which modern introductory courses overlap were not to be fully appreciated during the original writing sessions. The most satisfactory teaching experiences seemed to occur whenever it was possible to use material from one discipline to reinforce and reinterpret concepts in another. (An example: entropy, which was discussed originally in a physics context, was developed as a useful predictive quality in chemical calculations. Another example involves organic compounds of biological significance.) However, a number of opportunities for such integration were not exploited in the original version. (Examples occur in the discussion of atomic structure and nuclear properties.)

A major stumbling block which was encountered arose from the fact that the class necessarily consisted largely of freshmen. These students in the beginning are not only unaccustomed to the pace of college work, but are not practiced in the analytical and problem solving skills demanded by the physics material. This latter difficulty is compounded by the rather more rapid pace of the course (six credit-hours versus five credit-hours in the regular physics course).

Nonetheless, a number of advantages envisioned for the course arrangement have been born out. The present syllabus permits a student to complete his introductory science study with an expenditure of 17% fewer credit hours than would be required by the regular biology, chemistry, and physics courses. In addition he need not commit himself very early to a particular major as he is taking prerequisites for all of them. The laboratory-recitation arrangement permits a flexibility which is hard to manage in other courses: experiments have kept pace with the lecture material, some new experiments have been tried, afternoon hours are available for special activities such as films, student self-study groups or tutoring sessions, etc. (Having hours set aside for group activities is particularly significant in an urban institution where many students live at home.) The occasional change of subject emphasis and instructors does not appear to cause any difficulty. In fact there is reason to suspect that some students who might otherwise be swamped by a long continued exposure to one subject, are "kept afloat" by being permitted to change emphasis from time to time. However, definitive study of this factor has not been done. Conversation with faculty has revealed that team teaching of the sort practiced in this course can be of particular interest to those doing a significant amount of research, by making it feasible to divide a faculty member's load into efficient blocks devoted principally to teaching or to research.

(b) Evaluation.

Although the evaluation study seems to indicate that the combined course is fulfilling its stated objectives, the evidence is not overwhelming. There are several reasons for this lack of conclusiveness:

(1) Size of populations involved. Only a small number of students were involved initially (32), and this population was drastically reduced due to the large number of withdrawals of students from both treatment and control classes. (This is, of course, typical of introductory science courses.)

(2) Subject matter testing. It proved difficult to devise suitable questions for comparison of subject matter acheivement. The control and treatment groups covered much of the material in different terms of the year, or at different times during the term. In any case it is unusual that any two instructors would give the same amount of emphasis to any given item.

(3) Matching. The matching of control and treatment students was not perfect due to limited populations and some arbitrariness in selection of matching criteria. For instance, the comparative drop-out rates were probably influenced by the difference in the ratio of freshmen to sophomores in the two groups (see page 4 of Appendix B). Similarly, it is possible that the results obtained from the attitude questions 1 and 9 (see pages 7 and 8 of Appendix B), which shows a negative interest reaction to physics in the treatment group, simply reflects the greater biology orientation of these students compared with the physical-science and engineering orientation found in the traditional general physics courses.

(4) Limited test objectives. Although improvements can undoubtedly be made in the testing procedures, it is not clear that the short-range view revealed in this study has much bearing on the overall objective of the course, which is to provide a more efficient and effective groundwork for the training of future scientists and science-oriented professionals. The results given here are certainly interesting and of help in developing the future of the course, but the long-range objective is not being tested.

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

(a) Syllabus.

The program as it has so far developed has been successful in terms of teaching the pertinent subject matter at least as well as is done in standard courses, yet with the advantages for the student of added flexibility in his future planning and in credit-hour savings. It has not taken full advantage of some of its inherent potential arising largely from the fact that it involves many students who are brought together for relatively long periods of time in several science learning situations. In future planning the following points should be given consideration:

(1) The "cluster effect". More use should be made of the interpersonal relationships which develop among the students. Problem solving "labs" can be organized to help develop analytical skills earlier. Special math sections set aside for these students might improve the relatedness of this subject to the student's overall program.

(2) The interdisciplinary approach. Several major subject areas offer excellent prospects for meaningful integration. These include atomic structure, which lies at the chemistry-physics interface and includes material in mechanics, waves, electricity, and energetics; organic chemistry and molecular biology, at the chemistry-biology interface; and thermodynamics which includes topics in physics and chemistry as well as cellular biology.

(3) The "spiral" approach. Under the circumstances of this course, many topics in physics and chemistry cannot (indeed should not) be thoroughly treated at the first encounter. For instance, certain aspects of electricity and magnetism are required to understand atomic structure which in turn underlies organic chemistry and molecular biology. However, many other aspects of electricity and magnetism (such as currents, circuits, e-m induction, etc.) fit more naturally into the course at later stages, where they will also serve a secondary purpose of stimulating review and rethinking of earlier learned ideas.

(4) Laboratories. The uniform background of the students in all the sciences will permit the use of meaningful interdisciplinary lab experiments. Some examples of experiments which utilize fairly standard equipment are: nuclear lifetime measurements (phys-chem), gaseous diffusion (phys-chem), paper chromatography (chem-bio), and osmosis/dialysis (bio-phys).

(b) Evaluation.

It seems worthwhile to continue in the future the "short-range" study begun in this project. Some improvement will undoubtedly arise from the larger population samples expected in the future. In addition, some changes in the matching criteria ought to be examined (such as high school science preparation). Engineering and applied-science students ought to be excluded from the control groups. However, especially in view of the fact that the syllabus used was only a preliminary attempt, the survey reported herein can be largely regarded as a "dry run", i.e., a first model for use in the future. Moreover, the data handling and computational procedures ought to be developed for automated operation.

By and large, the most important need is to set up a system for "long-range" evaluation of the course. The treatment and control students' performance should be followed during their upper-division work and beyond. Only in this way can we hope to get a valid measure of the efficiency of the combined mode of instruction in training men and women of science.

SUMMARY

In view of the increasing need for broad scientific training of research workers, medical practitioners, and teachers, a two-year college core-science course has been developed which combines the materials of introductory courses in physics, biology, and chemistry at the science major level. A preliminary version of a detailed syllabus has been written for the first year of the course, as well as an outline of the second year syllabus. An evaluation study has been begun, in which subject matter comprehension and student attitudes were surveyed in the experimental course and compared with results obtained from matched populations enrolled in conventional science courses.

