A STUDY OF THE MINI-PHYSICS CURRICULUM
AT SOUTHWEST MISSOURI STATE COLLEGE

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CHAPTER I

INTRODUCTION

College physics has experienced a decrease in enrollment in recent years. Ernest C. Pollard (34) alludes to the growing alienation between science and society as an important factor in the decrease in physics enrollment. He also states that most students take physics only because the curriculum designers and Deans feel that physics is necessary for a liberal arts education.

A century ago, the study of physics was nearly always a philosophic pursuit of natural science. The intervening years have nearly eliminated the philosophical interests, while at the same time the total impact of science on society has greatly increased. A direct consequence of this trend has caused students too often to see no relevance to physics.

Katherine Swartz (45) gives a students view of the problem.

> Students often feel that at the moment, science is just polishing up quantum mechanics and running simulations in engineering. Students are fleeing the physical sciences and taking their energies and creative talents into the field of social science.

She goes on to say that she does not think this is a bad thing.

> It affords a splendid opportunity to develop new technologies in which the field of physical science can play an important role. However, it does imply that a change is needed in the physics curriculum.

H. R. Crane (9) warns us that we are in a crisis in physics teaching and we must demonstrate more "relevance" to life's interest if students are to be attracted to physics.

The Commission on College Physics (8) points out that the crisis in physics education is really part of a crisis in higher education generally. Three crises in higher education are listed by the Commission that are of particular concern to physics education for liberal arts students. They are: the increasing cost of education, the inertia of higher education to meaningful change, and the schism between the faculty and student view of the purpose of higher education.

The Newman Report (10) states:

> The professionalization of academic faculties has shaped the character of higher education in many ways. Increasingly, being a teacher has become part of a broader role centering around one's professional colleagues-attending professional conferences, writing and reviewing articles, sponsoring and recruiting apprentices into the discipline. Faculties at universities and the more prestigious colleges have come to view themselves as independent professionals responsible to their guilds rather than to the institutions which pay their salaries. They have established at their institutions a system of tenure and promotion designed to preserve their professional objectives. Those who slight the academic obligations of specialization, research, and publication are themselves slighted in promotion, esteem, and influence.
>
> In the undergraduate schools, courses tend to be taught as if the development of theoretical knowledge were the only proper business of liberal education. Those individuals who see themselves as recruits to an academic discipline are slighted in favor of the few (out of the total population) who display an interest and talent for theoretical training.
>
> This professionalization of faculties has influenced not only the content but the methods of undergraduate education. These faculties assume that their students will learn best the way they themselves learned best-by sitting in class listening to professors, and reading books. Sometimes faculty members will try to bring practitioners into the classroom to supplement their lectures, but rarely are courses organized around such individuals, and almost never are they brought into the academic inner sanctum.

Another revealing study is one made by Riesman and Gusfield (38). Based upon extensive interview with the faculty at a new state college

Riesman concludes that the "meritocratic" attitude of the physical science faculty resulted in their seeking only an elitist, specialist-type student while consciously and willingly discouraging all other students from their discipline.

The Commission on College Physics (8) in a study reports that over and over again they heard from physics faculties that their major problem was that their students were not capable; stupid; poorly prepared; not interested. That this is a challenge and an opportunity was rarely mentioned.

In response to the above reports the physics faculty at Southwest Missouri State College has adopted several priorities which they are attempting to implement. The priorities that affect the liberal arts curriculum are discussed below.

1. The Southwest Missouri State College physics faculty has redesigned their educational program so as to reach a substantial and representative fraction of the college community.

There is overwhelming evidence that physics departments have concentrated their attention on the education of physicists and scientists to the neglect of the general student. The percentage of students in the college population who see any kind of physics course is surely less than 20 percent (14). In addition, courses beyond the introductory level for the "nonscience" student and interdisciplinary courses in physics departments are conspicuous by their absence.

The curriculum designed by the physics faculty at Southwest Missouri State includes the content of courses and curriculum as well as the methods by which they are taught. But the most important change is to be in the attitude of the physics faculty. If "substantial" and "representative" are honestly interpreted, this priority is not for a program, but for an operational test of a program. Its success can be measured in numbers and percentages. It is a challenge that the college can respond to in different ways.

2. Evaluation of professional contributions to physics and to the community bear real and visible weight in departmental decisions on allocation of its resources.

In defining "professional contribution" to physics education, a distinction will be made between performance in the classroom and the kind of contribution exemplified by the design of a radically new course, the invention and publication of new demonstrations or laboratory experiments and the pioneering of an interdisciplinary course sequence or a new course formate.

Contributions to the community should be similarly professional as distinguished from PTA's or fund raising "community service". A physicist who becomes an information resource in a community ecological controversy for example, would be contributing "professionally".

The individual faculty members are establishing criteria for the evaluation of these broader contributions. Imput from peers, students, and administration is used in the evaluation in an attempt to give the effect of these broader contributions "real and visible weight".

3. The Department of Physics at Southwest Missouri State accepts responsibility for the improvement of their educational offering for nonscience students.

They will attempt to be responsive to the needs associated with keeping instruction up to date, not only with respect to physical facilities but with respect to advances in methods of instruction and learning theory.

4. The department head will provide leadership in designing the procedures to insure that effective teaching and creative educational innovations are rewarded in the area of physics for the nonscience student.

Components of such procedures include student evaluation of teachers and instruction. In addition, concrete steps (such as budgeted funds) to encourage effective teaching and innovations will be made. There is also active encouragement made to the faculty to pay some attention to improving their teaching.

One major effort made in behalf of the nonscience student by the Southwest Missouri State physics faculty-which is the subject of this study-is the mini-physics curriculum.

Background for the Study

There have been many attitude studies of students and they generally show "positive attitudes" toward science in that students consider science a good thing. However, when the question invölves a choice of taking a science course or not, the image presented by the same students is negative (27). More recent studies show that such attitudes persist (1).

Katherine Swartz (45) as a student stated:

> Ten years ago Charles Snow described the 'Two Cultures' in our society. Snow claimed that there exists in our society two cultures, that of the humanities and that of science, and that they are so different that people belong either to one or the other. Snow later suggested that the time was coming when a third culture would form and the people who would belong to it would be people who thought scientifically but would apply this mode of thinking to those humanities that today we call social science. I believe that time has come and members of

> my generation who ten years ago would have been in the scientific community now belong to this area.

Physics has, in many cases, a most grim reputation for the non-science student. A student who is casually interested in physics has to be a brave character to volunteer for a course in physics.

David Saxton and William Fretter (39) allude to two misconceptions found in physics education. They refute the often held opinion by both faculty and student that proficiency in physics requires that one excell in mathematics and that knowing how to work simple problems in physics indicates an understanding of physics. Such misconceptions about physics must be dispelled among the nonscience students if any number of them are to have a positive attitude toward enrollment in physics courses.

Lester Paldy (30) asks if it is possible to develop a coherent experience in physics that would require only a short time. He is of the opinion that it is not necessary to have only three or four hour credit courses in physics. He goes on to say that if short courses in physics are interesting and useful to the student, he will remain in the program. If not, the student can drop out without as great a penalty in loss of time and effort.

One way of approaching Paldy's suggestion is to employ the concept of mini-courses. Mini-courses have become increasingly common in recent years in an attempt to gain the interest of a broader spectrum of students.

The Hoover Drive Junior High School, Rochester, New York (11) has designed a series of short courses that attempt to recognize student social interests and problems. The block of time used is the final two weeks of school in June.

The Barton County Community Junior College, Great Bend, Kansas (29) uses mini-courses in the mathematics and business departments. The courses are staggered so they are available during the first, second, and third five week period in the fifteen week semester.

The Westfield High School, Westfield, New Jersey (19) has developed a mini-course approach in social studies. Their study of the program indicates a greater positive attitude toward social studies as a result of the mini-course effort.

The physics faculty at Southwest Missouri State believes that mini-courses incorporate the following ideas:

1. It affords the student an opportunity to select an area of interest for study.

2. It allows the student to become actively involved in curriculum content.

3. The mini-course approach is an effective means of capturing the advantages of a systems approach to teaching.

4. The mini-course approach breaks the courses and curriculum content of physics into small pieces for easier management in regard to developing new curriculum.

5. It affords the faculty a means to adapt more easily to meeting individual needs of students.

6. The mini-course approach enables students and teachers to work toward the achievement of specific measurable goals.

7. It is hoped that students will be more highly motivated by knowing to a greater degree exactly what is expected of them and by having a more adaptable program for the student to select from.

8. The teacher will be able to fill a broader role rather than just being a lecturer.

The physics faculty at Southwest Missouri State College has taken note of the tendency of nonscience students to avoid enrolling in general physics courses. In response, the faculty has developed a mini-course approach as an alternate way for the student to complete his natural science requirement. Five short courses are equivalent to a single five semester hour introductory course in physics.

These courses are devoted to a single topic which may vary from semester to semester depending upon student and faculty interest. The mini-physics curriculum consists of five series of courses (43):

> Physics 1311. A course that treats a single contemporary topic of physics. Examples are: The Bombs, What are the Alternatives to Fossil Fuels?, Fictional Physics, Physics of Sports, and Physics of Music. Since the content varies from semester to semester, the course can be repeated, with permission, to a total of two hours.
>
> Physics 1321. A course that treats a single theroretical area of physics. Examples are: Relativity, The Nature of Solids, Modeling in Physics, Cosmologies, Matter and Anti-Matter. Since the content of the course varies from semester to semester, the course may be repeated, with permission, to a total of two hours.
>
> Physics 1331. A course that treats a single area of physics from a historical viewpoint. Examples are: Faraday's Experiments, Midwives of the Quantum Theory, Einstein and His Universe, and The Calender. Since the content of the course varies from semester to semester, the course may be repeated, with permission, to a total of two hours.
>
> Physics 1411. A laboratory course that involves the use of scientific instruments and experience in collecting and analyzing data. A single topic of physics is used as the content of the course. Examples are: Newton's Laws of Motion, Radioisotope Tracing Methods, The Laser, and Heat and Temperature. Since the content of the course varies from semester to semester, the course may be repeated, with permission, to a total of two hours.
>
> Physics 1421. A laboratory course that deals with a single ecological problem. Some examples are: Pollution of The Upper Atmosphere, Noise Pollution, and Traffic Flow Patterns. Since the content of the course varies from semester to semester, the course may be repeated, with permission, to a total of two hours.

The basic ideas in each mini-physics course are not presented at a highly sophisticated mathematical level, nor are they merely watered down. An attempt is made to present the material in a way that ideas and attitudes are given a central role while the teaching formate is matched with the student's capacity for learning.

Physics 1005, Survey of Physics, is also offered if the student does not choose to fulfill his natural science requirement by taking the mini-physics curriculum. This course is a typical introductory physics course found in most colleges for nonscience students.

Statement of the Problem

This study will have as its goal to evaluate a mini-course approach to presenting physics for the nonscience student. To determine the effectiveness of this approach it will be necessary-subject to the limitations set forth presently-to measure the influence of this approach on the student's gain in knowledge (cognitive effect), his gain in knowledge of science concepts (cognitive effect), his final attitude toward the method of presentation (affective effect), and his attitude change toward physics as a subject (affective effect).

Hypotheses

The hypotheses that guide this study stated in the null form are as follows:

1. There is no difference (at the 0.05 level of confidence) in the distribution of students in the Mini-Physics Group and the Physics 1005 Group in regard to gender.
2. There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in

the Mini-Physics Group and those in the Physics 1005 Group in regard to class.

