AN HISTORICAL RESUME OF PHYSICS AND ITS TRENDS IN KANSAS HIGH SCHOOLS

by

IVER EUGENE ELLSWORTH PETERSON

B. S., Kansas State College of Agriculture and Applied Science, 1928

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Education

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1940

TABLE OF CONTENTS

INTRODUCTION

The early growth of physical science showed itself mainly through the solution of a large number of isolated, household, and industrial problems. How should one count time so as to know when his interest or principal was due, how should he measure the area of the land which he was about to buy, or how should he weigh the silver received for an ox that he had sold? The answer to these three questions introduced us at once to the three fundamental measurements of the modern physical laboratory, namely those of length, mass and time. Thus according to Crew (6, p. 5) it is perhaps not unfair to say that the history of physics begins with the invention of any machines, the description of any motions, the enunciation of any theories or the discovery of any principles which ameliorate life and clarify thought; which give us simplicity of view, and free us from superstition and fear. These things take us very far back, and raise the question as to what were the earliest machines. Thus it will be found that the contributions to physical science by the two great civilizations preceding that of Southern Europe were mainly of an utilitarian character, consisting largely of mechanical arts and commercial devices. There is nowhere to be found any formulation of the behavior of nature, nothing in the way of physical law, no distinct branch of knowledge which might be called physics, no general view of any field. The Egyptians were clearly familiar with the "3.4.5 rule", but there was no evidence that they were able to derive it from a more general principle (6, p. 9).

The first people who were able to take the dry facts collected by the Egyptians and Babylonians and weave them into a science were Greeks. How it ever happened that the Aryan people who early settled the Greek peninsula and that part of the west coast of Asia Minor known as Ionia, were able to break loose from tradition and superstition and to think about physical phenomena in a thoroughly rational and common sense manner is a question. How did such a highly intellectual world come into being somewhere between 800 and 600 B. C.? Was there a gradual growth of which the world has lost all record?

The answers which these questions have received can hardly be considered satisfactory. Some historians attempted to find an explanation in the genial climate, the fertile soil, and abundant leisure to talk things over in the market place and about the town pump. Archaeologists have traced back through several centuries the displacement of the pre-Greek inhabitants of the peninsula by the Greeks themselves, but still the reason why such a sudden change was brought about remains unknown (6, p. 10).

Cajori tells us (4, p. 1) that it would be incorrect for us to say that the Greeks possessed little or no aptitude for observing natural phenomena, but it is true that, as a rule, they were ignorant of the art of experimentation, and that many of their physical speculations were vague, trifling and worthless. The conclusions arrived at were for the main part the result of deductive reasoning and little or no attempt was made to verify speculation by experimental evidence.

The Greeks formulated the greater part of their philosophy in the following fields: mechanics, light, electricity, magnetism, meterology, sound, and the atomic theory. As stated before none of the conclusions were verified and many of them have since then been found to be erroneous but it was a great step forward as it was the first that such questions had received consideration.

After the fall of Athens from its political supremacy in 338 B. C. the center of Greek culture moved to Alexandria (2, p. 8) which, under the beneficient rule of the Ptolemies became the meeting place of philosophers from all parts of the world. The Alexandrians produced many famous scholars, including Euclid, Aristarchus, Apollonius, Hipparchus and later Ptolemy. It was particularly rich in geometers and astronomers.

Alexandria in turn fell in A. D. 640 into the hands of the Arabs who after a brief period of conquest and destruction, which carried them all over Northern Africa and Spain, assimilated Greek learning and at the end of the century became the sole guardian and teacher of the old philosophy. The rest of Europe, busy with migration of the Northern peoples, found its whole activities bound up in the movements which have since led to the present political division, and for a time, all previous scientific developments completely disappeared in what have been called the "dark ages".

The genius of the Roman people was exercised in war, but no effort was put forth for the advancement of pure mathematics or science. The scientific writers of Rome were content to collect the researches of their Greek predecessors. Thus it came about that the Romans added but little, if anything, new to the sciences, but did perform some service in organizing to some extent the contributions of those that had preceded them.

The growth of the Arabic nation presents an extraordinary spectacle in intellectual history. Scattered barbaric tribes were suddenly fused in the furnace blast of religious enthusiasm into a powerful nation. A career of war and conquest was followed by a period of intellectual activity. According to Buckley (2, p. 8) civilization owes a great debt to the Arabs who at this troublesome time in the history of Europe preserved and added very largely to the knowledge of previous civilizations. While the rest of Europe was, for a time, in intellectual darkness, priest-ridden, and under the stifling influences of authority and intolerance, the Khalifate encouraged learning, exalted the supremacy of reasoning, founded important universities and libraries, and did everything possible to apply scientific knowledge to the purposes of every day life, so much so that the Crusaders were astonished at the magnificence and splendor of the civilization which they confronted. So far as it is known (4, p. 17), there was only one branch of physics which was successfully cultivated on Arabic soil and but one man prominently identified with it. The branch was optics and the man was Al Hazen.

The year of 1492 witnessed the expulsion of the Arabs from Spain, and the extinction of that brilliant source of scholarship which has lasted so long. The effects of Arabian learning remained, however, and in Roger Bacon we possess the connecting link between the Arabs and the Renaissance which was partly the result of the capture of Constantinople by the Turks in 1453, and the consequent re-discovery of the original Greek philosophy, which the old quarrel between the Greek and Roman churches had guarded as the exclusive possession of Eastern Europe (2, p. 9).