As an alternative to the conventional courses the core-science program has proven to be a viable, interesting one in which the subject matter can be covered in less time. However, experience with the present syllabus has suggested several improvements. These include: (1) additional emphasis upon interdisciplinary material such as atomic structure, biochemistry, and thermodynamics; (2) teaching of some subjects in accordance with the so-called "spiral approach" in which students return to topics several times with increasing depth of treatment; and (3) increased opportunities for students to work together in much of their science and mathematics studies.

The preliminary evaluation study has shown the core-science course is at least as successful as the equivalent conventional course in terms of both subject matter achievement and student attitudes with one significant exception, viz., the students in the combined course are more flexible with respect to their future plans.

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MEMORANDUM

March 13, 1967

TO: All student counselors, Portland area high schools.

FROM: Division of Science, Portland State College.

SUBJECT: Science 201,-2,-3,-4,-5,-6, a new integrated core-science course for freshmen and sophomores at Portland State College.

1. This is to bring to your attention a new program for science majors and science-oriented students which has been in operation at Portland State College since last September. Entitled "Basic Science for Science Majors" it strives to combine the material from conventional one-year introductory courses in biology, chemistry, and physics into a unified two-year sequence. Completion of this course prepares the student to undertake upper division work in any of these three departments. This course is highly recommended for qualified students majoring in these areas or planning medical or dental careers. The program is being developed under a grant from the U.S. Office of Education in an attempt to respond to several challenges posed by the traditional college science curriculum, as outlined in paragraph (3) below.

2. In advising your senior students with respect to their college plans (in particular those who will be participating in our summer preregistration program), we urge you to keep this course in mind. In order to qualify, a student must have successfully completed high school courses in biology, chemistry, and physics. In addition, he must have a demonstrated competence in high school mathematics through plane trigonometry. This latter requirement can usually be interpreted as completion of trigonometry with a grade of B or above. We also urge you to alert your non-senior science-oriented students as to the availability of this course at Portland State College, so that they may take it into account when planning their high school programs.

3. Several of the aspects of modern science and science training which this course attempts to deal with are described below.

(a) Much modern work in the sciences is interdisciplinary in nature. For this reason, Portland State College has for some time required many of its science majors to take introductory courses in physics, chemistry, and biology. A purpose of the core-science course described above is to permit students to complete this introductory work in an efficient manner in their freshman and sophomore years, thus freeing them from a choice of a specific science major at the very beginning of their college careers.

(b) A broad program in introductory science consumes quite a large portion of a student's overall program. However, the core-course is rated at six hours per term, for a total of 36 hours, which is less than the number of hours required to complete the three traditional courses it is intended to replace.

(c) Under this program, the student is in an excellent position to undertake those upper division courses being offered at Portland State

College which are of an interdisciplinary nature, such as Biophysics, Electron Microscopy, Biochemistry, etc.

(d) We have reason to believe that this program is inherently more interesting to many students than the traditional ones. A team teaching approach is used; lecture and laboratory sessions rotate among the several disciplines in blocks encompassing several weeks of work.

4. For reference the catalog description is given below:

Science 201, 202, 203, 204, 205, 206. Basic Science for Science Majors. 6 credits each term.
A two-year unified sequence incorporating the subject matter of General Physics, Chemistry, and Principles of Biology, intended primarily for science majors and others desiring an extensive background in physics, chemistry, and biology. This course satisfies the prerequisites for upper division work in these three departments. Prerequisites: High School work in each of these three areas and competence in trigonometry. Four lectures; two three-hour laboratories, or four lectures, one recitation, and one three-hour laboratory.

For additional information, telephone Dr. A.D. Pickar, Department of Physics, Portland State College, Extension 337 or 401.

ADP:ph

APPENDIX B

of Final Report for
Grant OEG-4-7-068468-0060

PRELIMINARY EVALUATION

SCIENCE CORE COURSE

July 1967

Michael Fiasca

Robert Henselman

1. Introduction.

This report summarizes evaluation data obtained from students who were presented two modes of instruction in biology, chemistry and physics at Portland State College during the 1966-67 academic year.

In particular, this report will compare data in achievement and attitudes from students enrolled in the first year of a two year unified science course (PSC-Sci-201-202-203-204-205-206 Basic Science For Science Majors) combining the subject matter of general biology, chemistry and physics-- with data from students enrolled in biology, chemistry and physics courses studying the separate disciplines. The separate courses considered in this report were: General Physics (PSC-Ph-201-202-203); General Chemistry (PSC-Ch-204-205-206)/ and Principles of Biology (PSC-Bi-251-252-253).

Meeting patterns for the courses are listed below:

Sci-201...206	Four lectures and two three hour laboratories; or four lectures, one recitation, and one three hour laboratory.
Bi-251...253	Three lectures and two two hour laboratories.
Ch-204...206	Three lectures, one recitation, one three hour laboratory.
Ph-201...203	Three lectures and one recitation. The laboratory is offered as a distinct course Ph-204-205-206.

2. Matched Groups

For the purpose of analysis and comparison of achievement and attitude data matched treatment and control groups were established. The 32 students enrolled in Basic Science were used as the treatment group and 32 students in each of the areas of biology, chemistry, and physics were selected as matched control group members. Treatment and control students were matched on the basis of sex, year in school, major area of study, SAT verbal score, SAT math score, and high school grade-point average. (Appendix A) Exceptions in the matched treatment and control students with respect to the matching criteria of sex, year in school, and major area of study were caused by limited control populations and are noted in Appendix A.

The paired t-test was used to compare treatment and control groups with respect to SAT verbal scores, SAT math scores, and high school GPA. Similarity of the groups was demonstrated at the 0.5% level

3. Enrollment Patterns.

Table 1-A, below, illustrates the enrollment patterns for the sets of matched groups:

Table 1-A ENROLLMENT PATTERNS OF MATCHED INDIVIDUALS

Matched Set	Treatment Group	Biology Group	Chemistry Group	Physics Group
1	*	*	*	*
2	-	-	*X	-X
3	*X	*X	*X	*
4	-	-	*	-
5	-	-	*	*X
6	-	-	-	*
7	*	*	*	*
8	*	-	*	*
9	-	-	-	-
10	*	*	*	*
11	*	-	*	*
12	-	*	-	*X
13	-	*	-	-
14	*	*X	*	-
15	-	-	*	*
16	-	-	-	-
17	*	*	-	*X
18	-	-	*	-
19	-	-	-	*
20	*	*	*	*
21	*	*	*	-
22	*	*	-X	*
23	*	*	*	-
24	*	-	-	*
25	*	*	*	-
26	-	-	-	*
27	-	-	-	-
28	-	-	-	-
29	*	*	*	*
30	*	-	-	*
31	*	*X	*	*X
32	-	-X	-X	*X
Totals				
-	15	17	14	12
*	17	15	18	20
X	1	4	4	6