3. There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to the student's major area of emphasis.
4. There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to who recommended the course.
5. There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to who made the final decision to take the course.
6. There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to high school science and mathematics experience.
7. There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to college science.
8. There is no difference (at the 0.05 level of confidence) in the pretest and posttest mean scores of the Control Group for maturity in regard to knowledge of science processes.
9. There is no difference (at the 0.05 level of confidence) between the pretest and posttest mean scores of the Mini-Physics

Group with regard to knowledge of science processes.

10. There is no difference (at the 0.05 level of confidence) in the mean scores of the posttest Mini-Physics Group and the posttest Physics 1005 Group in regard to knowledge of science processes.
11. There is no difference (at the 0.05 level of confidence) in the mean scores of the Mini-Physics Group and the Physics 1005 Group in regard to factual knowledge of physics.
12. There is no difference (at the 0.05 level of confidence) in the pretest and the posttest scores of the Control Group for maturity in regard to attitude toward science.
13. There is no difference (at the 0.05 level of confidence) between the pretest and posttest scores of the Mini-Physics Group with regard to attitude toward science.
14. There is no difference (at the 0.05 level of confidence) in the mean scores of the posttest Mini-Physics Group and the posttest Mini-Physics Group in regard to attitude toward science.
15. There is no difference (at the 0.05 level of confidence) in the mean scores of the Mini-Physics Group and the Physics 1005 Group in regard to their ability to see themselves in the role of doing science activities.
16. There is no difference (at the 0.05 level of confidence) in the mean scores of the Mini-Physics and Physics 1005 Groups in regard to attitude toward how the class was presented.

Significance of the Study

There seems to be a growing conviction among physics educators that the conventional approaches to physics education must be modified to meet the needs of a broader spectrum of students. Perhaps our introductory physics courses would benefit if contemporary topics were used to illustrate the relevance of physical laws to everyday life. Politics, laws, economics, and other interests have a way of getting mixed up.

Alan Holden (20) states that physics is not a single thing and that trying to teach it as if it were is a mistake. He adds:

> There is a physics that is a single thing. It is the flesh and bloodless body of understanding, visualized by most young students, which descends like manna from Heaven and comes to rest in textbooks. But physics, like music, is made by people; and physicists, like composers come in all kinds.
>
> It is hard to believe that physics was the same thing to James Joule and his contemporary, Rudoff Clausius. Professor Andrade tells that, when Willy Wien said to Ernest Rutherford, 'But no Anglo-Saxon can understand relativity', Rutherford replied, 'No, they have too much sense'. J. J. Thompson wrote an Adams Prize essay examing the mathematical properties of toroidal vortices. R. W. Wood, so I am told, projected such vortices toward his audience and knocked the hats off the ladies. Can physics have been the same to both? When Wolfgane Pauli visited Bell Telephone Laboratories he examined the ongoing physical researches of which the institution was proudest. Asked what he thought of them he replied, I am told, 'Ach, das ist alles triviale': They were irrelevant to the problems that interested him.

Richard P. Feynman (16) Professor of Physics, California Institute of Technology, states:

> It is not science to know how to change Centigrade to Fahrenheit. It's necessary but it is not necessarily science. Science is a quality that teaches values of rational thought, patience, doubt, and the value of freedom of thought.

E. Leonard Jossen, (23) Chairman of the Commission on College Physics, suggests that we suffer from having no coherent theory of instruction to involk, and as a result, in all too may cases we do not know whether what we do is effective.

Layman (24) made a survey of the reports of new courses and course development programs during a twenty year period from 1949 to 1969. He found that only twenty-two attempts were reported in the field of physics instruction. Of these reports, nine attempts at evaluation were made.

John Fowler and Richard West (17) make the comment that:

> It may well be that the nonscience major is the most difficult challenge that physics educators face. Is it an important one? As physicists, we have to believe that it is. For, if present trends continue, our discipline will slip further outside the mainstream of liberal education.

It would seem from the above comments that the significance of this study lies in the fact that an effort will be made to evaluate a new approach to physics for the nonscience student. In addition it will be valuable to the physics faculty at Southwest Missouri State College in further attempts to define and implement objectives to meet the needs of such students.

Limitations of the Study

The study is limited to the population of students that make up the student body at Southwest Missouri State College who are enrolled in Physics 1005, a five semester hour survey of physics course, and those students in the mini-physics curriculum.

There was no way to randomly select the students in either curriculum. Therefore, the study is best described as a quasi-controlled group comparison.

There may be some instructor bias. Both approaches to physics, however, are taught on a regular basis by the physics faculty. This dual program for nonscience students has been offered for two years and it is hoped that any instructor bias due to the newness of the concept is not now a significant factor.

Only students who completed in one calender year, five mini-courses are included in this study. There were many students who sampled only one or two mini-courses that are not included in this study.

Only objective, multiple choice type questions were used in this study and therefore it is confined to conditions that utilize this form of testing. In addition, the format of the knowledge test is based upon the cognitive knowledge presented in a traditional introductory physics course and it is not well adapted to the format of the mini-physics courses.

Clarification of Terms

The following terms have specific meaning in this study.

Non-Science Student

Southwest Missouri State College students who are taking science courses only to fulfill a natural science requirement of the general studies part of their degree program.

Blocked Course

A course that meets at the same hour as another course. One course meets the first half semester while the second course meets the second half semester.

Mini-Physics

A series of one semester hour credit physics courses at Southwest

Missouri State College that will fulfill a student's requirement for natural science credit in the general studies part of their degree program.

Liberal Arts Education

A program of general studies including samples from most of the recognized fields of knowledge.

SMS

Southwest Missouri State College

Interdisciplinary Courses

Courses that go beyond the boundry of a particular subject area and will encompass a broader area of knowledge contained in two or more subject areas.

Attitude

Attitudes are feelings or opinions rather than knowledge, and in this study were gauged by responses made to questions or comments given the students in an attitude questionnaire administered at the end of the semester.

Affective Domain

The affective domain relates to feelings and emotions. This is related to and essentially synonymous with attitude as it is used in this study.

Favorable Response

Each statement on the Attitude Measure was listed as either positive or negative with respect to the goals of the course. A favorable response was one that had a score less than three on a negative question or one which had a score greater than three on a positive question.

Unfavorable Response

Each positive statement on the Attitude Measure of less than three was considered an unfavorable response. Likewise a response of greater than three on a negative statement would indicate an unfavorable response with respect to the goals of the course.

Knowledge

Knowledge is evidenced by an acquaintance, familiarity and understanding of the laws, relationships, and information associated with physics. Knowledge in respect to this study is that determined by pretest and posttest recognition of laws and relationships administered to both Mini-Physics and Physics 1005 students.

Concepts

An idea or generalization formed via the process of perceptual observation and verbal communication is a concept.

Cognition

Cognition is the process of knowing or perceiving.

Cognitive Process

The process involved in the act of gaining knowledge.

Systems Approach to Teaching

This approach defines measurable objectives and channels all energy and resources available toward meeting those objectives.

Systems Approach to Teaching

This approach defines measurable objectives and channels all energy and resources available toward meeting those objectives.

Substantive

This term refers to real, visible and measurable growth in knowledge or gain in attitude.

Basic Assumptions

This study will assume that the pretest and posttest examinations are an adequate measure of knowledge and concepts gained by the student during the course.

This study will assume that the attitude instruments are an adequate measure of the students attitude toward the method of presentation of the course and his feeling for physics as a worthwhile endeavor.

Because the students in the Mini-Physics Group required a year to finish the required five semester hours of physics while the Physics 1005 Group finished five semester hours in one semester, it was necessary to pretest and posttest a randomly selected group of nonscience students from the SMS population. It is assumed that any growth in cognitive and affective areas due to maturity will be adequately measured with this group.

CHAPTER II

REVIEW OF SELECTED LITERATURE

Introduction

In reviewing the physics education literature, a common thread of belief is found that physics is valuable for all scholars. However, it is also apparent that the writers do not believe that the present physics curriculum is presented in the most desirable way. The enrollment statistics show that only a small minority of students are approaching physics as a subject (14).

Physics and the Non-Science Student

Theordore Rozak (37) writes that:

> While the acts and literature of our times tell us with ever more desperation that the disease from which our age is dying is that of alienation, the sciences in their relentless pursuit of objectivity raise alienation to its apothesis as our only means of achieving a valid relationship to reality.

If Rozak is anywhere near the truth, then the physics curriculum is in need of an overhaul in order to accomodate the student who is not going to become a specialist in physics.

William Jacobson (22) is concerned with the lack of attention to what he calls, "..dimensions of the scientific enterprise in our science courses". He is concerned that students do not come into contact with a sociological view of science.

Herbert Thelen (46) writes with great concern that the goals of students are badly misdirected. He contends that the stress is placed altogether too much on a "hit or miss" coverage of many areas of content rather than an attempt to master fewer concepts. He also maintains that students mostly work for a good grade because they have been placed in a situation where they have no recourse except to work for grades to the exclusion of everything else. With their energies mainly exerted in that direction, the real value of science for the nonscience student is for the most part, lost.

The Educational Policies Commission (12) has listed seven values to be stressed and characterized in education.

> The schools should help to realize the great opportunities which the development of science has made apparent in the world. They can do this by promoting understanding of the values on which science is everywhere based. Although no particular scientist may fully exemplify all these values, they characterize the enterprise of science as a whole. We believe that the following values underlie science:
>
> 1. Longing to know and to understand.
> 2. Questioning of all things.
> 3. Search for data and their meaning.
> 4. Demand for verification.
> 5. Respect for logic.
> 6. Consideration of premises.
> 7. Consideration of consequences.

Like all values, these are only guidelines. It would be difficult to design instruction which would emphasize all seven of these values on any given day. However, any instruction which does not emphasize at least one of the values should be questioned.

Curriculums need to satisfy not only the intellectual requirements of society, but also its psychological, sociological, political, and economic aspects. The discoveries made by scientists such as Newton, Pasteur, Rutherford, Curie, and Einstein did not only affect our understanding of natural phenomenon, they-or their ideas-changed our history and our destiny.

Paul R. Brandwein (4) lists seven correctives that need to be applied to the science curriculum in order to meet the needs of students.

1. Science must be considered as a humanity. The courses in science should emphasize that the true certainty of science is uncertainty, and that scientists have no sure method except that of hard work and organization in the search for knowledge.

2. Provisions not only for problem doing but problem solving, that is, investigation should be provided for the student to do.

3. The laboratory must be restored to its former status and dignity.

4. The mere catalogueing of science must give way to processes and ideas. Conceptual schemes are durable for at least a generation, so that at least a student can emerge into a world of ideas. They will have been given guideposts and guidelines, not mere blotches of facts.

5. Teachers must accept the premise that new demands will be made upon them when the correctives are implemented and be prepared to meet those demands.

6. Literacy in science, in terms of comprehension of the world in which science has an ever-increasing impact, should be based on conceptual schemes which are fairly stable during a large part of a life span.

7. It should be stressed to students that conceptual schemes are not overthrown, only altered-and this is slow-in view of the self correction science imposes on itself.

The scientific age is here. It appears from the literature that we must have a more enlighten populace toward science; not just in knowledge of science, but also an attitude and philosophy of science that allows people to have a base of understanding about the implications of what science can do for the betterment of all people. Glenn T. Seaborg (40) wrote that, "The gulf between basic and applied science has narrowed, and in some instances has become imperceptable". One idea seems quite clear: the role of science in our culture, its integration into nearly every aspect of human life and human needs, demands a revamping of science teaching to develop a coherence of science and society.

Selection of Objectives

It is assumed that physics has a product and a process to be learned. The next step is to select from the product the knowledge to be taught. Physics is an immense and dynamic body of knowledge and that part of the knowledge selected to be taught poses critical problems.