Bacon through the scientific training which he acquired from the study of the Arabian commentators and philosophers developed a distrust of the doctrines and teachers of his day. He recognized that all sciences were connected together and mutually assisted one another. He had new ideas as to the origin of knowledge, reason and experiment. Experiment was a source recognized by him for the first time. He not only had opinions as to the importance of experimentation but practiced his own doctrines, particularly in optics, and made many important discoveries. Unfortunately, Bacon was ahead of his time and his work did not receive the appreciation which a more enlightened age would have accorded him. The invention of the printing press did not occur until many years later, so that many of his ideas did not bear fruit.

It is not to be thought that Bacon was the only one to formulate these ideas; for other philosophers, as well, in time arose, who recognized that progress was to be had by direct appeal to nature. It is found that the past procedures were being reversed and experimentation was being placed foremost in the process of finding new knowledge. According to Buckley (2, p. 11) Leonardo da Vinci wrote,

> Entreating any particular subject, I would first of all make some experiments, because my design is first to refer to experiments and then to demonstrate why bodies are constrained to act in such a manner. This is the method we ought to follow in investigating the phenomena of Nature. Theory is general, experiments are the soldiers. It is never wrong, but our judgment is sometimes deceived because we are expecting results which experiment refuses to give. We must consult experiment and vary the circumstances till we have deduced general laws, for it alone can furnish us with them.

Francis Bacon has been accredited by many as the founder of modern science. His claim to this distinction rests on a series of works having for their object the reorganization of the sciences and the development of a new method of learning through which the mind, by means of rules and precepts, should be enabled to make progress and discoveries in the various sciences. Bacon maintained that the value of knowledge depended upon its utility.

The experiment is found as the basis of the procedure that was to be followed in the development of our present day sciences. It has been followed up to, and is being continued at the present time with few changes. These accomplishments have not been brought about without struggles and strife, for both equipment and suitable housing were unknown at that time. Since then laboratories and ample equipment, as will be discussed later, have been developed. The strife caused by the church and state is well illustrated by the experiences of Galileo. It is recounted by Cajori (4, p. 31) that while Galileo was a professor at Padua, (1592-1610) he began to boldly preach Copernician doctrines. In consequence, he was summoned before the Inquisition at Rome where the theory of the earth's motion was condemned by the Inquisition, and Galileo received an injunction to remain quiet. For many years he remained silent though his mind was always at work. In 1632 he published, contrary to the edict of 1616, a new work, which was a brilliant success as an argument in favor of the Copernician theory. This brought about a second trial and the old man of 70 was subjected to indignity, imprisonment and threat. Examples such as this illustrate the nature of the opposition the founders of our modern science faced.

Since that time and up to the present day the sciences have progressed steadily but not without opposition and handicaps, possibly the greatest handicap being the slow development of laboratories and apparatus. In the development of physics many noted scientists have made enormous contributions in its various fields. It is impossible to take up a discussion of each one of these in this review, but wish to emphasize the fact that experimentation has always been used for verification.

A study of the history of laboratory work in secondary schools reveals several interesting facts. One of these is that it gained its prominent position in the closing years of the nineteenth century, and this largely was a result of college influences. The first record of the construction of a high school laboratory dates back much farther, to St. Louis, 1854. A laboratory in actual use by pupils belongs to a date 10 or 11 years later indicating that the spread of the movement was gradual. Even up to and including the prosperous year of 1929, funds providing for equipment adequate for systematic laboratory teaching were lacking in many school districts. Often locally selected teachers were not competent to use such equipment as they had. Conditions have improved but slightly in the last decade.

Even in colleges and universities in the older days there was no regular laboratory work. The professor's private laboratory, the only one existing at the time, was at best meagerly furnished, for reagents and apparatus in any great variety could not be obtained with the same ease as today. According to Cajori (4, p. 291) a few teachers permitted the most enthusiastic and promising of their students to enter their private laboratories which were usually located in their homes. This stimulated great interest among the students and was later recognized by the schools. At first the schools supplemented the already existing private laboratories, later establishing their own.

The fact that it was difficult to secure apparatus and reagents easily proved to be of an advantage in that it stimulated ingenuity in devising and providing suitable demonstration and experimental materials. As the college classes grew larger in number the close laboratory intimacy that had prevailed between professor and student waned. Classes had to be sectioned for laboratory work, special hours were set, assistants employed and formal written manuals or direction sheets prepared. The laboratory thus became separated from the rest of the course and has almost evolved into a course in itself. This is much different than it was in earlier times. Cajori tells us (4, p. 293) the laboratory corps, as it used to be called, has been known to divide itself into two squads--one working through the day, the other during the night, for weeks at a time.

The value of laboratory work in college, even after the separation, is unquestioned by student and instructors. It brings about actual contact with materials and processes. Perhaps a chief fault to be found is that the laboratory in college science departments is too often prescribed alike for all students. Too little consideration is given to the varying interests and needs of student groups. Little attempt is made to determine the relative value of laboratory courses in particular programs of study.