In Table 1-A above:
- indicates individuals not enrolled spring term
* indicates individuals enrolled spring term
X indicates that student is a sophomore

Table 1-B, below, summarizes the data on students enrolled at the end of spring term:

Table 1-B INDIVIDUALS ENROLLED AT THE END OF SPRING TERM

Year	Treatment Number-%	Biology Number-%	Chemistry Number-%	Physics Number-%
Freshmen	16-49.6%	12-37.2%	16-49.6%	15-46.5%
Sophomores	1- 3.1%	3- 9.3%	2- 6.2%	5-15.5%
Totals	17-52.7%	15-46.5%	18-55.8%	20-62.0%

Formula used to calculate per-centages was number of individuals involved in each instance divided by total number of students in the group; i. e. n/32.

Table 1-C, below, summarizes the data on students not enrolled at the end of spring term:

Table 1-C INDIVIDUALS DROPPED BY THE END OF SPRING TERM

Year	Treatment Number-%	Biology Number-%	Chemistry Number-%	Physics Number-%
Freshmen	15-46.5%	16-49.6%	12-37.2%	11-34.1%
Sophomores	0-.0.0%	1- 3.1%	2- 6.2%	1- 3.1%
Totals	15-46.5%	17-52.7%	14-43.4%	12-37.2%

Formula used to calculate per-centages was number of individuals involved in each instance divided by total number of students in the group; i. e. n/32.

While the totals in the above table do not favor the treatment students it should be pointed out that the drop-out rate for all freshmen in all groups (113) was 47.7% (54/113) while all sophomores in all groups (15) had a drop-out rate of 26.6% (4/15). And since 14 of the 15 sophomores were members of the control groups the different rates of attrition for freshmen and sophomores tend to cause the control group students to have higher rates of enrollment at the end of spring term and lower rates of drop-out. Further comment in this area will have to await next year's study.

4. Achievement.

Subject matter achievement was measured by teacher made tests. The treatment and control groups completed common test items. The paired t-test already mentioned was used to analyze achievement data from the matched treatment and control groups. Results obtained are listed below:

A. Treatment compared with Biology Controls: (Raw scores Appendix B) The calculated t value is 3.0217 (13 df) and the allowable range for the t value at the 5 % level of significance is ± 1.771. Therefore the t value is significant. The biology students' achievement was significantly better than the treatment students in the area of biology.

B. Treatment compared with Chemistry Controls: (Raw scores Appendix C) The calculated t value is -.9340 (16 df) and the allowable range for the t value at the 5 % level of significance is ± 1.740. Therefore the t value is not significant. The chemistry and treatment students' performance is similar in the area of chemistry.

C. Treatment compared with Physics Controls: (Raw scores Appendix D) The calculated t value is -.4614 (11 df) and the allowable range for the t value at the 5 % level of significance is ± 1.796. Therefore the t value is not significant. The physics and treatment students' performance is similar in the area of physics.

Therefore in the area of subject matter achievement it appears that the control students performed significantly better than the treatment students in the subject matter area of biology. In the other areas, chemistry and physics, the treatment and control groups recorded similar performances although in each case treatment students demonstrated a slight subject matter achievement advantage.

5. Attitudes.

Attitudes were sampled with a 15 question Reaction Inventory (Appendix E) which was completed by treatment and control groups. Point values were assigned to the various answers to inventory questions. Tables of raw scores of matched groups for each inventory question can be found in Appendix F.. These sets of raw scores were then analyzed with the paired t-test method and a table of calculated t values can be found at the end of Appendix F. It should be noted here that questions 2 and 6 are not treated in the above fashion and will be discussed later in this report.

Reactions to questions 4, 5, 7, 8, 14 and 15 demonstrated that there is no significant difference between treatment and control students on these items.

Inventory questions with significant differences between treatment and control groups are listed below:

1. My experiences in this course have

   a. intensified my interest in science
   b. had no impact on my interest in science
   c. lessened my interest in science

A significant difference was noted for treatment students compared with physics students. The calculated t value is 2.345 (11 df) and the allowable range for the t value at the 5 % level of significance is $\pm$ 1.796 (Appendix F). Therefore the t value is significant. The physics control group indicated a more intensified interest in science. The t values for treatment students compared with biology students and treatment students compared with chemistry students were not significant. (Appendix F)

3. My experiences in this course have caused me to

   a. elect different courses than I had originally intended for next year
   b. make no changes in my course selection for next year

A significant difference was noted for treatment students compared with chemistry students. The calculated t value is -2.3905 (10 df) and the allowable range for the t value at the 5 % level of significance is $\pm$ 1.812. (Appendix F) Therefore the t value is significant. The treatment students indicated that their experiences in basic science have caused them to elect courses different than originally intended for next year to a greater degree than their matched chemistry control counterparts. The t values for treatment students compared with biology students and treatment students compared with physics students were not significant. (Appendix F)

9. I would rate the instruction that I have received in this course as

   a. quite stimulating
   b. of average interest
   c. quite dull

A significant difference was noted for treatment students compared with physics students. The calculated t value is 1.9367 (10 df) and the allowable range for the t value at the 5 % level of significance is $\pm$ 1.812. (Appendix F) Therefore the t value is significant. The physics control students found the instruction quite stimulating. The t values for treatment students compared with biology students and treatment students compared with chemistry students were not significant. (Appendix F)

10. I feel that the course has been

   a. challenging to me
   b. of average difficulty
   c. rather easy

Significant differences were noted for treatment students compared with biology students and treatment students compared with chemistry students. For treatment students compared with biology students the calculated t value is -2.2520 (12 df) and the allowable range for the t value at the 5 % level of significance is ± 1.782. Therefore the t value is significant. (Appendix F) And, for treatment students compared with chemistry students the calculated t value is -2.5693 (11 df) and the allowable range for the t value at the 5 % level of significance is ± 1.796. Therefore the t value is significant. (Appendix F) In both of the above cases the treatment students felt that the course was more challenging than the matched control students. The t value for treatment students compared with physics students was not significant. (Appendix F)