Paul Hurd (21) states:

> An important process in the planning and development of a science curriculum is that of identifying its purposes. These become the objectives that orient the teacher's efforts and define the responsibilities of the learner. Objectives indicate the nature of the educational endeavor and denote the direction it should take; they serve as a guide for the choice of teaching procedures and provide hypotheses for making curriculum decisions. They suggest to the teacher why his work is important, how to plan it, and how to evaluate it. Only when objectives are clearly identified and supported by a personal loyalty can the teacher maximize his efforts in the learning process.

Eric Rodgers (36) makes the following observation about the selection of objectives.

> Suppose we think of our students as planning to be non-scientists but taking some science courses as part of their general education. With what questions should we test the success of such courses? We should hardly be content to ask: Can they think scientifically? Do they understand what science is about and how scientists go about their work? Have they a friendly feeling toward science and scientists? Are they likely to read scientific books in later life with enjoyment and understanding: Could they enjoy intellectual discussions with scientists? Could they work with scientific advisors in business or government?

Milton Pella (32) believes that science should be an intellectual influence in the lives of all citizens.

> The schools and teachers must see scientific literacy to social literacy, to humanistic literacy, to technological literacy. To educate for today only is to prepare to live only today, and is to prepare to cease to live tomorrow. To educate at the conceptual level, to help pupils see how knowledge develops, to accept the ethics of science as their own, to see science and society as interrelated, and to accept science as one of the humanities, as well as to prepare people to live now and in the future.

Benjamin Bloom (3) proposes four principles in selecting content for instructional use: "How much knowledge would be required learning?"; "How precisely need the student learn the required material?"; "How is the knowledge best organized for learning?"; and "How meaningful need the required knowledge be to the student?".

The psychologist, Jerome Bruner (7) also lists four principles for content selection. "The principle emphasis in education should be placed on skills; skills in handling, in seeing, imagining, and in symbolic operations."

Philip Phenix (33) adds four principles for the selection and organization of content.

> The teacher should draw upon the specialized disciplines as the most dependable and rewarding resources for instructional materials. While he should seek to make the disciplined materials his own, he should not presume to originate the knowledge to be taught, nor should he expect the fruits of learning to come forth as if by miracle from the shared experience of the students or as the products of common sense.
>
> The second principle for the selection of content is that from the large resources of material in any given discipline, those items should be chosen that are particularly representative of the field as a whole.
>
> A third and related principle is that content should be chosen so as to exemplify the methods of inquiry and the modes of understanding in the discipline studied. It is more important for the student to become skillful in the ways of knowing than in learning about any particular product of investigation.
>
> A fourth principle of selection is that the materials chosen should arouse imagination. Growth in meaning occurs

> only when the mind of the learner actively assimilates and re-creates the materials of instruction.

Good instruction has a past, a present, and particularly a future. It provides meaningful experiences and prepares the student for new experiences. Each piece and each hierachy must be examined in terms of the criteria of good instruction and tested with the student population.

Method of Instruction

After selecting the materials to be taught, some consideration must be given to the method of instruction that will cause the most learning to take place.

Jerome Bruner (6) identifies learning as a process having three complete parts: acquisition, transformation, and evaluation. These three parts form a learning episode. Bruner defines acquisition as the absorbing of information that is either new information or that replacement for information that is already held. His definition of transformation is the finding of relationships within that new information to the old information. He further states that the two parts of the learning episode defined above can go on simultaneously. Bruner then defines evaluation as the acceptance or rejection of information. Evaluation follows immediately after the transformation episode. Bruner goes on to say that if the information is accepted, then there is an internalization that results in a change in behavior (a definition of learning).

Searles (41) using the ideas of Bruner identifies four compelling forces acting within the human mind that causes learning to taken place.

One compelling force for learning is curiosity. A person is bombarded with hundreds of stimuli from his environment to the point where he is compelled to find out what is going on. Searles suggests that this curiosity is sometimes conditioned out of a person. Therefore the instructor needs to awaken this natural curiosity of the learner so that he may be satisfied with the results of learning.

A second impelling force identified by Searles is the desire to be competent, that is, to have "expertness" in an area of activity. This drive to be competent may be a negative expression as far as society is concerned such as expertness in safecracking.

The third impelling force for learning identified by Searles is that the learner identifies with a model. Since the teacher is the most visible factor in the classroom, it should not be suprising that students select their instructor as a model. The teacher should make sure that he presents a model that the students can respect and identify with in a profitable way.

Finally, there is what Searles calls reciprocity. This is the idea that the human mind needs and desires to have interaction with other minds. This interaction which takes the form usually of a dialog between the learner's mind and the instructor is not nearly as desirable as a two way dialog.

Searles has produced a model (Figure 1) developed from Bruner's and Bloom's work that illustrates the teaching and learning processes. His thesis is that the process of instruction can be defined and from this definition certain principles can be derived. The parts of his system will need to be defined.

John Searles conceives of his system as having four basic elements; the learner's mind, the instructor's mind, the search image, and the power imput. He defines three of the elements in his system as:

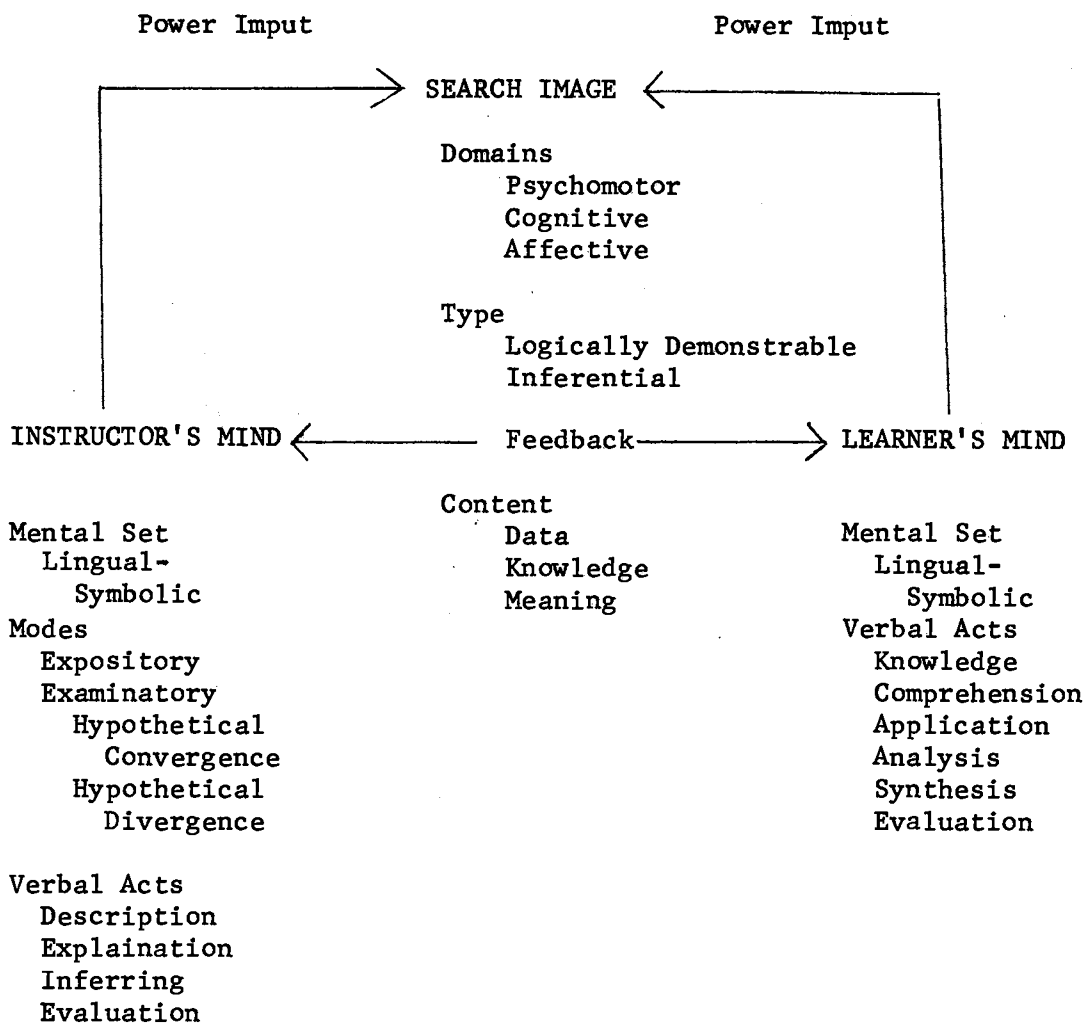

Figure 1. Teaching and Learning Processes

The learner: the mind at which instruction is aimed. In Bruner's words, 'Instruction is a provisional state that has as its object to make the learner or problem solver self-sufficient'.

The instructor: the person responsible for the system, and for guiding and shaping the processes until something in the way of learning of the search image has taken place.

The search image: the immediate learning task in the system. Generally small, well ordered, and learnable, it can be in the cognitive, affective, or psychomotor domain.

Domain refers to the educational objectives and contains three broad categories of search images. Some search images are in the cognitive area (understanding of knowledge), while others have to do with the affective area (attitudes and values), and in addition, there is the psychomotor area (manipulative skills).

The system remains static until an energy imput is produced. In the Searles system, the energy imput is in the form of dialog. Each principal in the system must add a particular energy to the total effort. The instructor must add energy in the form of demonstrations and verbal acts that present the search image in a clear manner while the learner must add energy in the form of desire to reach out, grasp and conceptualize the search image. The system cannot work unless the student provides this power. Often it is the main task of the instructor to activate this energy on the part of the learner.

If the learner supplies this needed power, then things can begin to happen. With this energy present, analysis based on an examination of premises and evidence can take place.

In addition, there is an extra dimension present. According to Searles it is the ordering of knowledge. The student learns both the product of knowledge and the process for its derivation. In an attempt to define the processes of thinking in his model Searles incorporates Bloom's Taxonomy of Educational Objectives to his model (see Figure 1 under learner's mind).

B. O. Smith (42) has characterized the verbal acts on the part of the teacher into two modes, the expository and the examinatory.

The expository mode is on the product level of thinking and consists of certain verbal acts on the part of the teacher. One of these acts is that of describing which consists of stating a fact, reporting a finding, defining an idea, and designating patterns and categories. When a teacher is using the expository mode his voice is dominating the classroom.

The examinatory mode involves the student more than the expository mode. There are two choices open for the instructor when he is in this mode of operation; one is an examination of a hypothesis, while the other is that of speculation. The hypothesis is a proposition proposed by the instructor to which there can be a convergence of the minds of the learners and a concensus can be accepted. A speculation is a proposition that resists conveyance and perhaps invites divergence. On this level the system of instruction is completely on the process level.

According to Searles, the major verbal act outlined by B. O. Smith that occurs in this mode is that of inferring. One type of inferring that the teacher can use is that of analogy which is the employment of a certain metaphoric sense on the part of the teacher wherein he describes something as being like something else.

There is another area of inference that can be used by a teacher, and that is called conditional inference. In this mode the instructor establishes certain conditions in the student's mind and lets the student draw his own conclusions.

With the ideas of Smith incorporated into the model (see Figure 1) the four elements of Searles' system is complete.

Social-Emotional Climate in the Classroom

A major factor that operates in a classroom is known as the social-emotional climate. It may very well determine the amount of student effort put forth. Some of the best research done in this area has been contributed by John Withall (49).