The same type of work descended to the high schools by mandate of the colleges when the latter opened their doors wide enough to allow sciences to be used for entrance credit. As a rule (24, p. 168), the offering of science for entrance meant not only passing an examination, but also submitting a notebook, certified by the teacher, containing the record of a stipulated number of laboratory experiments. If a school did not devote at least a prescribed amount of time each week to this particular type of activity, its students were not eligible. Thus, in the high school the main purpose of laboratory work soon came to be interpreted not as preparation for living, but as formal preparation for college entrance. Because the teacher was required to certify that the notebook represented an individual record kept by a certain student under his direction and that the drawings, observations, and measurements were entered in it in the laboratory and at the time the experiment was performed, many a conscientious teacher could find no means of protecting this guarantee other than that of keeping the notebook locked up out of the pupil's reach except during actual experimentation. Under these circumstances the notebook was naturally of little functional value to the student.

The secondary school of today retains one advantage over the college in that it has not handed over to young assistants the task of laboratory teaching and control. Thus the laboratory and recitation work are kept more nearly parallel in point of view. But even here, the exigencies of time schedules and room assignments tend to keep the two apart, when as a matter of fact they should be closely integrated.

In a study of the methods of teaching used, it is found that they have passed through a slow and troublesome development. Difficulty was experienced in bringing about the transition from the old to the new. The progress that has been made in teaching methods is remarkable. Memorizing was the basis of learning in the beginning when students repeated after their teacher until the passages considered important were mastered. Today, it is the opinion that all the senses should be appealed to in order to bring about learning, and accordingly teaching devices such as demonstration, laboratory, tests and visual aids have been developed in recent years.

The latest of the newer teaching devices to be developed is visual education. Only recently through the application of moving pictures, film strips, and the development of authentic charts it has been possible to use successfully these methods. The importance of visual aids is well expressed by Bossing (3, p. 385) when he wrote,

> One may build up very erroneous mental imagery when dependent on word symbolism for his ideas of a definite place or thing. In spite of an elaborate word picture of a modern telephone transmitter, if a youth had never seen one, he might easily fail to recognize it when casually brought into his presence.

The mental imagery set up as a result of a description might bear but little resemblance to the visual imagery the thing itself produced.

Tests and testing programs have been developed to a considerable extent during the last 25 years where they formerly were used to compare students, secure grades and complete school records; today they are used more scientifically and accurately in measuring abilities and aptitudes, determining interests, and measuring progress (7, p. 357-62).

It was after considerable reading that the problem chosen for research, was definitely decided upon. It is to be expected that a person who had been directly connected with the sciences as a student and teacher for the past 14 years would find his research interests lying in that field. It was after a study of the process of development through which the sciences have gone that a curiosity as to their status in the high schools of Kansas was aroused. Upon inquiry and investigation, little or no direct information was available and accordingly the problem of the status of physics in the high schools of Kansas was selected. The idea at first, was to make a study of the methods employed in the teaching of physics but it was found that this would in no way solve the problem as to the status of the course as it exists in the state. Accordingly, the scope was broadened and, to a great extent, took into consideration a cross-sectional investigation of the content of the course together with the methods of presentation.

METHOD OF PROCEDURE

A questionnaire of twenty general questions was prepared; 88 technical questions were included (Appendix). The questionnaires were sent to the various schools of the state, asking for definite answers and their early return. The schools included every high school in the first and second class cities, all community high schools of the state, as well as a sampling of the third class city and rural high schools throughout the state. To secure a representative sampling of the third class city and rural high schools of the state a questionnaire was sent to every fifth high school as they are listed in the State Educational Directory of 1938, (18). This made a total of 169 questionnaires.

Of the 169 questionnaires sent out 99 were returned, which would be a return of 58.58 per cent. It might be added here that the questionnaires were sent to the principals who were asked to put them in the hands of the person in charge of the physics department.

Upon the return of the questionnaires the results were tabulated and analyzed. These results were then compared with the standards set up in the Handbook on organization and practices for the secondary schools of Kansas, (11). For further evaluation the standards as set up for physics in the surrounding and other selected states were compared. The states were Colorado, Nebraska, Iowa, Missouri, Oklahoma, Ohio, Massachusetts and New York.

FINDINGS

Consulting Table 1, it is seen that returns were received from 11 schools of the cities of the first class, giving a 73.33 per cent return from this area. Of the schools of the cities of the second class, 40 reported making a 56.01 per cent return from the schools of this classification. Fifteen of the community high schools reported, giving a return of 62.25 per cent. Of the third class city and rural high schools 30 reported, giving a return of 55 per cent.

Table 1. Comparison of the number of questionnaires sent and returned.

Class of schools	Number of questionnaires sent out	Number of questionnaires returned	Per cent returned
High schools in first class cities	15	11	73.33
High schools in second class cities	70	40	57.01
Community high schools	24	15	62.25
Third class city and rural high schools	60	33	55.00
Total	169	99	58.58

The reason the returns from the third class city and rural high schools were so few can no doubt be accounted for by the fact that the course is offered in many schools on alternate years and at this time no instructor was employed who could furnish definite information.

Referring to Table 2, it is found that in the high schools of first class cities all but one offer physics every year which is 90.9 per cent of the schools reporting. The other school operating on the 6-4-4 plan offers physics in the thirteenth grade. In the high schools of the cities of the second class 36 or 90 per cent of the schools reporting offer it every year, while four or 10 per cent do not offer it. In the third class city and rural high schools 13 or 39.39 per cent offer it every year while 18 or 54.54 per cent offer it on alternate years and two or 6.06 per cent do not offer it. No doubt the reason that so many of the schools of this group offer it only on alternate years is because of small enrollments and the limited corps of teachers.