11. I consider the quality of the lecture given to be

a. of high caliber
b. average
c. poor in quality

Significant differences were noted for treatment students compared with biology students and treatment students compared with chemistry students. For treatment students compared with biology students the calculated t value is 3.3178 (11 df) and the allowable range for the t value at the 5 % level of significance is ± 1.796. Therefore the t value is significant. (Appendix F) The biology control students felt that the quality of the lecture given was of high caliber. And, for treatment students compared with chemistry students the calculated t value is -2.0244 (10 df) and the allowable range for the t value at the 5 % level of significance is ± 1.812. Therefore the t value is significant. (Appendix F) In this case the treatment students felt that the quality of the lecture given was of highest caliber. The t value for treatment students compared with physics students was not significant. (Appendix F)

12. I consider the assignments made were

a. reasonable
b. average
c. unreasonable

A significant difference was noted for treatment students compared with physics students. The calculated t value is 2.9994 (9 df) and the allowable range for the t value at the 5% level of significance is ± 1.833. Therefore the t value is significant. (Appendix F) The physics control students felt that the assignments made were more reasonable than did the matched treatment students. The t values for treatment students compared with biology students and treatment students compared with chemistry students were not significant. (Appendix F)

13. I consider the laboratory experiences

a. contributed significantly to my understanding
b. were average in their contribution to my understanding
c. contributed little to my understanding

Significant differences were noted for treatment students compared with biology students and treatment students compared with chemistry students. For treatment students compared with biology students the calculated t value is 2.6353 (12 df) and the allowable range for the t balue at the 5% level of significance is ± 1.782. Therefore the t value is significant. (Appendix F) And, for treatment students compared with chemistry students the calculated t value is 3.3167 (10 df) and the allowable range for the t value is ± 1.812. Therefore the t value is significant. (Appendix F) In both cases above the control students were more satisfied than their treatment counterparts that laboratory experiences contributed more to their understanding. The t value for treatment students compared with physics students was not significant. (Appendix F)

6. Effects On Changes In Science Majors And Science Careers.

Questions 2 and 6 on the Reaction Inventory show rather interesting results. It is demonstrated that early experience with all sciences does cause students to change their minds about the choices of science majors and science career choices. This must be looked on as an advantage of the integrated mode of instruction.

The questions and numerical tabulations of the responses by group are listed below:

2. My experiences in this course have

   a. caused me to consider changing my major from science to another field of study
   b. caused me to consider changing my major from one science to another
   c. had no effect on my choice of majors

6. As a result of my experiences in this course

   a. I am considering changing my career choice from one which is science oriented to some other vocation
   b. I am considering changing my career choice from one science vocation to another science vocation
   c. I have not considered making a change in my choice of careers

TABLE 2 NUMERICAL TABULATION OF RESPONSES TO QUESTION 2

Group	Answer a.	Answer b.	Answer c.
Treatment	3	7	7
Biology	1	4	7
Chemistry	0	2	10
Physics	1	1	9
Totals	5	14	33

TABLE 3 NUMERICAL TABULATION OF RESPONSES TO QUESTION 6

Group	Answer a.	Answer b.	Answer c.
Treatment	3	5	9
Biology	0	4	8
Chemistry	1	0	11
Physics	1	1	9
Totals	5	10	37

TREATMENT GROUP AND MATCHED CONTROL GROUPS

Group key:

1) TREATMENT GROUP

2) BIOLOGY GROUP

3) CHEMISTRY GROUP

4) PHYSICS GROUP

Matching item code:

SEX: M-Male F-Female

YEAR: F-Freshman S-Sophomore

MAJOR: S-Science O-Other

VERBAL: SAT Verbal Score

MATH: SAT Math Score

HSGPA: High School GPA

A * placed with the code letter in the items of sex, year and major indicates that the treatment and control are not matched in that item.

An x placed in the column under DROP-OUT indicates that the student dropped out of the course.

The number in the SET column indicates particular sets of matched Treatment, Biology, Chemistry and Physics students. These SET numbers are used throughout this report in presenting data in the various tables.

SET	GROUP	SEX	YEAR	MAJOR	VERBAL	MATH	HSGPA	DROP-OUT
	1	F	F	S	710	690	3.9	
	2	F	F	O*	680	590	3.8	
1	3	M*	S*	S	620	620	3.7	
	4	M*	S*	S	570	610	3.9	
	1	M	F	S	610	750	2.6	x
	2	M	F	S	450	520	2.6	x
2	3	M	F	S	460	570	2.6	
	4	M	F	S	650	580	2.6	x
	1	M	S	S	___	___	2.2	
	2	M	S	S	___	___	2.4	
3	3	M	S	S	___	___	2.4	
	4	M	F*	S	___	___	2.1	
	1	M	F	S	___	___	2.9	x
	2	M	F	S	___	___	2.9	x
4	3	M	F	S	___	___	2.7	
	4	M	F	S	___	___	2.9	x
	1	M	F	O	620	640	3.2	x
	2	M	F	O	540	470	3.5	x
5	3	M	F	S*	670	680	3.1	
	4	M	S*	S*	670	680	3.1	
	1	F	F	S	___	___	3.4	x
	2	F	F	S	___	___	3.4	x
6	3	F	F	S	___	___	3.4	x
	4	M*	F	S	___	___	3.4	
	1	M	F	S	460	680	3.4	
	2	M	F	S	450	680	3.4	
7	3	M	F	S	450	680	3.4	
	4	M	F	S	470	640	3.4	
	1	M	F	S	470	570	3.2	
	2	M	F	S	540	530	3.0	x
8	3	M	F	S	460	530	3.2	
	4	M	F	S	450	550	3.3	
	1	M	F	S	620	650	2.7	x
	2	M	F	S	540	640	2.9	x
9	3	M	F	S	540	640	2.9	x
	4	M	F	S	500	650	3.1	x
	1	M	F	S	510	600	3.1	
	2	M	F	S	450	580	3.1	
10	3	M	F	S	610	630	3.0	
	4	M	F	S	470	560	3.1	