> Each teacher-statement contains one of two dominant kinds of intent. These are:
> a. intent to sustain the teacher and his behavior (teacher-centered statements) or
> b. intent to sustain the learner and his behavior (learner-centered statements are included under this intent).
>
> By analysis of both the context and the content of a teacher statement it may be possible to determine whether the dominant intent of a statement is to sustain the teacher or learner.
>
> Once the dominant intent of a teacher-statement has been determined, one can proceed to determine the technique by which the support is conveyed.
>
> 1. If the statement is intended primarily to sustain the teacher, one or possibly a combination of the two following techniques may be used:
>   a. reproof of the learner (category 6).
>   b. directing or advising the learner (category 7).
>
> Frequently the intent of the statements is to sustain the teacher yet neither of the above techniques is used. In that event, the statement is simply a self-supportive remark which defends the teacher or evidences perseverance in support of the teacher's position or ideas (category 5).
>
> 2. If the intent of a statement is to sustain the learner, then one or possibly a combination of the two following techniques may be used:
>   a. clarification and acceptance of the learner's feelings or ideas (category 2).
>   b. problem-structuring statements (category 3).
>
> Frequently the intent of a statement is to sustain the

learner yet neither of the above techniques is used. In that event, the statement is simply one that reassures, commends, agrees with, or otherwise sustains the learner (category 1).

The seven categories will allow the teacher to observe his verbal behavior which presumably affects the social-emotional atmosphere. It would appear from Withall's research that the more a teacher operates in the pupil-supportive area, the more effective he will be.

How the Searles Model Works

A simulated dialog will be used to illustrate how the Searles System works. This dialog was taken from Searles (41).

I_1 Class, here on the board is a sentence. As you can see, it is not absolutely provable-no one can say that it is completely true or false. But it is well worth looking into. We are not so much interested in facts to be memorized as we are in bringing the facts together into a logical thought process. So let us speculate about this. What does the statement (Kennedy could not have been elected in 1960 if Stevenson had not been the candidate in 1952 and 1956) compare?

L_1 It doesn't compare anything.

I_2 I mean, what does it ask you to compare as you think about it?

L_2 Kennedy and Stevenson?

I_3 That's right. But before we compare them what else is in that statement on the board? It has to do with the comparison of time.

L_3 I guess the elections of 1952, '56 and '60.

I_4 That's right, but should we look for likenesses or differences between Stevenson and Kennedy?

L_4 Likenesses.

I_5 That's right, because according to the postulate, Kennedy built on Stevenson. Or another way of saying it, Stevenson paved the way. So voters looked for similar things. So what were these likenesses?

L_5 Excuse me for saying this, but I hardly remember Kennedy and I don't remember Stevenson at all. All I remember of the 1956 election is that we voted in the third grade and Eisenhower won.

I_6 Oh, I guess I had forgotten how young the young are, or how old I am. What does the book say?

L_6 Very little about Stevenson except that he was governor of Illinois and nobody could have won against Eisenhower.

I_7 I guess the book doesn't help us here so let me add what I can. It seems to me that where Stevenson and Kennedy were alike was in their feeling for the intellect. Both of them were expert in the use of words; their speeches are marvelous reading. In fact, Stevenson spent so much time polishing his speeches that his aides often despaired. They thought he was neglecting the other parts of campaigning. This characteristic of his-his intellectual quality-often was used against him. He was called an 'egghead'. To many people in that time there was something wrong with being interested in the world of ideas, in using graceful words. His defense was often a merry quip. One of his comments was 'Eggheads unite-you have nothing to lose but your yolks'.

L_7 He seemed to be quite a wit. Wasn't, didn't Kennedy make a lot of jokes too?

I_8 Certainly. Since his death there have been many collections published containing his jokes and quips.

L_8 Tell us some of them.

I_9 There goes the bell, I'll save them for tomorrow.

The dialog above can be charted to determine the teacher and learner activity within the framework of the teaching system developed by Searles (Figure 1).

Analysis of this dialog shows that all proceeds well. The learner and instructor verbal activity is at a level that involves the minds at a higher level than just knowledge. The social-emotional climate is somewhat learner-supportive. The whole thing seems to be a rather genial and warm exercise with the instructor and learner in happy pur-

TABLE I

DIALOG CHART

Dialog Number	Cognitive Instructor	Cognitive Learner	Social-Emotional Climate
1	De	Com	3
2	In	An	3
3	In	An	1,3
4	In	An	1,3
5	In,Ev	An	1,3
6	Ev,De	Com	7,3
7	Ex	Com	3
8	De	Kn	1,3
9	De	-	4

De scribing	Kn owledge	1-Learner Supportive
Ex plaining	Com prehension	2-Acceptant
In ferring	Ap plication	3-Problem Structuring
Ev aluating	An alysis	4-Neutral Class Managing
	Sy nthesis	5-Directive
	Ev aluation	6-Reproving, Disapproving

Summary

The design and goals for the mini-physics program are now complete. The reason for being has been discussed both from the schools purpose and the presumed needs of the students and a model has been selected to bring about the objectives of the program.

Although the courses are short-about six weeks-and involve only one topic there is closure, that is, a sense of beginning and ending. Mastery of the topic is stressed to satisfy the student's presumed need for competence. The topics chosen are far ranging and encompass the whole of physics knowledge, thus hopefully allowing the student to select and choose those courses that will stimulate his curiosity. Provisions for problem doing are maintained especially in the laboratory mini-physics courses. Many of these problems are unique to introductory physics courses such as measuring noise and the use of the laser. Physics is presented so as to involve the total community of learning. The courses relate to such areas as economics, music, sports, philosophy and other areas as exemplified in courses titled, "The Physics of Sports", "The Physics of Music", and "The Physical World and Man". Appendix A contains a list of mini-physics courses presented since the beginning of this program.

The physics faculty is attempting to turn the problem of selection of content around so that it can become operational. The question is: What kind of school environment can be fashioned so that non-science students can have the greatest opportunity to learn how to do the activities of science?

Brandwein (5) states succintly the basic goal of the mini-physics curriculum.

> In the absence of tests clearly designed to select the investigator, it seems just as clear that our present road is to prepare so rich a learning environment that the student-investigator will elect the opportunity to investigate. Election of opportunity, rather than selection of students, is our bias; but not without carefully planned yet noncoercive identification of the able students. The kind of identification preferred occurs mainly through participation in imaginative learning, made possible by teachers who are scholars and vibrant people, as well as through formal guidance and careful testing.

In providing for the greatest range of topics in physics possible, an attempt is being made to present the philosophy of science as basically that of humanism, except the sequence is reversed. It begins with a sympathy with nature and links the human experience with that. From this, it is hoped the student will grasp a sense of man's unique place in nature and can realize that a sense of purpose and harmony exists between him and nature.

CHAPTER III

METHOD AND DESIGN

Introduction

Physics for the nonscience student should be taught in such a way that the course is challenging, but on a level commensurate with the skills of the student. It should cause the student to feel that physics is vital, interesting, and nonthreatening.

S. E. Erichsen (15) characterizes the major obligation of the university as "teaching students how to think". The best way to accomplish this according to Erichsen is to help the student acquire abstract relationships fundamental to a particular discipline through thinking rather than memorization. This would imply that a more limited coverage of topics or ideas should be taught. Arons (2) supports this belief by stating that students should have a chance to suggest alternate ideas and be allowed to test these ideas before rushing on to the next topic.

The practice of limiting the coverage to fewer basic ideas-but covered more thoroughly-is inherent in the philosophy of a mini-physics approach to teaching physics. Previously cited literature show that students generally feel that science is a good thing, but at the same time find it difficult to see themselves in a role of doing the activities of science. Two main objectives of the mini-physics curriculum are to change the students self concept about taking part in science activities and to develop a sense of understanding of a scientist's approach to science.

It is important to note at this point that measuring gain in knowledge by traditional achievement tests is definitely not a major objective of this approach to physics teaching. The focus is on student attitude and process understanding. Table II gives the components of this learning as perceived by the physics faculty.

Assessing the objectives of the mini-physics curriculum does not necessarily mean that a comparison group is needed. However, the existence of an alternative method (a conventional survey course) of instruction suggests that there is a need for comparison. When a new curriculum is developed to achieve specified objectives there is a need not only to demonstrate the extent to which the specified objectives are met, but if achieved as effectively as the other viable method. For this reason Physics 1005, Survey of Physics, students are used as a comparison group to the mini-physics group of students. A description of the student samples are found below.

Description of the Sample

The characteristics of the students in this study were obtained by a voluntary questionnaire (see Appendix B) distributed to 95 students enrolled in Physics 1005 and 370 students enrolled in the mini-physics curriculum. The information requested was: a) the major in which the student was enrolled; b) reasons for taking the course; c) science and mathematics background; d) his or her class in school; and e) who was finally responsible for the decision to enroll in the course. Table III and Table IV give the results of the questionnaire for this study.

TABLE II

MINI-PHYSICS OBJECTIVES

Substantive:

1. To teach nonscience students how to collect data, analyze it and draw correct conclusions based on the data.

2. To encourage the observation of natural phenomena among nonscience students.

3. To encourage curiosity about natural phenomena and to teach nonscience students how to formulate questions about physical situations.

4. To teach nonscience students the concept of model building in science as a tool for solving problems in science.

5. To show the limitations of science.

6. To provide an awareness of the current problems in science.

Attitudinal:

1. To convince students that science courses are nonthreatening.

2. To persuade students that they can develop the ability to analyze events in a scientific way.

3. To convey to the student that science is a humanitarian activity.

4. To develop in the student an awareness of the beauty of nature and the power of logical analysis.

5. To convince students that activities in physics courses can be enjoyable as well as educational.

Tabulation of the responses from the questionnaire reveal that in both Physics 1005 and the mini-physics courses, the largest category of students are undecided about their major area of study. This category of students at Southwest Missouri State compose a major group of stu-

TABLE III

BACKGROUND CHARACTERISTICS OF THE TWO GROUPS

Mini-Physics				Physics 1005			
Gender		High School Courses		Gender		High School Courses	
Male	209	Algebra I	210	Male	69	Algebra I	88
Female	161	Algebra II	158	Female	26	Algebra II	28
		Geometry	186			Geometry	37
Total	370	Math Analysis		Total	95	Math Analysis	
		or equivalent	90			or equivalent	13
Class				Class			
		Chemistry	115			Chemistry	16
Freshman	118	Physics	37	Freshman	35	Physics	11
Sophomore	87			Sophomore	25		
Junior	92	College Science Courses		Junior	22	College Science Courses	
Senior	61			Senior	12		
Other	12	none	299	Other	1	none	78
		one	34			one	7
Total	370	two or more	37	Total	95	two or more	10
		College Mathematics Courses				College Mathematics Courses	
		none	-			none	2
		one	283			one	70
		two	51			two	16
		three or more	36			three or more	7

TABLE IV

POPULATION DISTRIBUTION BY CLASS AND MAJOR

Major Area of Study	Freshman	Sophomore	Junior	Senior	Other	Subtotal	
<u>Physics</u> <u>1005</u>							
Social Science	7	2	3	-	-	12	(12.63%)
Humanities	2	4	1	3	-	10	(10.53%)
Business	5	1	5	6	-	17	(17.89%)
Natural Science and Mathematics	3	2	2	-	-	7	(7.37%)
Industrial Education	4	8	2	-	-	14	(14.74%)
Undecided	13	4	2	-	-	19	(20.00%)
Other	1	4	7	3	1	16	(16.84%)
Subtotal	35 (36.84%)	25 (26.32%)	22 (23.16%)	12 (12.63%)	1 (1.05%)	95	(100.00%)
<u>Mini</u>-<u>Physics</u>							
Social Science	13	15	17	6	3	54	(16.49%)
Humanities	20	12	14	11	3	60	(15.14%)
Business	18	12	21	7	1	59	(17.03%)
Natural Science and Mathematics	5	13	9	13	1	41	(9.19%)
Industrial Education	1	2	5	5	-	13	(3.15%)
Undecided	52	25	4	-	-	81	(21.89%)
Other	9	8	22	19	4	62	(16.76%)
Subtotal	118 (31.89%)	87 (23.51%)	92 (24.87%)	61 (16.49%)	12 (3.24%)	370	(100.00%)

dents that the physics faculty is attempting to reach. It is assumed that these students are shopping around for experiences in various subject areas before deciding upon a major area of interest. There is no overt attempt by the physics faculty to recruit the undecided student to major in physics but merely to cause these students to become aware of an opportunity to select some physics courses to sample.