Table 2. The number of high schools offering physics and frequency of offerings.

Class of schools	Number of schools reporting	Offer physics every year	Per cent offering physics every year	Offer physics on alternate years	Per cent offering physics on alternate years	Do not offer physics	Per cent not offering physics
High schools in first class cities	11	10	90.91	--	--	1*	9.00
High schools in second class cities	40	36	90.00	--	--	4	10.00
Community high schools	15	13	86.67	1	6.67	1	6.67
Third class city and rural high schools	33	13	39.39	18	54.54	2	6.06
Total	99	72	72.72	19	19.09	8	8.08

* In this case a junior college exists so the 6-4-4 plan is used and a general course in the physical sciences is offered in the twelfth year and physics in the thirteenth year.

Looking at the schools as a group it is found that 72 or 72.72 per cent of the schools reporting offer physics every year, 19 or 19.09 per cent of the schools offer the course on alternate years and only eight or 8.08 per cent do not offer the course. This is sufficient evidence to verify the statement that physics is an important elective course in our high school curriculum.

It is shown in Table 3 that only two or 20 per cent of the physics teachers in the high schools of first class cities consider physics a necessary prerequisite for chemistry and eight or 80 per cent do not. Of the physics teachers of the high schools in second class cities, five or 13.89 per cent consider physics a necessary prerequisite for chemistry, while 31 or 86.11 per cent do not. Of the physics teachers of the community high schools, one or 7.14 per cent consider physics a necessary prerequisite and 13 or 92.86 per cent do not. In the case of third class city and rural high schools, seven or 22.58 per cent of the physics teachers consider physics a necessary prerequisite for chemistry, while 24 or 77.42 per cent do not.

Table 3. The extent physics is considered a necessary prerequisite to chemistry.

Class of schools	Number of schools offering physics	Consider physics a necessary prerequisite for chemistry		Do not consider physics a necessary prerequisite for chemistry	
		Number	Per cent	Number	Per cent
High schools in first class cities	10	2	20.00	8	80.00
High schools in second class cities	36	5	13.89	31	86.11
Community high schools	14	1	7.14	13	92.86
Third class city and rural high schools	31	7	22.58	24	77.42
Total	91	15	16.48	76	83.52

Of all the physics teachers of the state reporting, it is found 15 or 16.48 per cent consider physics as a necessary prerequisite for chemistry, while 76 or 83.52 per cent do not.

Consulting Table 4, it is found that of the high schools in first class cities, five or 50 per cent require two years of mathematics and two or 20 per cent require one year of mathematics as a prerequisite to physics, while three or 30 per cent set up no mathematical requirement. Of the high schools in second class cities, it is found that 13 or 36.11 per cent require two years of mathematics and nine or 25 per cent require one year of mathematics as a necessary prerequisite, while 14 or 38.89 per cent set up no mathematic prerequisite. Of the community high schools five or 35.71 per cent set up two years of mathematics and six or 42.86 per cent set up one year of mathematics as a prerequisite to physics, while three or 21.43 per cent set up no mathematical prerequisite. Of the third class city and rural high schools one or 3.23 per cent require three years of mathematics as a prerequisite to physics, which can without a doubt be accounted for by the fact that it is a very small school with a narrow curriculum and a small faculty. It is found that three or 9.68 per cent require two years and 11 or 35.48 per cent require one year of mathematics as a prerequisite to physics, while 16 or 51.61 per cent do not set up a mathematical prerequisite.

Table 4. Mathematics as a required prerequisite to physics.

Class of schools	Number of schools offering physics	Require three years of mathematics		Require two years of mathematics		Require one year of mathematics		Require no mathematics	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
High schools in first class cities	10	--	--	5	50.00	2	20.00	3	30.00
High schools in second class cities	36	--	--	13	36.11	9	25.00	14	38.89
Community high schools	14	--	--	5	35.71	6	42.86	3	21.43
Third class city and rural high schools	31	1	3.23	3	9.68	11	35.48	16	51.61
Total	91	1	1.10	26	28.57	28	30.76	36	39.56

In viewing the high schools of the state as a group, it is found one or 1.10 per cent require three years, 26 or 28.57 per cent require two years and 28 or 30.76 per cent require one year of mathematics as a prerequisite to physics, while 36 or 39.56 per cent do not set up a mathematical prerequisite.

As the figures shown in Table 4 will verify, some high school mathematics is desirable before taking a course in physics. The amount to take is a question; however, it is the general opinion of physics teachers that at least one year of mathematics should be required.

Table 5 gives definite information as to the place of physics in the curriculum of the different classes of high schools in Kansas. Consulting Table 5, it is found that 78 or 85.71 per cent of the high schools offering physics place it as a free elective. Of the high schools in the first class cities nine or 90 per cent place it as a free elective; 32 or 88.88 per cent of the high schools in second class cities place it as a free elective; 12 or 85.71 per cent of the community high schools place it as a free elective and 25 or 80.65 per cent of the third class city and rural high schools place it as a free elective.