SET	GROUP	SEX	YEAR	MAJOR	VERBAL	MATH	HSGPA	DROP-OUT
	1	M	F	S	490	500	2.3	
	2	M	F	S	480	540	2.4	x
11	3	M	F	S	450	560	2.6	
	4	M	F	S	530	510	2.4	
	1	M	F	S	370	620	3.3	x
	2	M	F	S	560	630	3.3	
12	3	M	F	S	350	630	2.8	x
	4	M	S*	S	440	660	3.2	
	1	M	F	S	750	680	3.9	x
	2	M	F	S	440	500	3.4	
13	3	M	F	S	560	610	3.7	x
	4	M	F	S	610	650	3.9	x
	1	F	F	S	610	650	3.0	
	2	F	F	S	510	410	3.0	
14	3	F	S*	S	510	570	3.3	
	4	M*	F	O*	570	620	3.0	x
	1	M	F	S	610	660	2.5	x
	2	M	F	S	450	570	2.5	x
15	3	M	F	S	430	630	2.6	
	4	M	F	S	420	610	2.5	
	1	M	F	S	410	460	2.7	x
	2	M	F	S	430	460	2.6	x
16	3	M	F	S	350	430	2.5	x
	4	M	F	S	440	440	2.4	
	1	M	F	S	500	440	4.0	
	2	M	F	S	550	440	3.1	
17	3	M	F	S	530	550	3.9	x
	4	M	S*	S	550	640	3.9	
	1	F	F	S	410	530	2.9	x
	2	F	F	S	530	510	3.2	x
18	3	F	F	S	390	510	3.0	
	4	M*	F	S	510	550	3.1	x
	1	M	F	S	580	610	2.9	x
	2	M	F	O*	490	600	3.1	x
19	3	M	F	S	480	590	2.9	x
	4	M	F	S	560	630	3.0	
	1	M	F	O	640	590	3.3	
	2	M	F	O	640	550	3.5	
20	3	M	F	S*	390	590	3.4	
	4	M	F	S*	410	540	3.3	
	1	F	F	S	740	570	3.4	
	2	F	F	S	570	530	3.4	
21	3	F	F	S	620	660	3.6	
	4	M*	F	S	600	610	3.6	x

SET	GROUP	SEX	YEAR	MAJOR	VERBAL	MATH	HSGPA	DROP-OUT
	1	M	F	O	390	510	2.3	
	2	M	F	O	490	490	2.2	
22	3	M	S*	S*	500	550	2.4	x
	4	M	F	S*	550	540	2.3	x
	1	M	F	S	620	720	3.9	
	2	M	F	S	530	730	3.7	
23	3	M	F	S	520	720	3.3	
	4	M	F	S	520	700	3.9	x
	1	M	F	O	570	660	2.6	
	2	M	F	O	570	640	2.1	x
24	3	M	F	S*	500	640	2.8	x
	4	M	F	S*	470	650	2.7	
	1	M	F	S	530	540	3.2	
	2	M	F	S	570	510	3.3	
25	3	M	F	S	560	510	3.1	
	4	M	F	S	510	560	3.1	x
	1	F	F	S	580	550	3.0	x
	2	F	F	S	590	590	2.9	x
26	3	F	F	S	540	480	3.0	x
	4	F	F	S	570	550	3.0	
	1	M	F	O	620	640	3.0	x
	2	M	F	O	480	630	2.9	x
27	3	M	F	S*	570	610	3.2	x
	4	M	F	O	520	640	2.9	x
	1	F	F	S	610	580	3.0	x
	2	F	F	S	530	590	3.0	x
28	3	F	F	S	530	590	3.0	x
	4	M*	F	S	620	620	3.0	x
	1	M	F	S	--	--	3.5	
	2	M	F	S	--	--	3.5	
29	3	M	F	S	--	--	3.5	
	4	M	F	S	--	--	3.5	
	1	M	F	S	430	530	2.3	
	2	M	F	S	600	430	2.0	x
30	3	M	F	S	410	570	2.4	x
	4	M	F	S	390	580	2.3	
	1	M	F	S	630	680	3.4	
	2	M	S*	S	490	430	3.4	
31	3	M	F	S	570	470	3.3	
	4	M	S*	S	530	540	3.4	
	1	M	F	S	510	600	3.1	x
	2	M	S*	S	590	620	3.1	x
32	3	M	S*	S	590	620	3.1	x
	4	M	S*	S	510	630	3.1	

Paired t-test values for treatment and control matching items:

Matched Groups	SAT Verbal	SAT Math	High School Grade Point
	t range ± 2.771 (27 df)	t range ± 2.771 (27df)	t range ± 2.745 (31df)
	t value	t value	t value
Treatment & Biology	1.428	2.657	0.944
Treatment & Chemistry	2.665	1.000	0.090
Treatment & Physics	2.402	0.903	1.401

t ranges listed above at the .5% level; all t values listed are within their respective t range and therefore the groups are to be considered matched on these items.

SET	TREATMENT	BIOLOGY
1	12	14
2	-	-
3	14	14
4	-	-
5	-	-
6	-	-
7	12	14
8	8	-
9	-	-
10	9	13
11	9	-
12	12	10
13	-	-
14	17	18
15	-	-
16	-	-
17	9	12
18	-	-
19	-	-
20	8	13
21	10	14
22	5	11
23	14	14
24	12	-
25	11	18
26	-	-
27	-	-
28	-	-
29	12	9
30	10	-
31	9	17
32	-	-

SET	TREATMENT	CHEMISTRY
1	35	32
2	32	24
3	-	-
4	-	-
5	-	-
6	-	-
7	30	32
8	28	35
9	-	-
10	33	28
11	37	35
12	32	24
13	-	-
14	35	35
15	-	-
16	-	-
17	20	30
18	-	-
19	-	-
20	35	32
21	33	15
22	-	-
23	35	31
24	32	18
25	28	27
26	-	-
27	-	-
28	-	-
29	30	25
30	-	-
31	32	28
32	0	23

SET	TREATMENT	PHYSICS
1	5	0
2	-	-
3	5	10
4	-	-
5	-	5
6	-	-
7	4	2
8	10	10
9	-	-
10	0	1
11	5	0
12	10	10
13	-	-
14	-	-
15	-	4
16	-	3
17	7	5
18	-	-
19	-	10
20	-	-
21	-	-
22	-	-
23	-	-
24	10	15
25	-	-
26	-	10
27	-	-
28	-	-
29	10	1
30	5	10
31	10	10
32	-	5

Course ________ I. D. Number ____________ Section ____________

REACTION INVENTORY

This reaction inventory was prepared to assist the Science Faculty of Portland State College to improve its undergraduate instruction. The answers you provide will be held in strict confidence. No instructor of this course will see your response sheet. He will be provided a tally of the results, however.