Another target group the mini-physics curriculum was designed to reach is the female nonscience student. Table III reveals that this objective is being met with some degree of success in that 161 of 370 students enrolled in the mini-physics courses during this study were females.

It was surprising to the investigator to find the extent of mathematics preparation of each group. Welch (47) in a study of the Physical Science for the Non-Science Student curriculum found the same high level of mathematics training indicated in his sample population of nonscience students. This led Welch to state that, "These findings suggest that perhaps the newer curriculums for the nonscience student are not taking advantage of such students apparent knowledge of mathematics." In addition, he found that the nonscience population in his study seemed interested in science but had a low interest in mathematics. Welch makes the observation that to refer to such students as nonscience students may be a misnomer. He adds, "Perhaps the clue to their main characteristic is the low interest in mathematics exibited by these students." A study of the academic interests of students in Table III and Table IV reveal essentially the same observation; that is, less than ten percent of either group are majoring in either mathematics or a natural science. The implications of this finding for physics curriculums for nonscience students is discussed in Chapter V.

Further study of Table III and Table IV reveal that both Physics 1005 and mini-physics courses serve a cross section of nonscience students from all areas of instruction at the college except education. Business students make up the largest group of students after the undecided major.

The elementary education major at Southwest Missouri State is served by a physics course (Physics 1014) especially structured for these students. Physics 1014 is required for all elementary education majors at SMS. The number of secondary education majors was quite small (less than ten in each group) and it was necessary to include them in the "other" group.

Design of the Study

It was impossible to randomly assign students to either group. It is apparent then, that the study is best described as a quasi-controlled group comparison. While the limitations of such a design is fully recognized, it is felt that the usefulness of the study is improved by the fact that the two groups are generally the same type of student as revealed by the questionnaire concerning student characteristics, and due to the large numbers of students involved in the study.

A difficulty in carrying out the study lies in the fact that any particular mini-physics course contains students who have enrolled in various numbers of mini-courses. Some will be finishing their initial course, or have taken their second, third, or fourth course. This situation dictated that a design (The Recurrent Institutional Cycle Design) described by Stanley and Campbell (44) would be used. Table V illu-

TABLE V

THE RECURRENT INSTITUTIONAL CYCLE DESIGN

Mini-Physics Group				
Group A			X	0_1
Group B_1	R	0_2	X	0_3
Group B_2	R		X	0_4
Group C		0_5	X	
Control	R	0_6		0_7
Physics 1005 Group				
		0_8		0_9

strates this design. Group B_1 and Group B_2 are composed of students placed in either group by a random selection procedure. The R in front of the Control Group also indicates a random group.

The X's represent the experimental treatment, the mini-physics curriculum, while the O's represent the pretesting or posttesting.

The number of mini-physics courses the student had taken as well as when the student entered the program during the study was used as the criteria for placing a student into a particular group in the design. For example, beginning in the fall semester, if the student was enrolled in his first short course he was given an identifying number and placed by random selection in either Group B_1 or B_2. Campbell and Stanley suggest that this be done to provide a comparison measure of any test retest effects. In addition, the splitting of Group B makes any comparison between 0_4 and 0_5 more clear cut than would be an 0_3 and 0_5 comparison.

If in the beginning of the study, a student was finishing his fifth and final course of mini-physics, he was placed in Group C. Students in their second, third, or fourth class were not assigned a group until they were enrolled in their fifth class. Upon taking the fifth class they were assigned to Group C, (refer to Table V) and posttested. During the testing periods before being assigned to Group C these students were given false tests. They were not told that the tests were meaningless, however they were told that the tests were different because they were in a different level of the mini-physics curriculum.

Students entering the program at the end of the study were assigned to Group A and pretested.

Where the testing is done all at the same time period, the confounding variable of instrumentation, or shifts in the nature of the measuring instruments seems unlikely. In the typical comparison of the difference in attitudes of freshmen and sophomores, for example, the effect or mortality is also a rival explanation: 0_1 and 0_2 differ just because of the kind of people that have dropped out from Group A but are still represented in Group B. This weakness is avoided by identifying the responses by individual assigned number and then waiting until the conclusion of the study and eliminating from 0_2 all those measures belonging to respondents who later failed to complete the curriculum.

The effect of X can be documented in three separate comparisons, 0_1 with 0_2, 0_2 with 0_3, and 0_3 with 0_4. The introduction of 0_5 (Group C) tested before being exposed to X provides another pretest that can be compared with 0_4 and 0_1 giving further redundancy.

The design as represented through measurements 0_1 through 0_5 fails to control for maturation. For this reason 0_6 and 0_7 have been added to the design to provide a cross sectional test of the general maturation trend of nonscience students in the area being tested.

A group of students was selected at random from the Southwest Missouri State student population based upon their meeting the requirement of being a nonscience student. They were paid the sum of four dollars to participate in the study. Thirty seven of the forty students selected agreed to participate.

This design does not control very well for history. However, as Campbell and Stanley (44) state:

> Such a design as this lacks a clear cut control for history in the comparison of 0_1 with 0_2, and 0_4 with 0_5 because of lack of simultaneity. However, if the effect were present an explanation in terms of the effect cannot be made except by postulating quite a series of complicated coincidences.

A period of time was used during each course for the pretesting and posttesting. Each student was given a test booklet that applied to his level in mini-courses taken. Some were given the pretest, while others were given false tests or the posttest according to which instrument applied to their level. Students were not required to take the tests, however only four students refused to respond to the instruments.

Instruments Used

Two cognitive instruments were used to gain information about the degree to which the objectives of the mini-physics curriculum are being met.

One instrument selected is the Science Process Inventory (48). This instrument consists of 135 statements about the concepts of science and the respondent is asked to either agree or disagree with each statement. Content validity of this instrument was established by opinion of science experts with regard to the original description outline of science processes. The test consists only of those items that were accepted by at least 75 percent of the scientists sampled.

The Kuder Richardson formula 20 estimates a reliability of 0.86 derived from a population of 2500 students enrolled in various schools throughout the country. In addition, the inventory was correlated with the Allport-Vernon-Lindsey Study of Values, The Physics Achievement Measure, The Rokeach Dogmatism Scale, and the Herman-Nelson IQ Measure. These correlations were in most cases significant to the 0.01 level of confidence.

A second cognitive test used was the Layman Factual Test (24). It is used to determine to what extent students in the mini-physics curriculum gain knowledge taught in a more traditional introductory physics course. Such formal knowledge is not taught in a formal way in the mini-physics curriculum but only when needed to develop a particular topic. The author of this test reports a validity of 0.89 for this instrument.

The Science Process Inventory was given as a pretest and posttest while the factual test was given as a posttest to the Physics 1005 students and as a posttest to the Group B_1 and B_2 students in mini-physics courses.

In order to measure the attitudinal objectives of the mini-physics curriculum it was necessary to use three attitudinal instruments.

The Inventory of Scientific Attitudes (28) consists of sixty items about science attitudes to which the student responds. The students were asked to indicate their level of agreement or disagreement with each statement on a four point scale.

The Inventory of Scientific Attitudes was developed to fill the need for an attitude instrument in science that contains all four of the following characteristics:

1. Preparation based upon specification of the particular attitude to be assessed.

2. Use of several items to assess each attitude.

3. Provisions for the respondent to indicate the extent of his acceptance or rejection of an attitude statement.

4. Concern with intellectual and emotional scientific attitudes.

In an effort to insure the content validity of the Scientific Attitude Inventory, the universe of content "scientific attitudes" is defined by four categories: (1) positive intellectual, (2) negative intellectual, (3) positive emotional, and (4) negative emotional attitudes. The attitudes to be assessed are based upon the concerns of science educators for objectives of science teaching indicated in the NSSE fifty-ninth yearbook. The validity of the instrument is reported as 0.93.

The Scientific Attitude Inventory was used in this study as a pretest and a posttest. The intent was to measure the degree to which attitudinal objectives two, three, and four (see Table II) were being met.

Approximately half of the statements in the Inventory were considered negative statements with respect to the stated goals while the other half were positive statements. If there was high agreement with the positive statements and low agreement with the negative statements, the student was considered to have a positive attitude toward science. If there was low agreement with the positive statements and high agreement with the negative statements, the student was considered to have a negative attitude toward science.

Scoring of the individual statements depended on whether it was considered a positive or negative statement. The weight used was 3, 2, 1, 0 if the statement was a positive one. A score of three indicates "strong agreement" while a score of 0 indicates "strong disagreement". If the statement was a negative one, the weighting was reversed. In this manner a low score indicates a more negative attitude, and a high score indicates a more positive attitude. Thus the minimum score that could be made would be 0, indicating the most negative response possible. This whole procedure is called the method of summated ratings, and is credited to Likert (25).

Edwards (13) warns that one may not in general interpret that a middle score on a summed rating scale is the neutral point. The absence of knowledge of where the midpoint is, is not considered a handicap if two large groups are being compared. It would be a handicap if a single individual score was to be interpreted. However, in this study only a group comparison is being made with the smallest group being twenty seven.

A second attitudinal instrument, a semantic differential, was used in this study as a posttest to assess attitudinal objectives one and five (see Table II). The items in this instrument have been used in previous studies (18) (48). The students were asked to respond on a seven point scale their rating of the concepts, under the heading "Me-Learning Physics", of "fun", "interesting", "easy", "safe", and "useful". A second heading used was "Physics Courses" with the same concept concepts rated as in "Me-Learning Physics". For example, in response to the concept, "Physics Courses", the student is asked to rate on a seven point scale their feeling about physics courses between the two pole words, "useful", and "useless". The test validity of each concept is reported in Table VI.

In scoring the semantic differential instrument the most negative response was weighted 0, while the most positive response was weighted 6.

A third attitude instrument of twenty items was used to measure the effectiveness of the classroom presentation to the student. The method of scoring was that of a summated rating on a five point scale with 0 being the lowest or most negative response, while a score of 4 represents the highest or most positive response to a statement. The maximum score possible would be 80 representing the greatest positive attitude possible, while the minimum score possible would be 0 representing the least positive attitude possible.

Table VI gives a summary of the validity reported in the literature for each instrument used in this study.

In each instance concerning the use of the three attitudinal instruments, no identification on the part of the student was asked for. In the case of the Scientific Attitude Inventory an identifying number was attached to the paper for the purpose of matching the pretest and posttest scores.

Statistical Procedures

There are several factors present in behavioral research that are difficult or impossible to control. Such factors are classroom noise, lighting, general health of the student on testing day, or any other extraneous factor such as the ones mentioned. These factors could not be measured but were effectively controlled if they were randomly distributed throughout the two groups. One of the assumptions of this study is that such factors are randomly distributed among the two groups.

Of interest is the extent to which the student population of mini-physics courses resembles the population of students in Physics 1005. The enrollment of students in Physics 1005 has remained essentially constant at about 90 students during the last eight years although the college has underwent a very large growth in student numbers. The college has grown from about 5,000 students to 9,650 students during the eight year period (35). The Physics 1005 class has never been "closed", that is, the class has never been so large as to have to turn students away. The implication is that if the college enrollment had remained constant the enrollment in Physics 1005 would have fallen off rather drastically. This is not due to the fact that Physics 1005 is a difficult course, for it is not, but rather seems to be a part of the trend of decreasing enrollment in physics all across the country.