It is a required subject in the college preparatory curriculum by three or 30 per cent of the high schools reporting in first class cities, by ten or 27.78 per cent of the high schools in the second class cities, by four or 28.57 per cent of the community high schools and by five or 16.13 per cent of the third class city and rural high schools. Of the 91 schools offering physics it is found 22 or 24.18 per cent require physics in the college preparatory course. Physics is required in the normal training curriculum by two or 5.55 per cent of the high schools in second class cities and by three or 16.06 per cent of the third class city and rural high schools. This makes a total of five or 5.49 per cent of the high schools that reported offering physics requiring the course in the normal training curriculum. No doubt the reason for this percentage being so low is because normal training is not offered in many high schools and when it is, a choice of either biology or physics is permissible. Physics is a required course in a science major, by one or 10 per cent of the high schools in first class cities, by four or 11.11 per cent of the high schools in second class cities, and by one or 3.23 per cent of the third class city and rural high schools, while it is not required in any of the community high schools. Of all the schools six or 6.59 per cent require physics in a science major.

It is found that in only one school is physics required of all students and that is in a small third class city high school. This school has a very limited curriculum and a small staff of teachers, which is no doubt the cause for the requirement. There is one community high school and one rural high school requiring physics of all boys.

It is found that physics or biology is required in one or 7.14 per cent of the community high schools and four or 12.9 per cent of the third class city and rural high schools. Either physics or chemistry is required in two or 5.55 per cent of the high schools of second class cities, one or 7.14 per cent of the community high schools and one or

3.23 per cent of the third class city and rural high schools. The reason for this choice is that the students may follow their interest and all of them will at least receive some information concerning the sciences.

Table 5. The position of physics in the curriculum.

Class of schools	Number of schools offering physics	Number offering physics as a free elective		Number of schools requiring physics for: College preparatory		Normal training		Science major		Required of: All students		All boys		Require physics or: Biology		Chemistry		Basis of selection where practiced: General intelligence tests		Interest and ability		No basis given	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
High schools in first class cities	10	9	90.00	3	30.00	--	--	1	10.00	--	--	--	--	--	--	--	--	1	10.00	--	--	--	--
High schools in second class cities	36	32	88.88	10	27.78	2	5.55	4	11.11	--	--	--	--	--	--	2	5.55	--	--	1	2.78	1	2.78
Community high schools	14	12	85.71	4	28.57	--	--	--	--	--	--	1	7.14	1	7.14	1	7.14	--	--	--	--	--	--
Third class city and rural high schools	31	25	80.65	5	16.13	3	9.68	1	3.23	1	3.23	1	3.23	4	12.90	1	3.23	--	--	1	3.23	5	16.13
Total	91	78	85.71	22	24.18	5	5.49	6	6.59	1	1.10	2	2.20	5	5.49	4	4.40	1	1.10	2	2.20	6	6.59

Where selection is practiced in determining who may take physics it is found that general intelligence tests are used in one or 10 per cent of the high schools in first class cities; and that interest and ability is the basis of selection in one or 2.78 per cent of the high schools of second class cities and one or 3.23 per cent of the third class city and rural high schools.

Consulting Table 6, it will be seen that there are 952 students enrolled in physics in the high schools reporting from first class cities; 250 being the greatest number enrolled in any one school; 33

being the smallest number enrolled in any one school. In the high schools of second class cities, there are 1025 students enrolled in physics, the largest number in any school being 120 and the smallest being eight. There are 320 students enrolled in physics in the community high schools, the number in any school varying from eight to 50 students. There are 314 students enrolled in physics in the third class city and rural high schools; at this time, this is not a fair figure as a great many of these schools, as has been shown, offer the course only on alternate years. In the schools of this classification the enrollment varies from seven to 38 students in any school.

Table 6. The physics enrollments.

Class of schools	Number enrolled	Largest single enrollment	Smallest single enrollment
High schools in first class cities	952	250	33
High schools in second class cities	1025	120	8
Community high schools	320	50	8
Third class city and rural high schools	314	38	7

It is interesting to note that in only two cases are there more than one physics teacher in a school. These cases occur in the high schools of first class cities where the enrollments are large. In each of these cases there are two teachers and their time is divided between physics and chemistry.

Observing Table 7, it is obvious that the time allotted per week for recitation and laboratory work in physics is uniform throughout the high schools of the state without exception as to class of school. The time allotted is three hours per week for recitation and two hours for laboratory. This prorating of time is found to be in accordance with the suggestions set up by the state departments of Kansas and the surrounding selected states used for comparison.

It is found that the state approved textbook and accompanying workbook and laboratory manual are used in each case. In all schools certain required experiments must be worked by the students. This latter condition is necessary because of the lack of time on the part of the teacher and the lack of equipment in the laboratory. This idea runs counter to the opinions expressed by writers of the history of the development of the laboratory.

Table 7. The time allotted per week for recitation and laboratory work.

Class of schools	Time per week used for recitation Hours	Time per week used for laboratory Hours
High schools in first class cities	3	2
High schools in second class cities	3	2
Community high schools	3	2
Third class city and rural high schools	3	2

Observing Table 8, it will be seen that standardized tests are used in seven or 70 per cent of the high schools in first class cities, in six or 42.86 per cent of the community high schools, in 14 or 38.89 per cent of the high schools in second class cities and in 15 or 48.39 per cent of the third class city and rural high schools.

Two of the high schools of the first class cities and one high school of the second class cities use other standardized tests. In these cases, either the Iowa tests or other standardized tests are used. It will be seen that 39 of the 42 high schools using standardized tests in teaching physics use Henderson's tests. This can be readily accounted for because of the ease of securing Henderson's tests, and because of the economy as his tests can be secured for little or nothing.

Table 8. The extent that standardized tests, Emporia tests and general intelligence tests are used.