Instructions: Please give your reactions to the following list of items regarding your experience in this course. Draw a circle around the letter that corresponds to the statement that most nearly registers your true feelings.

1. My experiences in this course have

   a. intensified my interest in science
   b. had no impact on my interest in science
   c. lessened my interest in science

2. My experiences in this course have

   a. caused me to consider changing my major from science to another field of study
   b. caused me to consider changing my major from one science to another
   c. had no effect on my choice of majors

3. My experiences in this course have caused me to

   a. elect different courses than I had originally intended for next year
   b. make no changes in my course selection for next year

4. To what extent has this course met your expectations with respect to improving your subject matter competence

   a. very well satisfied
   b. satisfied
   c. disappointed

5. As a result of my experience in this course I am

   a. considerably more aware of the impact of science on human affairs
   b. somewhat more aware of the impact of science on human affairs
   c. no more aware of the impact of science on human affairs

6. As a result of my experiences in this course

   a. I am considering changing my career choice from one which is science oriented to some other vocation
   b. I am considering changing my career choice from one science vocation to another science vocation
   c. I have not considered making a change in my choice of careers

7. As a result of my experience in this course

   a. I am more aware of the interdependence of all the sciences
   b. I have not changed my views about the interdependence of the sciences

8. I would rate the overall instruction I have received in this course as

   a. excellent
   b. good
   c. fair
   d. poor

9. I would rate the instruction I have received in this course as

   a. quite stimulating
   b. of average interest
   c. quite dull

10. I feel this course has been

   a. challenging to me
   b. of average difficulty
   c. rather easy

11. I consider the quality of lecture given to be

   a. of high caliber
   b. average
   c. poor in quality

12. I consider the assignments made were

   a. reasonable
   b. average
   c. unreasonable

13. I consider the laboratory experiences

   a. contributed significantly to my understanding
   b. were average in their contribution to my understanding
   c. contributed little to my understanding

14. I consider that the recitation groups

   a. contributed significantly to my understanding
   b. were average in their contribution to my understanding
   c. contributed little to my understanding

15. I consider that the examinations were

   a. appropriate
   b. inappropriate

   for the course

The following tables represent the raw scores obtained from responding matched treatment and control group students on the Reaction Inventory. Each table represents the individual matched treatment and control student responses for a particular question. Questions 2 and 6 are not included in this breakdown, but a summary of student responses on these items appears elsewhere in this report.

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* indicates no response

Question 1:

Set	Treatment	Biology	Chemistry	Physics
1	1	1	1	1
3	1	-1	0	0
7	-1	1	0	0
8	-1	*	1	1
10	1	0	1	1
11	1	*	0	1
14	1	1	0	*
17	0	0	*	0
20	0	0	1	1
21	1	1	*	*
22	0	1	*	*
23	0	1	1	*
24	0	*	*	1
25	1	1	-1	*
29	1	0	1	1
30	-1	*	*	1
31	-1	0	0	1

Question 3:

1	0	1	0	0
3	0	0	0	1
7	0	0	0	0
8	1	*	0	0
10	0	0	0	1
11	1	*	0	1
14	1	1	0	*
17	0	0	*	0
20	0	*	0	0
21	1	0	*	*
22	0	0	*	*
23	0	0	0	*
24	0	*	*	*
25	1	0	0	*
29	0	1	0	0
30	1	*	*	0
31	1	0	*	0

Question 4:

Set	Treatment	Biology	Chemistry	Physics
1	1	1	0	0
3	-1	0	1	-1
7	0	1	0	0
8	-1	*	0	1
10	0	1	0	0
11	0	*	0	0
14	0	0	-1	*
17	0	-1	*	0
20	0	0	1	0
21	-1	0	*	*
22	0	0	*	*
23	0	1	1	*
24	0	*	*	1
25	1	1	0	*
29	0	-1	0	0
30	0	*	*	0
31	-1	0	1	0

Question 5:

1	2	1	0	2
3	2	2	1	1
7	1	2	1	2
8	1	*	2	1
10	1	1	1	1
11	2	*	2	2
14	2	2	1	*
17	1	2	*	1
20	2	1	1	1
21	2	1	*	*
22	1	2	*	*
23	1	2	2	*
24	1	*	*	2
25	2	2	2	*
29	1	1	1	2
30	1	*	*	2
31	0	1	1	1

Question 7:

Set	Treatment	Biology	Chemistry	Physics
1	1	0	1	0
3	1	1	1	1
7	1	1	1	1
8	1	*	1	0
10	1	1	1	1
11	1	*	1	1
14	1	0	0	*
17	1	1	*	1
20	1	0	1	0
21	1	1	*	*
22	1	1	*	*
23	0	1	0	*
24	1	*	*	*
25	1	1	0	*
29	1	0	1	1
30	1	*	*	1
31	0	1	0	1

Question 8:

1	3	2	2	2
3	1	2	3	1
7	2	3	1	2
8	2	*	2	3
10	3	3	2	2
11	3	*	2	3
14	3	3	1	*
17	2	0	*	1
20	2	2	2	2
21	2	3	*	*
22	1	3	*	*
23	2	3	2	*
24	3	*	*	3
25	3	3	2	*
29	3	1	2	2
30	2	*	*	2
31	1	2	2	1

Question 9:

Set	Treatment	Biology	Chemistry	Physics
1	2	1	0	2
3	1	2	1	1
7	1	2	1	2
8	1	*	2	2
10	2	2	1	2
11	2	*	1	2
14	2	1	0	*
17	1	1	*	1
20	1	1	2	2
21	1	1	*	*
22	1	1	*	*
23	1	2	2	*
24	2	*	*	2
25	2	2	0	*
29	2	1	1	2
30	1	*	*	1
31	*	1	1	1

Question 10:

1	2	2	1	2
3	2	1	2	2
7	2	1	1	2
8	1	*	2	2
10	2	1	2	1
11	2	*	1	2
14	2	1	1	*
17	2	2	*	2
20	2	2	2	2
21	1	1	*	*
22	2	2	*	*
23	1	2	0	*
24	2	*	*	0
25	2	1	1	*
29	2	1	1	2
30	2	*	*	2
31	2	1	2	2

Question 11:

Set	Treatment	Biology	Chemistry	Physics
1	2	2	0	1
3	1	2	2	1
7	1	2	1	2
8	1	*	2	2
10	2	2	1	*
11	2	*	0	1
14	2	2	0	*
17	1	2	*	0
20	1	2	1	1
21	2	2	*	*
22	1	2	*	*
23	1	2	1	*
24	2	*	*	2
25	2	2	0	*
29	2	2	1	2
30	2	*	*	1
31	*	2	1	1

Question 12:

1	2	1	2	2
3	0	2	1	1
7	1	2	1	2
8	2	*	2	2
10	1	2	2	2
11	1	*	2	2
14	1	2	1	*
17	2	1	*	2
20	2	1	2	2
21	2	2	*	*
22	0	2	*	*
23	2	2	2	*
24	2	*	*	*
25	2	2	1	*
29	2	2	2	2
30	1	*	*	2
31	*	1	2	2

Question 13:

Set	Treatment	Biology	Chemistry	Physics
1	2	1	2	1
3	0	1	1	1
7	2	1	1	1
8	1	*	2	1
10	0	1	2	0
11	1	*	*	0
14	0	1	2	*
17	2	2	*	1
20	0	1	2	1
21	1	2	*	*
22	0	2	*	*
23	0	2	2	*
24	1	*	*	0
25	1	2	2	*
29	1	1	1	2
30	1	*	*	1
31	0	1	1	0

Question 14:

Set	Treatment	Biology	Chemistry	Physics
1	2	0	1	2
3	0	0	0	1
7	2	2	2	2
8	2	*	2	0
10	2	0	2	2
11	1	*	1	2
14	1	*	2	*
17	1	1	*	0
20	1	0	2	0
21	1	1	*	*
22	0	2	*	*
23	2	*	0	*
24	1	*	*	0
25	2	1	2	*
29	1	*	2	2
30	1	*	*	0
31	1	1	2	1

Question 15:

Set	Treatment	Biology	Chemistry	Physics
1	1	1	1	1
3	-1	1	1	-1
7	1	1	1	1
8	1	*	1	1
10	1	1	1	1
11	1	*	*	1
14	1	1	1	*
17	1	-1	*	1
20	1	1	1	-1
21	1	1	*	*
22	1	1	*	*
23	1	1	1	*
24	1	*	*	1
25	1	1	1	*
29	1	1	1	1
30	1	*	*	1
31	-1	1	1	1

Calculated t Values For Reaction Inventory Questions

t values significant at 5% level are underlined

Reaction Inventory Question Number	T B df	T B t value	T C	T C t value	T P df	T P t value
1	12	0.2672	11	0.2472	11	2.345
3	11	0.4317	10	-2.3905	10	-0.4714
4	12	1.4771	11	0.3402	11	1.1488
5	12	0.6924	11	0.6159	11	1.1480
7	12	-0.8052	11	-1.4827	10	-0.9995
8	12	0.4566	11	-1.3320	11	-1.3935
9	11	0.0000	10	-1.4905	10	1.9367
10	12	-2.2520	11	-2.5693	11	-0.8045
11	11	3.3178	10	-4.0244	9	-0.8019
12	11	1.0763	10	1.0000	9	2.9994
13	12	2.6353	10	3.3167	11	0.6915
14	9	1.0775	11	0.3206	11	-0.8970
15	12	0.6171	10	1.4909	11	0.0000

df is degrees of freedom; n-1 in this case

T B is treatment and biology

T C is treatment and chemistry

T P is treatment and physics

Number of df	Allowable t value range* (page 520)
9	~~± 1.833~~
10	± 1.812
11	± 1.796
12	± 1.782

*t value range [illegible] from: Li, Jerome C.R.: Introduction To Statistical Inference; distributed by Edwards Brothers, Inc. Ann Arbor, Michigan; 1957.

SCIence 201 outline- Fall 1966. APPENDIX C

	M	T	W	Th	F
1	Sept. 26. Introduction to course.	PH.recitation: Slide rule, math.	PH:Introduction to physics. Vectors. Chapters 1, 2.	CH.lab: Check-in. Chem. balances. Ch.manual: p.2-6.	PH: Particle kinematics. Chap. 3.
2	Oct. 3. PH: Kinematics concluded.	PH.rec:kinematics and vector probs.	PH: Brief quiz (vectors,kinemat.) Particle dynamics, Newton's laws. Chapters 4 and 5.	PH.lab:Measuremnts &errors. Intro&Ex 1	
3	Oct. 10. PH:Statics of rigid bodies. Chap.7.	PH.rec: Dynamics problems.	PH:Quiz(dynamics). Statics concluded.	PH:Rotational motion, orbits, rigid body dynamics. Chapters 8, 9, 10. PH.lab:Gravitat. accel.(Ex.4);rotat. accel.(Exp.6).	
4	Oct. 17. PH:Rotation concluded. Work and energy. Chap.11,12	PH.rec: Statics, rotation probs.	PH:Quiz(rotation). Work and energy concluded.	PH.lab: Exp. 4 and 6 continued.	PH: Impulse and linear momentum. Chapter 13.
5	Oct. 24. PH:Nuclear scattering. Angular momentum.Chap.13.	PH.rec: Energy, momentum probs.	PH: Quiz(work and energy). Gyroscopic motion.	CH: Atomic structure; periodic table. Chapters 1 and 2. PH.lab:Collisions and scattering.	
6	Oct. 31. CH:Atomic struct. completed.Nuclear chem. Chapter 14.	CH.rec:Atomic str, atomic & molec.wt. Prob. book Chap.3.	CH: Nuclear chemistry concluded ---------.	CH.lab:Perc- comp.;rela atomic wt. 3).	
7	Nov. 7. CH: Electronic structure of atom. Chapter 3.	CH.rec: Nuclear chem. Problem book Chapter 18.	CH: Electronic structure of the atom concluded.	CH.lab: Periodic law(Ex.4);changes, substances(Exp.5).	CH:Chem. changes and chem. bonds. Chapter 4.
8	Nov. 14. CH: Chem. changes and bonds contd.	CH.rec:Lab manual exerc.6 + review chapters 2,3,14.	CH:Exam (Chapters 2, 3, 14).	CH:Chem.changes & bonds concluded. CH.lab: Electrolytes,acids,bases, salts (Exp. 7).	CH: Organic chemistry. Chapter 25
9	Nov.21. CH: Organic chem. continued.	CH.rec: Organic nomenclature.	CH: Organic chem. contd.Chapter 26.		
10	Nov. 28. CH: Organic chem. continued.	CH.rec: Organic chemistry.	CH: Organic chemistry concluded. Chapters 27 and 28.	CH.lab: Organic chemistry.	
11	Dec. 5. BI: Origin of the universe. Chem. text Chapter 29.	CH.lab: Organic chemistry.	BI: Evolution of the elements.	BI: Formation of solar system. Film: Cosmology.	BI: Early earth: chem. evolution.