The introduction of the mini-physics curriculum has not affected the generally constant Physics 1005 enrollment. In this study an attempt is made to identify several factors concerning the student characteristics of both groups and check for randomness of their distribution. These were: sex, major area of study, reason for taking the course, who recommended the course, who made the final decision for taking the course, his or her high school science and mathematics background, and their college science and mathematics background. Randomness was investigated by using a chi-square test.

It was beyond the power of the investigator to randomly assign students to either group involved in this study. For this reason the statistics used are mainly confined to testing for differences in mean scores. F tests are used to check for homogeneity of variances. If homogeneity is indicated a pooled varience t-test is used as a basis of accepting or rejecting the hypotheses stated in this study. If homogeneity is not indicated, a nonparametric statistic, the Mann Whitney Test, is used as a basis of accepting or rejecting the hypotheses stated in this study.

TABLE VI

INSTRUMENT RELIABILITY

Test	r	Reporter
<u>Cognitive</u>		
Science Process Inventory	0.86	Welch
Factual Test	0.89	Layman
<u>Affective</u>		
Scientific Attitude Inventory	0.93	Moore
Class Presentation	0.84	McCall
Me-Learning Physics		Welch
fun	0.84	
useful	0.84	
interesting	0.84	
safe	0.68	
easy	0.73	
Physics Courses		Welch
fun	0.82	
useful	0.59	
interesting	0.49	
safe	0.54	
easy	0.52	

CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

Introduction

The goals of this study were to compare students enrolled in the mini-physics curriculum to students enrolled in Physics 1005 as to knowledge of the processes of science, the factual knowledge of physics, and the attitude toward selected stated objectives. The results of the study are presented in this chapter.

Population Distribution

The distribution of the students by group (Physics 1005 and Mini-Physics) is shown in Table II and Table III. A Chi-square test of the two populations was carried out to determine if the two populations differed in respect to any of the selected background factors. A summary of the results can be found in Table VII, and the individual Chi-square tables may be found in Table VIII through Table XIV.

The only factor tested that is not randomly distributed is that of gender. In the Mini-Physics Group, 45.2 percent of the students were female, while 27.3 percent of the students in Physics 1005 were female.

Hypothesis 1: There is no difference (at the 0.05 level of confidence) in the distribution of students in the Mini-Physics Group and the Physics 1005 Group in regard to gender. The obtained Chi-square value

TABLE VII

SUMMARY OF THE CHI-SQUARE TESTS OF RANDOM DISTRIBUTION OF VARIOUS FACTORS BETWEEN THE PHYSICS 1005 AND MINI-PHYSICS GROUPS

Factor	Degrees of Freedom	Chi-square		Distribution
		Calculated	Tabular 0.05	
Gender	1	8.20	3.84	Not Random
Class	3	0.66	7.82	Random
Major Area of Interest	6	2.85	12.59	Random
Who Recommended	3	0.62	7.85	Random
Final Decision	2	1.33	5.99	Random
High School Courses	5	2.14	11.07	Random
College Courses	6	5.32	12.59	Random

TABLE VIII

CHI-SQUARE TEST OF DISTRIBUTION BY GENDER*

Group	Gender				Row Subtotal
	Male		Female		
Mini-Physics	209	(221.19)	161	(148.81)	370
Physics 1005	69	(56.79)	26	(38.21)	95
Column Subtotal	278		187		465 Total

*Expected frequencies in parentheses

$\chi^2 = 8.20$ df = 1

$\chi^2_{0.05} = 3.84$

The males and females are not randomly distributed between the Mini-Physics and Physics 1005 Groups.

TABLE IX

CHI-SQUARE TEST OF DISTRIBUTION BY CLASS*

Class	Group: Mini-Physics		Physics 1005		Row Subtotals
Freshman	118	(121.74)	35	(31.26)	153
Sophomore	87	(89.12)	25	(22.88)	112
Junior	92	(90.71)	22	(23.29)	114
Senior**	73	(68.43)	13	(17.57)	86
Column Subtotals	370		95		465 Total

*Expected value in parentheses

**The Physics 1005 Group contains one special student and the Mini-Physics Group contains thirteen special students.

$\chi^2 = 0.66$ df = 3

$\chi^2_{0.05} = 7.82$

The Mini-Physics Group and the Physics 1005 Group are randomly distributed by class.

TABLE X

CHI-SQUARE TEST OF DISTRIBUTION BY MAJOR AREA OF INTEREST*

Area of Interest	Group: Mini-Physics		Group: Physics 1005		Row Subtotals
Natural Science and Mathematics	34	(32.62)	7	(8.38)	41
Business	63	(63.66)	17	(16.34)	80
Industrial Education	13	(21.48)	14	(5.52)	27
Undecided	81	(79.57)	19	(20.43)	100
Humanities	56	(52.52)	10	(13.48)	66
Social Studies	61	(58.09)	12	(14.91)	73
Other	62	(62.07)	16	(15.94)	78
Column Subtotal	370		95		465 Total

*Expected frequencies in parentheses.

$\chi^2 = 2.85$ df = 6

$\chi^2_{0.05} = 12.59$

The students are randomly distributed by the major area of interest in which they are enrolled.

TABLE XI

CHI-SQUARE TEST OF DISTRIBUTION BY WHO RECOMMENDED THE COURSE

Recommendor	Group: Mini-Physics		Physics 1005		Row Subtotals	
Advisor	48	(50.92)	16	(13.08)	64	
Students	89	(92.30)	27	(23.70)	116	
Self	213	(206.88)	47	(53.12)	260	
Other	20	(19.89)	5	(5.11)	25	
Column Subtotals	370		95		465	Total

*Expected frequencies in parentheses.

$\chi^2 = 0.62$ df = 3

$\chi^2_{0.05} = 7.82$

There is a random distribution of students when classed by "Who recommended the course".

TABLE XII

CHI-SQUARE TEST OF DISTRIBUTION BY "WHO MADE THE FINAL CHOICE THAT YOU WOULD TAKE THE COURSE?"*

Final Decision	Group: Mini-Physics		Group: Physics 1005		Row Subtotals
Advisor	6	(4.77)	0	(1.23)	6
Self	331	(331.81)	86	(85.19)	417
Self and Advisor	33	(33.42)	9	(8.58)	42
Column Subtotals	370		95		465 Total

*Expected frequencies in parentheses.

$\chi^2 = 1.33$ df = 2

$\chi^2_{0.05} = 5.99$

There is random distribution of the students classified by who made the final choice that you would take the course.

TABLE XIII

CHI-SQUARE TEST OF DISTRIBUTION OF HIGH SCHOOL COURSE BACKGROUND*

High School Courses	Group: Mini-Physics		Physics 1005		Row Subtotals
Algebra I	210	(238.65)	88	(59.35)	298
Algebra II	158	(148.95)	28	(37.05)	186
Geometry	166	(162.57)	37	(40.43)	203
Math Analysis or equivalent	90	(82.49)	13	(20.52)	103
Chemistry	115	(104.91)	16	(26.09)	131
Physics	37	(38.44)	11	(9.56)	48
Column Subtotals	776		193		969 Total

*Expected frequencies in parentheses.

$\chi^2 = 2.14$ df = 5

$\chi^2_{0.05} = 11.07$

The students are randomly distributed between the two groups when high school science and mathematics courses are considered.

TABLE XIV

CHI-SQUARE TEST OF DISTRIBUTION BY COLLEGE COURSE BACKGROUND*

College Courses	Group				Row Subtotals
	Mini-Physics		Physics 1005		
No Mathematics Course	0	(1.56)	2	(0.44)	2
One Mathematics Course	283	(288.89)	80	(81.11)	363
Two Mathematics Courses	68	(50.75)	4	(21.75)	72
More Than Two Mathematics Courses	19	(22.28)	9	(5.72)	28
No Science Course	299	(299.08)	78	(77.92)	377
One Science Course	34	(32.01)	7	(8.99)	41
More than One Science Course	37	(36.70)	10	(10.30)	47
Column Subtotals	740		190		930 Total

*Expected frequency in parentheses.

$\chi^2 = 6.75$ df = 6

$\chi^2_{0.05} = 12.59$

The students are randomly distributed between the two groups when college course background in mathematics and science is considered.

was 8.20. The probability of this chi-square value is greater than 0.05. Hypothesis 1 is rejected.

Hypothesis 2: There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to class.

There was very close agreement with the observed frequencies and the expected frequencies. The chi-square value obtained (Table IX) was 0.66. The probability of this chi-square value is less than 0.05. Hypothesis 2 is accepted.

Hypothesis 3: There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to the student's major area of emphasis.

The chi-square value obtained (Table X) was 2.85. The probability of this chi-square value is less than 0.05. Hypothesis 3 is accepted.

Hypothesis 4: There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to who recommended the course.

The chi-square value obtained (Table XI) was 0.62. The probability of this chi-square value is less than 0.05. Hypothesis 4 is accepted.

Hypothesis 5: There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to who made the final decision to take the course.

The chi-square value obtained (Table XII) was 1.33. The probability of this chi-square value is less than 0.05. Hypothesis 5 is accepted.

Hypothesis 6: There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to high school science and mathematics experience.

The chi-square value obtained (Table XIII) was 2.14. The probability of this chi-square value is less than 0.05. Hypothesis 6 is accepted.

Hypothesis 7: There is no difference (at the 0.05 level of confidence) in the distribution of background characteristics of students in the Mini-Physics Group and those in the Physics 1005 Group in regard to college science and mathematics background.

The chi-square value obtained (Table XIV) was 6.75. The probability of this chi-square value is less than 0.05. Hypothesis 7 is accepted.

Control Group Knowledge of Science Processes

For this study, the Control Group was needed as the statistical design fails to control for maturity. The results of the pretest and posttest for the Control Group are shown in Table XV.

Hypothesis 8: There will be no difference (at the 0.05 level of confidence) in the pretest and posttest mean scores of the Control Group for Maturity with regard to knowledge of science processes.

Although there was a slight increase in the mean scores of the Control Group, the t-value obtained for knowledge of science processes is not significant. As a result, hypothesis 8 is accepted.

TABLE XV

t-TEST OF SIGNIFICANT DIFFERENCE IN SCORES ON THE SCIENCE PROCESS INVENTORY BY THE CONTROL GROUP

	Number	Mean	Standard Deviation	F	$F_{0.05}$ (36,36)	Decision
Pretest	37	108.08	6.41			
Posttest	37	109.35	6.51	1.03	1.71	Random
			t = 0.83			

Knowledge Comparisons

Comparisons of knowledge of science processes were made between Group A, Group B, and Group C of Mini-Physics. The means, standard deviations, and F ratios with the decision about the homogeneity of variance are given in Table XVI.

The F test decisions in Table XVI lead to the decision to combine the pretest groups and the posttests groups. A combined mean and standard deviation was calculated to be compared with the Physics 1005 Group. The results are found in Table XVII.

Hypothesis 9: There will be no difference (at the 0.05 level of confidence) between the pretest and posttest mean scores of the Mini-Physics Group with regard to knowledge of science processes.