Class of schools	Number of schools offering physics	Standardized tests				Use Henderson tests		Use other tests		Emporia state tests				General intelligence tests			
		Used by		Not used by						Used by		Not used by		Used by		Not used by	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
High schools in first class cities	10	7	70.00	3	30.00	5	50.00	2	20.00	6	60.00	4	40.00	3	30.00	7	70.00
High schools in second class cities	36	14	38.89	22	61.11	13	36.11	1	2.78	12	33.33	24	33.33	12	33.33	24	66.67
Community high schools	14	6	42.86	8	57.14	6	42.86	--	--	10	71.43	4	28.57	4	28.57	10	71.43
Third class city and rural high schools	31	15	48.39	16	51.61	15	48.39	--	--	19	61.29	12	38.71	5	16.13	26	83.87
Total	91	42	46.15	49	53.85	39	42.86	3	3.30	47	51.65	44	48.35	24	26.37	67	73.63

Naturally during the last few years of reduced budgets the economy feature has been a determining factor. The fact that the tests cover the material in the textbook and workbook and laboratory manual is a great advantage.

The Emporia state tests are used by six or 60 per cent of the high schools of first class cities, by 12 or 33.33 per cent of the high schools of the second class cities, by ten or 71.43 per cent of the community high schools and by 19 or 61.29 per cent of the third class city and rural high schools. Of all the schools reporting offering physics 47 or 51.65 per cent use the Emporia state tests. One advantage of the Emporia tests fully appreciated by the teachers is that they furnish a definite basis for comparison with other schools as well as give the physics teachers an opportunity to check on themselves, as to their efficiency in teaching the subjects.

General intelligence tests are made use of by three or 30 per cent of the high schools in first class cities, by 12 or 33.33 per cent of the high schools in second class cities, by four or 28.57 per cent of the community high schools and by five or 16.13 per cent of the third class city and rural high schools. This makes a total of 24 or 26.37 per cent of the high schools reporting. The reasons that the use of general intelligence tests is so limited are numerous, but the main ones are: lack of funds with which to obtain them and the lack of time and the ability on the part of the teachers, especially in the smaller schools, to administer and grade the tests and interpret the scores.

Table 9 shows that the vocational possibilities are exploited in five or 50 per cent of the high schools in first class cities, in 26 or 72.22 per cent of the high schools in second class cities, in 11 or 78.57 per cent of the community high schools and in 23 or 74.19 per cent of the third class city and rural high schools. Of all the high schools reporting, 65 or 71.43 per cent exploit the vocational possibilities of the course.

It will be observed that only 50 per cent of the high schools in the first class cities exploit the vocational possibilities of the course. This percentage is much lower than that of any other class of schools, as well as the percentage of all the schools reporting. This, no doubt, indicates a weakness in the objectives and instructional outcomes in the high schools of the first class cities. Certainly cities of this size should afford much greater opportunities for pointing out the vocational possibilities and applications of the course, as they have a greater variety and larger institutions than the smaller cities.

Table 9. The extent to which the vocational possibilities existing in the teaching of physics are exploited.

Class of schools	Number of schools offering physics	Number of schools exploiting vocational possibilities		Number of schools not exploiting vocational possibilities	
	No.	No.	Per cent	No.	Per cent
High schools in first class cities	10	5	50.00	5	50.00
High schools in second class cities	36	26	72.22	10	27.78
Community high schools	14	11	78.57	3	21.43
Third class city and rural high schools	31	23	74.19	8	25.81
Total	91	65	71.43	26	28.57

Table 10 shows the time as it is apportioned in weeks to the various phases of physics, as the course is divided into sections by Henderson, the author of the state approved text, by the different classes of high schools in the state. Fundamentals are given from two to three weeks by all classes of schools. The section on mechanics of fluids is given from five to six weeks by the high schools in first class cities, while in all the other classes of high schools it is given from four to five weeks, which is only a slight variation. The time given to mechanics of solids shows greater variation, receiving from two to three weeks in the high schools of first class cities, while five or six weeks are given in the high schools of the second class cities. The community high schools allot from four to five weeks to mechanics of solids, while the third class city and rural high schools use three to four weeks.

The time allotted to the studying of heat shows the same variation and practically the same amount of time allotted in each case as was given to the mechanics of solids, the exception being that the third class city and rural high schools give heat from five to six weeks, where they gave mechanics of solids from three to four weeks.

Table 10. The time allottment in weeks to the divisions of physics.

Divisions of physics	High schools in first class cities	High schools in second class cities	Community high schools	Third class city and rural high schools
Fundamentals	2	2	2 - 3	2 - 3
Mechanics of fluids	5 - 6	4 - 5	4 - 5	4 - 5
Mechanics of solids	2 - 3	5 - 6	4 - 5	3 - 4
Heat	2 - 4	5 - 6	4 - 5	5 - 6
Electricity				
Magnetism	1	1 - 2	2	1 - 2
Static electricity	1 - 2	1 - 2	2 - 3	2 - 3
Current electricity	3 - 4	1 - 2	2 - 3	4 - 5
Magnetic and heating effects of current	2 - 3	2 - 3	3 - 4	2 - 3
Electromagnetic induction and alternating current	3 - 4	3 - 4	2 - 3	2 - 3
Sound	2 - 3	3 - 4	4 - 5	3 - 4
Light	3 - 4	4 - 5	5 - 6	3 - 4