SCIence 202 outline- Winter 1967.

	M	T	W	Th	F
1		Jan. 3. BI.lab: cellular and organismic organization.	BI: Compounds of biological significance. Pp. 65-78.	BI.lab: Cellular and organismic organization.	BI: Theories of biological evolution. Pp.37-51.
2	Jan. 9. BI: Evolution of life. Pp. 51-58.	BI.lab: Cellular and organismic organization.	BI: Nutrition and the oxygen revolution. Pp.59-64.	BI: Reproduction- the genetic code. Pp. 443-461. BI.lab: The role of enzymes.	
3	Jan. 16. BI: Changes in the code & consequences. Pp.94-118.	BI: Exam.	PH: Fluid statics and dynamics. Chapters 17, 18.	PH.lab: Surface tension and capillarity (Exp.13).	
4	Jan. 23. PH: Frictional work. Chapter 6.	PH.rec: Fluid and friction probs.	PH: Quiz (fluids). Heat and temperature; ideal gases. Chapters 19,20,21.	PH.lab: Calorimetry (Exp. 23)- half of class.	
5	Jan. 30. PH: Heat and temp. concluded.	PH.rec: Heat probs. PH.lab: Calorimetry-half of class.	PH: Quiz (heat). Thermodynamics and kinetic theory. Chapter 22.	CH.lab: Diffusion (Exp.14); molar gas volume (Exp. 16).	
6	Feb. 6. PH: Thermodynamics etc. continued.	PH.rec: Thermo. & kinetic theory problems.	PH: Quiz (Thermo. etc.) Thermo. concluded.	CH: Thermochemistry. Chapter 16 (in part). CH.lab: Heat of reaction (Exp.27).	
7	Feb. 13. CH: Thermochemistry concluded.	CH.rec: Thermochemistry.	CH: Oxygen, hydrogen, and water. Chapter 6.	CH.lab: Specific heat of a solid (Exp. 28).	
8	Feb. 20. CH: Solutions. Chapters 9, 10.	CH.rec: Concentration. Problem book chapter 9.	CH: Solutions (chapter 10) - continued.	CH.lab: Oxygen (Exp.9); hydrogen (Exp.10).	
9	Feb. 27. CH: Solutions concluded.	CH.rec: Review.	CH: Exam.	CH: Colloids. Chapter 11. CH.lab: Colligative properties (Exp.19 or 20).	
10	Mar. 6. CH: Colloids continued.	BI.lab: Amino acids (separation & identification).	CH: Colloids concluded.	BI: Physical nature of protoplasm. Pp. 78-82. BI.lab: Movement materials-liv.org.	BI: Movement of materials (cellular level). Pp. 78-82.

SCIence 203- Spring 1967.

	M	T	W	Th	F	S/S
1			Mar. 29. PH: Oscillations, simple harmonic motion. Chapter 15.	PH.lab: Spring pendulum (Exp.8); torsion pend. (Exp.11)		
2	April 3. PH: Mechanical waves. Chapter 23.	PH.rec: Oscillations problems.	PH: Quiz(oscillations. Waves (continued) and sound. Chapters 23 and 24.	PH.lab: Resonance & waves (Exp.60,61)		
3	April 10. PH: Similarities in wave behavior.	PH.rec: Wave problems.	PH: Quiz (waves). Electromagnetic waves. Sect.31-14.	PH: Geometrical optics -reflection and refraction. Chapter 32. PH.lab: Resonance continued.		1 weekend- biology field trip.
4	April 17. PH: Relativity.	PH.rec: Optics problems.	PH: Quiz(optics). Relativity concluded.	PH: Geometrical optics- lenses and optical instruments. Chapter 33. PH.lab: Prism spectrometer (Exp.74); compound microscp.		
5	April 24. PH: Microscopes (guest lecture).	PH.rec: Optics problems.	PH: Quiz(optics). Coupled oscillators.	BI: The taxonomic system. Pp.161-169. PH.lab: Spectrometer & microscope continued.	BI: The monera. Pp. 169-177.	
6	May 1. BI: Protista-algae. Pp.178-192.	BI.lab: Diversity of life.	BI: Protista -protozoa and fungi. Pp. 193-211.	BI.lab: Diversity of life continued.	BI: Plantae-bryophytes. Pp. 213-219.	
7	May 8. BI: Plantae-tracheophytes. Pp.219-251.	BI.lab: Diversity of life continued.	BI: Plantae-tracheophytes concldd.	BI: Animalia-acoelomates & pseudo-coelomates. Pp253-72 BI.lab: Diversity of life continued.	BI: Animalia-schizocoelomates. Pp. 272-288.	
8	May 15. BI: Animalia-schizocoelomates concldd.	BI.lab: Diversity of life continued.	BI: Animalia-enterocoelomates. Pp. 288-301.	BI: Exam. BI.lab: Diversity of life concluded.	CH: Oxidation and reduction. Chap.18 (in part).	
9	May 22. CH: Oxidation and reduction contd.	CH.rec: Oxid.-red. Prob.book chap.5.	CH: Oxidation and reduction concldd.	BI: Molecular biology-ATP. Pp.395-98; 423-439. CH.lab: Oxid.-red. titration (Exp.31).	BI: Photosynthesis, photolysis. Pp. 329-345.	
10	May 29. BI: Photosynthesis-CO_2 fixation. Pp. 345-352.		BI: Cellular respiration. Pp. 399- 420.	BI.lab: Metabolism.		

Term content (unrevised) - Core course second year.

	Physics	Chemistry	Biology
Fall		Equilibrium: Acids, bases, salts; solubility products; hydrolysis. (Weeks 1 thru 5.)	Nutrition; Respiration; circulation; structure and movement; integration. (Weeks 6 thru 10.)
Winter	Electricity and magnetism. (Weeks 6 thru 10.)		Reproduction; development; genetics; evolution. (Weeks 1 thru 5.)
Spring	Physical optics; Modern topics. (Weeks 6 thru 8.)	Electrochemistry; descriptive inorganic. (Weeks 1 thru 5.)	Ecology. (Weeks 9 and 10.)