Table XVII contains the posttest and pretest means and standard deviations for the Mini-Physics Group. The difference in pretest and posttest means is 6.41. The Mini-Physics Group pretest mean was 104.71

TABLE XVI

GROUP A, GROUP B, AND GROUP C SCORES IN KNOWLEDGE OF SCIENCE PROCESSES

Group	Number	Mean	Standard Deviation	F	$F_{0.05}$	Decision
Pre-Test						
B_1	34	102.26	6.27	1.58	1.70	Homogeneous Variance
C	46	106.53	7.71			
Post-Test						
A	23	110.87	5.69	1.30	2.26	Homogeneous Variance
B_1	34	111.63	4.99			
A	23	110.87	5.69	1.58	2.70	Homogeneous Variance
B_2	27	110.69	4.53			
B_1	34	111.63	4.99	1.22	2.47	Homogeneous Variance
B_2	27	110.69	4.53			

TABLE XVII

MINI-PHYSICS AND PHYSICS 1005 SCIENCE PROCESS SCORES

Group	Number	Mean	Standard Deviation	
Mini-Physics				
Pretest	80	104.71	7.44	
Posttest	84	111.12	5.09	$t = 6.41$
Physics 1005				
Pretest	95	106.04	7.98	
Posttest	95	110.58	5.07	$t = 4.82$

which is somewhat lower than the Physics 1005 mean of 106.04. The t-value for the difference in science process pretest and posttest means for the Mini-Physics Group was found to be 6.41. This value is significant at the 0.05 level of confidence. Hypothesis 9 is rejected based upon this information. The science process pretest and posttest means for the Physics 1005 Group are placed in Table XVII for the purpose of comparison.

Hypothesis 10: There will be no difference (at the 0.05 level of confidence) in the mean scores of the posttest Mini-Physics Group and posttest Physics 1005 Group in regard to knowledge of science processes.

Table XVII contains the posttest means and standard deviations of the respective groups. An F test yields a value of 1.01 confirming homogeneity of variance. Although the Mini-Physics Group showed a larger gain in mean score, 6.41 vs. 4.54, the posttest means are essentially the same. A t-value of 0.65 confirms this observation. The t-value predicts no significant difference in the posttest means of the two groups. Hypothesis 10 is accepted.

Hypothesis 11: There will be no difference (at the 0.05 level of confidence) in the mean scores of the Mini-Physics Group and the Physics 1005 Group in regard to factual knowledge of physics.

The Factual Test was given to Groups B_1 and Group B_2 as a posttest and to a random sample of Physics 1005 students as part of their final examination in the course. The means, standard deviations and F tests are shown in Table XVIII.

The Physics 1005 Group mean was 5.12 higher than the Mini-Physics Group mean. The F test of homogeneity predicts that the variance of the two groups is not homogeneous. As a result, the statistic chosen to test for significance of the difference of the means was the Mann Whitney Test. The z value of the Mann Whitney (U) exceeds the critical value for significance. The difference of means between the two groups is accepted as being significant, and as a result, hypothesis 11 is rejected.

TABLE XVIII

FACTUAL TEST COMPARISON OF MINI-PHYSICS AND PHYSICS 1005

Group	Number	Mean	Standard Deviation	F	$F_{0.05}$	Decision
Mini-Physics	56	18.93	6.60			
Physics 1005	41	24.05	3.23	4.18	1.63	Not Homogeneous
U = 427		$S.D._u = 146.52$		z = 5.62	$-z_{0.025} = -1.96$	

Control Group Attitude Toward Science

The results of the Control Group Scientific Attitude Inventory pretest and posttest scores are found in Table XIX.

Hypothesis 12: There is no difference (at the 0.05 level of confidence) in the pretest and posttest scores of the Control Group for maturity in regard to attitude toward science.

The pretest and posttest means of the Control Group attitude toward science is virtually the same. The variance of the two scores are homogeneous as revealed by an F test. A t-value of 0.05 for the differ-

TABLE XIX

CONTROL GROUP ATTITUDE TOWARD SCIENCE

Group	Number	Mean	Standard Deviation	F	$F_{0.05}$	Decision
Pretest	37	112.54	6.47			
Posttest	37	112.46	6.17	1.10	1.73	Homogeneous Variance
			t = 0.05			

ence of the means is not significant. Hypothesis 12 is accepted.

Attitude Comparisons

Comparisons were first made between Group A, Group B, and Group C of Mini-Physics. The means, standard deviations and decisions about homogeneity of variance are found in Table XX.

The F values obtained (Table XX) indicate that each pair of scores are homogeneous in variance. Based upon this result, it was decided to combine the pretest and posttest Scientific Attitude Inventory scores of the Mini-Physics Groups. The mean posttest attitude score for Group A is somewhat higher than the other groups. The investigator knows of no reason why this should be so. The combined group scores are found in Table XXI.

Hypothesis 13: There will be no difference (at the 0.05 level of confidence) between the pretest and posttest scores of the Mini-Physics Group with regard to attitude toward science.

TABLE XX

GROUP A, GROUP B, AND GROUP C SCORES ON SCIENTIFIC ATTITUDES*

Group	Number	Mean	Standard Deviation	F	$F_{0.05}$	Decision
<u>Pre-Test</u>						
B_1	34	113.24	10.91	1.42	1.70	Homogeneous
C	46	111.61	9.07			Variance
<u>Post-Test</u>						
A	23	118.09	6.40	2.27	1.98	Homogeneous
B_1	34	114.65	9.65			Variance*
A	23	118.09	6.30	1.92	2.00	Homogeneous
B_2	27	113.15	8.75			Variance
B_1	34	114.65	9.65	1.22	1.80	Homogeneous
B_2	27	113.15	8.75			Variance

* Homogeneous at the 0.01 level of confidence

TABLE XXI

MINI-PHYSICS AND PHYSICS 1005 SCIENTIFIC ATTITUDE SCORES

Group	Number	Mean	Standard Deviation	
<u>Mini-Physics</u>				
Pretest	80	112.34	9.93	
Posttest	84	113.65	10.66	t = 0.80
Physics 1005				
Pretest	95	113.53	9.43	
Posttest	95	115.32	10.17	t = 0.82

The difference between the pretest and posttest means is 2.64. The Mini-Physics pretest mean was 112.34 which is somewhat lower than the Physics 1005 mean of 113.53. The t-value for the difference in scientific attitude pretest and posttest means for the Mini-Physics Group was found to be 0.80 and, as a result, hypothesis 13 is accepted.

Hypothesis 14: There will be no difference (at the 0.05 level of confidence) in the mean scores of the posttest Mini-Physics Group and the posttest Physics 1005 Group in regard to attitude toward science.

Table XXI contains the posttest means and standard deviations of the respective groups. An F test yields a value of 1.10 confirming homogeneity of variance. Although the Physics 1005 Group has a slightly higher posttest mean score, 115.32 vs. 113.65, a t-value of 0.82 predicts that there is no significant difference in the two means at the 0.05 level of confidence. As a result of the t-test, hypothesis 14 is accepted.

A detailed inspection of student self-concepts about taking part in the activities of physics was carried out by using a t-test comparison of mean scores of each polar word in the semantic differential inventory used in this study. The results are shown in Table XXII. Statistically significant difference (at the 0.05 level of confidence) of means are indicated with an asterisk by the t-value. The F ratio is an indication of homogeneity of variance.

The mean scores can be translated into levels of acceptance by keeping in mind that there was six spaces between each pole word in the semantic differential and that they are scored from 0 for the space next to the negative pole word up to 5 for the space next to the positive pole word. A score of 2.5 represents a theoretical neutral point.

TABLE XXII

t COMPARISON OF MEAN ATTITUDE SCORES OF THE TWO GROUPS

Pole Word	Group	Mean	Standard Deviation	F	Degrees of Freedom	t score
Me-Learning Physics						
Useful	Mini	4.13	1.10	1.42	177	0.34
	1005	4.23	0.92			
Interesting	Mini	4.47	1.15	1.14	177	0.01
	1005	4.52	1.08			
Safe	Mini	4.30	1.15	1.19	177	0.26
	1005	4.34	1.19			
Easy	Mini	3.28	1.02	1.37	177	1.31
	1005	3.47	1.19			
Fun	Mini	3.92	1.20	1.15	177	0.48
	1005	4.00	1.12			
Physics Courses						
Useful	Mini	4.14	1.14	1.21	177	1.80
	1005	4.42	1.10			
Interesting	Mini	3.81	1.15	1.04	177	2.11*
	1005	4.15	1.17			
Safe	Mini	4.13	1.16	1.10	177	6.54*
	1005	3.77	1.10			
Easy	Mini	3.03	1.14	1.09	177	0.35
	1005	2.98	1.09			
Fun	Mini	3.71	0.90	1.31	177	0.27
	1005	3.75	1.02			

All the mean scores of both Groups in the Semantic Differential Inventory were on the positive side of the neutral point. The closest approach to the supposed neutral point of 2.5 was the "easy-hard" pole words under "Physics Courses", which resulted in a mean of 2.98 for the Physics 1005 Group.

Two difference of means, both under "Physics Courses", were found to be significant. Using the pole words, "interesting-dull", the Physics 1005 Group mean of 4.15 was significantly higher than the Mini-Physics Group mean of 3.81. The other significant difference of means found was with the pole words, "safe-dangerous". The Mini-Physics Group mean of 4.13 was significantly higher than the Physics 1005 Group mean of 3.77.

Hypothesis 15: There will be no difference (at the 0.05 level of confidence) in the mean scores of the Mini-Physics Group and the Physics 1005 Group in regard to their ability to see themselves in the role of doing science activities.

The combined scores of the semantic differential results in a mean of 3.89 and a standard deviation of 1.19 for the Mini-Physics Group, and a mean of 3.96 with a standard deviation of 1.10 for the Physics 1005 Group. An F test verifies the homogeneity of variance and the resulting t-test gives a t-value of 0.44. The t-value is not significant, and as a result, hypothesis 15 is accepted.

A third attitude test used in this study was an instrument designed to measure the student attitude toward the presentation of the class. A detailed inspection of student attitude difference was carried out by using a t-comparison of the mean attitude scores of each group on each question. The results are shown in Table XXIII.

Statistically significant differences (0.05 level of confidence) are indicated with an asterisk by the t-value. The F ratio indicated in this table is the F test of homogeneity of variance. Values of less than $F_{0.05}$ (100,100) allow the use of pooled variance t-tests for comparison of means. This value is exceeded in four cases, namely in statements 3, 4, 15, and 17. The difference in means in these cases are so small that there is no difficulty with homogeneity of variance.

As with the semantic differential the mean scores can be translated into levels of agreement and disagreement, keeping in mind whether the question is a positive one or a negative one. Two examples would be statements 1 and 6.

Statement 1 is a positive statement indicating that a favorable response would conform to one of the goals of the course. Scores of 2.21 for the Mini-Physics Group and 2.60 for the Physics 1005 Group indicate agreement with this positive statement. Subtracting these scores from 2, which would be a neutral response, yields the level of agreement for each group.

In statement 6 which is a negative statement, a great deal of disagreement is present for both groups. Agreement with this statement is undesirable for either group.