Henderson divides electricity into magnetism, static electricity, current electricity, magnetic and heating effects of a current, and electromagnetic induction and alternating current. Table 10 shows the time given to each of these phases of electricity. Magnetism is given from one to two weeks by all classes of high schools. Static electricity is given from one to two weeks by the high schools in first and second class cities, while it is given from two to three weeks by third class city, community and rural high schools. Considerable variation is shown in the time given to current electricity where it is given from one to two weeks in the high schools in second class cities, two to three weeks in community high schools, three to four weeks in the high schools in first class cities and from four to five weeks in the third class city and rural high schools. The phase covering magnetic and heating effects of a current is given from two to three weeks in first, second, and third class city and rural high schools, while the community high schools give it from three to four weeks. The area of electromagnetic induction and alternating current is given from three to four weeks in the high schools in first and second class cities, while it receives from two to three weeks in third class city, community and rural high schools.

The high schools of first class cities allot from two to three weeks to sound. Second and third class cities and rural high schools give from three to four weeks to sound, while the community high schools give it from four to five weeks. The first and third class city and rural high schools give from three to four weeks to the study of light, while it is given from four to five weeks in the high schools in second class cities. The community high schools allot from five to six weeks to the study of light.

There are several reasons that make it impossible to set a definite amount of time for the study of each phase of physics. The amount of equipment and apparatus in the different schools varies not only in the different phases, but in many small schools the apparatus in all areas is shamefully limited and much of that available is self-improvised and very frequently inaccurate, and accordingly influences the time that can be profitably used. The interests and past experiences of the students also have a great effect on the time needed to cover the various phases. The industries of the locality also influence the time that can profitably be used for the study of the various phases of physics.

Tables 11, 12, 13 and 14 are concerned with the instructional devices used in the teaching of physics in the high schools in first class cities, high schools in second class cities, community high schools and third class city and rural high schools respectively. The tables are so designed as to show the first, second and third choices of teaching methods for each of the phases of physics. The methods are arranged in each table in the order of their frequency of use.

From Table 11 it is observed that demonstration is made the first choice 31 times in the various phases of physics and second choice seven times and that it is also used in every phase of physics as reported from first class cities. Laboratory is second in rank as a teaching aid, being first choice in eight cases, second choice in 24 cases and third choice in seven cases. This method is also used in all phases of physics. Drill and lecture rank third and fourth respectively, each being the first choice eight times, drill second choice three times and lecture second choice five times, while drill is third choice nine times

Table 11. Teaching devices in the high schools of first class cities.

	Divisions of physics																							
	Fundamental concepts			Mechanics of fluids			Mechanics of solids			Heat			Electricity and magnetism			Sound			Light			Total		
Choice	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Teaching devices																								
Demonstration	-	1	-	6	2	-	5	-	-	5	1	-	6	1	-	5	-	-	4	2	-	31	7	-
Laboratory	1	1	1	1	5	-	1	4	1	1	5	-	-	5	2	1	2	1	3	2	2	8	24	7
Drill	2	2	2	1	-	1	1	1	-	1	-	1	1	-	3	1	-	1	1	-	1	8	3	9
Lecture	4	-	-	-	-	-	2	-	-	-	1	1	1	1	-	1	2	-	-	1	1	8	5	2
Recitation	2	1	-	1	-	2	-	1	1	1	-	-	1	-	2	-	-	2	-	-	2	5	2	7
Discussion	-	1	1	-	1	2	-	1	1	-	1	1	-	1	-	-	2	1	-	1	1	-	8	7
Visual	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	1	-	-	-	3	1	1	3	6
Review	-	1	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	5
Tests	-	1	-	-	-	1	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	1	4
Problems	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	1	1	-	-	-	-	2	2
Individual report	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1

and lecture third choice two times. Discussion was not selected as a first choice in a single instance, but was second choice eight times and third choice six times. None of the latter methods is widely used but one of the three choices in some phases of physics by an occasional teacher of physics. It is found that review is the third choice by three teachers in the mastery of fundamentals and that is the greatest extent to which any of the latter methods are used.

In studying Table 12, it will again be found that demonstration is the most popular and widely used method of instruction by the teachers of physics in the high schools in second class cities. It is the first choice 53 times, second choice 50 times and third choice 34 times. Laboratory again ranks second in use as a teaching aid being first choice 38 times, second choice 63 times and third choice 37 times in the various phases of physics. Lecture ranks next in usage being first choice 38 times, second choice 15 times and third choice 14 times. Recitation ranks fourth in usage, being first choice 25 times, second choice 19 times and third choice 11 times. Discussion is the next most used method, being first choice 24 times, second choice 14 times and third choice 46 times. Drill ranks sixth in usage being first choice ten times, second choice eight times and third choice ten times. Visual aids are next in rank of the teaching device, being first choice five times, second choice 13 times and third choice six times. The remaining teaching methods rank in usage as listed in the table and show only occasional choices on the part of the physics teachers in the various

Table 12. Teaching devices in the high schools of second class cities.