In summary, there were five statistically significant differences in response to the twenty attitude questions or statements. Questions one, "...received valuable experiences in physics", and eight, "...im proved my ability to think logically", received significantly higher responses from the physics 1005 Group. Statements two, "...real enthusiasm for science", ten, "...importance of physics to everyday living", and eighteen, "...too much written work", received significantly

TABLE XXIII

t COMPARISON OF MEAN ATTITUDE TOWARD CLASS PRESENTATION OF THE MINI-PHYSICS AND PHYSICS 1005 GROUPS

Question	Type	Group	Mean Score	Standard Deviation	F	Degrees of Freedom	t Score
1	+	Mini	2.21	0.91	1.04	166	2.29*
		1005	2.60	0.97			
2	+	Mini	1.93	1.08	1.07	166	2.19*
		1005	1.48	1.19			
3	-	Mini	3.11	0.94	1.72	166	0.28
		1005	3.15	0.73			
4	-	Mini	3.09	0.85	1.87	166	0.17
		1005	2.70	1.25			
5	-	Mini	2.91	0.89	1.26	166	1.70
		1005	2.63	1.00			
6	-	Mini	3.06	1.03	1.20	166	0.51
		1005	2.77	0.88			
7	-	Mini	2.90	0.96	1.38	166	0.60
		1005	2.80	0.81			
8	+	Mini	1.86	0.96	1.12	166	2.22*
		1005	2.25	1.02			
9	-	Mini	2.93	0.95	1.29	166	0.46
		1005	2.85	1.08			
10	+	Mini	3.10	0.62	1.36	166	3.14*
		1005	2.61	0.92			
11	+	Mini	1.84	1.20	1.15	166	0.89
		1005	2.03	1.04			
12	+	Mini	2.70	1.12	1.31	166	1.40
		1005	2.97	0.96			
13	-	Mini	2.16	1.12	1.03	166	0.66
		1005	2.30	1.11			
14	+	Mini	2.37	1.27	1.25	166	0.71
		1005	2.50	1.14			

TABLE XXIII (Continued)

Question	Type	Group	Mean Score	Standard Deviation	F	Degrees of Freedom	t-score
15	+	Mini	3.05	0.75	2.00	166	0.19
		1005	2.62	1.06			
16	-	Mini	2.72	0.88	1.29	166	0.16
		1005	2.75	0.99			
17	-	Mini	2.48	1.25	1.52	166	0.29
		1005	2.33	1.02			
18	-	Mini	3.19	0.95	1.18	166	3.34*
		1005	2.65	0.87			
19	-	Mini	2.05	1.09	1.09	166	1.01
		1005	2.25	1.04			
20	-	Mini	2.78	1.03	1.20	166	0.84
		1005	2.63	0.94			

*Indicates a significant difference at the 0.05 level of confidence higher scores from the Mini-Physics Group.

Hypothesis 16: There will be no difference (at the 0.05 level of confidence) in the mean scores of the Mini-Physics and Physics 1005 Groups with regard to attitude toward how the class was presented.

The combined mean score for the Mini-Physics Group was 2.62 with a standard deviation of 0.99, while the combined mean score for the Physics 1005 Group was 2.54 with a standard deviation of 1.00. Both groups show a positive attitude toward how the classes were presented. A t-value of 0.03 predicts that there is virtually no difference in the mean scores. Hypothesis 16 is accepted.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to attempt to measure the effectiveness of an alternate approach to teaching physics for nonscience students. The results of the study are compared with a more traditional method of teaching physics.

The major objective of the mini-physics courses was to provide an opportunity in physics experiences that would cause more nonscience students to elect a physics course to complete their natural science requirement. An effort was made to provide experiences in physics that would be not only intellectually satisfying, but also to present physics in a way that would cause the student to leave the course with a positive attitude about their ability to do the activities of science and to understand the scientist's method. Contemporary, historical and theoretical topics were chosen by the faculty interest and by student request.

The emphasis in these courses was placed on learning science processes, and improving scientific attitudes. Pretests and posttests were used to measure the gain in knowledge of science processes and scientific attitudes. Posttests of factual knowledge of physics, attitude toward the presentation of the course, and a semantic differential based upon the activities of physics were used to measure the goals set forth in this study.

Reliability coefficents, chi-square, and t-tests for significance were used to analyze the resulting data. The null hypotheses were then confirmed or rejected on the basis of this analysis

The instruments used in this study have all been validated in previous studies.

Conclusions

The background characteristics of the nonscience students electing to take mini-physics courses resemble the student who takes Physics 1005 with the exception of gender. Far more women elected the mini-physics courses than in the Physics 1005 course.

An interesting finding about the background of these students is the extent of their mathematical experiences in high school and college. It is apparent these students are being underestimated with regard to their ability in mathematics. In spite of their apparent knowledge of mathematics, these students express an almost universal dislike of mathematics.

Parque (31) in a study of nonscience students may have found a reason for this dislike of mathematics in relation to science. His study notes that most mathematics used in science courses for beginners is centered around trigonometric functions, proportions, significant figures, calculation of percentage error, fractional equations and powers of ten. His study concluded that nonscience students are usually deficient in these areas.

If Parque's conclusions are correct about mini-physics students then there is an opportunity for new objectives in the curriculum.

It may be construed that a basic weakness of the mini-physics curriculum is the significantly lower mean score on factual knowledge of physics. This weakness can be overcome and a recommendation will be made later in this chapter.

A second area of disappointment is found in the results of the classroom presentation. A major effort is made to provide experiences to the student in mini-physics courses that he can value and use in his own everyday experiences. Although the mean attitude of the students was favorable with a mean score of 2.62 compared with a neutral point of 2, it is the opinion of the investigator that this is a disappointing score considering the effort put forth by the faculty in the presentation of physics to these students.

The mini-physics curriculum has strengths in that a significant change was noted in the student's knowledge of science processes. In addition, the semantic differential instrument shows that the students have a very positive attitude about playing a role in science activities. The Physics 1005 Group also left their course with a high positive attitude toward science and doing the activities of science.

This study did not detect the reason why students will choose the mini-physics courses over the Physics 1005 course. As noted in chapter three, the enrollment in Physics 1005 has remained constant although the college has almost doubled in size. The mini-physics courses are growing very rapidly at this time.

Subject to the limitations of the study, the following conclusions were drawn:

1. There was a significant difference in the number of women who

elect mini-physics courses over Physics 1005. There were no other significant differences between the two groups in other selected background characteristics.

2. The gain in knowledge of science processes by mini-physics students was significant. The gain in knowledge of science processes of mini-physics students is not significantly different than the gain experienced by the Physics 1005 students.

3. There was no significant gain in the mean scores of scientific attitudes by either group.

4. The Physics 1005 students mean score on factual knowledge of physics was significantly higher than the mean score made by students enrolled in mini-physics courses.

5. There was no significant difference in mean scores of either group in regard to ability to conceive of themselves playing a role in doing science activities.

Recommendations

1. The means to develop a random selected study should be provided. Then a multivarient F could be used to detect any interactions of the variables.

2. Studies of any mathematical deficiencies of the students should be made. The results should be used to incorporate remedial experiences into the physics curriculum.

3. The Mini-Physics curriculum is in a period of rapid growth. This study should be replicated when the growth stabilizes.

4. In this study much demographic information was gathered from the students. The use of factorial analysis would enable the researcher

to look for interaction between some of these variables.

5. Factual knowledge of physics should be made more specific in objectives written for Mini-Physics. This would allow for a more organized effort to present essential factual knowledge to these students.

The results of this study would indicate the advantage of trying this approach to others who have responsibility for introductory physics courses, although it is recognized that the approach requires much planning and cannot be undertaken lightly.

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APPENDIX A

MINI-PHYSICS COURSES OFFERED WITH ENROLLMENT

Course	Instructor	Enrollment
Fall 1970		
Apollo Missions	Northrip	70
Physics of Flight	Northrip	20
Spring 1971		
Atmospheric Pollution	McInnis	51
Nuclear Energy-Benefits-Risks	Banks	29
Space and Time	Schmit	39
History of Energy	Soxman	27
Man and Radiation	Northrip	30
Physics of Music	Petefish	16
Summer 1971		
Air Pollution	Northrip	28
Optics in Nature	Petefish	9
Fall 1971		
Physics and Man	Northrip	49
Great Experiments in Physics	Soxman	33
Micheal Faraday	Soxman	26
Cosomology	Wolf	23
Physics of Music	Petefish	45
Lasers and Light	Hardman	8
Spring 1971		
Atmospheric Pollution	McInnis	98
The Calender	McInnis	51
Microphysics	Northrip	17
Optics and Nature	Petefish	52
Particles	Northrip	10
Physics of TV	Schmit	8
Photography and Physics	Northrip	12
Physics of Music	Petefish	16

Summer 1972	Instructor	Enrollment
Concepts of Physics	Northrip	38
Physics of Sports	Northrip	29
Demonstrations of Physics	Petefish	18
Fall 1972		
The AEC	Soxman	12
Project Skylab	Soxman	28
Man and Energy	Northrip	35
Particles	Northrip	17
Waves	Petefish	12
Physics and Life	Soxman	68
Great Experiments in Physics	Thurman	27
Foundations of Astrology	Wolf	77
History of Electricity	Schmit	14
Household Physics	Schmit	39
Amateur Telescope Construction	Banks	7
Physics of TV	Northrip	9
Physics of Sports	Northrip	45
Spring 1973		
Science and Society	Northrip	53
Women and Physics	Spears	27
History of Electricity	Schmit	13
Motion	Schmit	28
All About Lightening	McInnis	51
Traffic Flow Patterns	Raferty	41
Noise and Pollution	Thurman	28
Physics of Gems and Minerals	Northrip	75
Foundations of Astrology	Wolf	53
Cloud Physics	Thurman	32
Household Physics	Spears	38
Physics for Bicyclists	Northrip	66
Fall 1973		
Real Cool Physics		
Physics of Gems and Minerals		
Women in Physics		
All About Lightening		
Foundation of Astrology		
Mechanics		
Waves		
Particles		
Physics for Bicyclists		
Cloud Physics		
Science and Society		
Household Physics		
Physics and Man		

APPENDIX B

QUESTIONNAIRE

Name ______________________________ (1) male (2) female

Class (3) Fr. (4) So. (5) Jr. (6) Sr. (7) Other

Why are you taking this course? ______________________________.

Who recommended this course:
(8) Your college advisor? (9) Other students? (10) Self?

(11) Other ______________________________

Who made the final decision?

(12) Advisor (13) Self (14) Self and Advisor

Which of these high school courses have you taken?

(15) Algebra I (16) Algebra II (17) Geometry (18) Math Analysis or its equivalent (19) Chemistry (20) Physics

How many college mathematics courses have you taken?

(21) none (22) one (23) two (24) three (25) more than three

How many college science courses have you taken?

(26) none (27) one (28) two (29) more than two

APPENDIX C

CLASSROOM ATTITUDE MEASURE

We would like to know your opinions regarding the following statements. Please mark your response according to the following code:

1. I STRONGLY AGREE with this statement
2. I AGREE with this statement
3. I am undecided about this statement
4. I DISAGREE with this statement
5. I STRONGLY DISAGREE with this statement

1. I received valuable experiences in physics that I can use all my life.
2. This physics course gave me my first real enthusiasm for science.
3. Physics does not teach you to think.
4. This physics course should be eliminated from the general education requirements.
5. Most topics in this physics course were of little value.
6. Only the brightest students benefit from this course in physics.
7. The subject matter of this physics course was much too mechanical and formalized.
8. This physics class has improved my ability to think logically in any type of situation.
9. I would not recommend this course to anyone.
10. This physics course has helped me to appreciate the importance of physics to everday living.
11. This course was excellent for the slower student who needed more repetition and prodding than most.
12. I like the way physics was taught this semester.
13. I would have liked to ask more questions during this course.
14. I knew how I was doing in physics all semester.
15. The grading was fair this semester in this course.
16. I wasn't able to keep up with the other students.
17. We covered the subject too fast in this physics course.
18. I believe too much written work was given in this course.
19. I believe this course would benefit all students.
20. I think more teaching aids, (charts, films, etc.) should have been used in this course.

VITA ✓

Franklin Ray Hoggard

Candidate for the Degree of

Doctor of Education

Thesis: A STUDY OF THE MINI-PHYSICS CURRICULUM AT SOUTHWEST MISSOURI STATE COLLEGE

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