	Divisions of physics																							
	Fundamental concepts			Mechanics of fluids			Mechanics of solids			Heat			Electricity and magnetism			Sound			Light			Total		
Choice	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Teaching devices																								
Demonstration	3	8	2	8	8	4	6	8	7	6	7	4	11	2	8	8	8	7	11	9	2	53	50	34
Laboratory	2	6	8	6	9	6	5	14	3	11	7	6	5	9	5	6	10	3	3	8	6	38	63	37
Lecture	8	-	2	5	3	2	5	-	4	5	3	4	5	5	2	6	4	-	4	4	-	38	15	14
Recitation	4	4	-	4	1	2	5	3	2	4	3	1	3	2	1	2	3	3	3	3	2	25	19	11
Discussion	1	2	3	4	1	4	6	1	6	4	5	8	4	1	8	1	2	8	4	2	9	24	14	46
Drill	6	3	5	1	1	3	1	2	1	1	1	-	-	-	-	-	1	1	1	-	-	10	8	10
Visual	1	2	1	-	-	-	-	-	-	-	2	1	-	3	1	1	2	1	3	2	2	5	13	6
Review	2	2	5	-	-	2	-	-	2	-	-	3	-	-	2	-	-	2	-	-	2	2	2	16
Tests	-	2	2	-	2	2	2	1	-	1	-	1	-	-	2	-	-	1	1	-	1	3	5	9
Individual reports	-	-	-	-	-	1	-	-	1	-	-	1	-	-	1	-	-	-	-	-	1	-	-	5
Problems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

phases of physics. It will be observed that not in a single instance was the problem a first, second or third choice of the teaching methods for any phase of physics.

Table 13 shows the same type of information as Tables 11 and 12 for the community high schools. Again demonstration and laboratory are the most used methods of teaching the various phases of physics. Demonstration is first choice 36 times, second choice 15 times and third choice one time. Laboratory is first choice ten times, second choice 28 times and third choice eight times. Lecture is first choice 18 times, second choice six times and third choice one time. Lecture is followed by discussion in rank of usage as a teaching aid, being first choice eight times, second choice eight times and third choice 13 times. Recitation ranks fifth in usage as a method of teaching, being first choice four times, second choice four times and third choice 15 times. There is very little difference in the amount that recitation is used with that of the use of visual aids. Visual aids are first choice three times, second choice four times and third choice 13 times. The other methods are only occasionally one of the first three choices of teaching aids, as shown by the table. Again, it is found that never in a single instance was the problem among the first three choices.

Table 13. Teaching devices in the community high schools.

	Divisions of physics																							
	Fundamental concepts			Mechanics of fluids			Mechanics of solids			Heat			Electricity and magnetism			Sound			Light			Total		
Choice	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Teaching devices																								
Demonstration	-	2	-	7	3	-	5	2	-	4	1	1	5	3	-	7	2	-	8	2	-	36	15	1
Laboratory	1	1	1	1	5	2	3	6	2	3	2	1	2	5	1	-	4	-	-	5	1	10	28	8
Lecture	4	1	-	3	1	-	1	1	-	4	1	-	3	-	1	2	1	-	1	1	-	18	6	1
Discussion	2	1	3	1	2	1	1	1	1	1	1	2	1	1	1	1	1	3	1	1	2	8	8	13
Recitation	1	1	1	-	-	3	1	-	4	-	2	2	-	-	2	1	1	2	1	-	1	4	4	15
Visual	1	2	-	-	-	3	-	-	3	-	-	1	1	-	1	-	-	2	1	2	3	3	4	13
Tests	-	1	3	-	1	2	-	1	1	-	3	2	-	-	2	-	1	2	-	-	2	-	7	14
Review	-	1	1	-	-	1	-	-	1	-	-	1	-	-	1	-	1	-	-	2	-	-	3	5
Drill	1	1	1	1	-	-	1	1	-	-	1	1	-	-	1	-	-	-	-	-	-	3	3	2
Individual report	-	1	1	-	-	-	-	-	-	-	-	1	-	1	1	-	-	1	-	1	-	-	3	4
Problems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 14 shows the first, second and third choices of the teaching devices by the physics teachers in the third class city and rural high schools in the various phases of physics. Demonstration ranks first in usage, being first choice 58 times, second choice 28 times and third choice 29 times. Laboratory is next in rank being first choice 17 times, second choice 57 times and third choice 27 times. Recitation is third in rank as a method of teaching, being first choice 30 times, second choice 20 times and third choice 28 times. Lecture is next in rank of usage, being first choice 34 times, second choice 25 times and third choice nine times. Discussion, drill, and visual aids rank fifth, sixth and seventh in respect to usage. Discussion is first choice nine times, second choice 17 times and third choice 24 times. Drill is first choice two times, second choice nine times and third choice six times. Visual aids are first choice one time, second choice four times and third choice ten times. The other methods of teaching are chosen as one of the first three choices only occasionally, and again it is found that in a single instance was the problem among the first three choices.

Table 14. Teaching devices in third class city and rural high schools.

	Divisions of physics																							
	Fundamental concepts			Mechanics of fluids			Mechanics of solids			Heat			Electricity and magnetism			Sound			Light			Total		
Choice	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Teaching devices																								
Demonstration	1	8	1	12	3	5	11	2	4	10	2	4	11	5	3	7	4	6	6	4	6	58	28	29
Laboratory	1	-	3	3	11	1	6	9	3	1	12	5	2	10	4	2	8	6	2	7	5	17	57	27
Recitation	4	-	4	4	2	4	2	6	3	7	2	5	5	1	6	5	4	3	3	5	3	30	20	28
Lecture	13	1	1	1	3	2	3	2	2	3	2	2	4	4	-	5	2	2	5	11	-	34	25	9
Discussion	1	5	2	1	2	5	-	2	4	2	2	5	-	1	5	3	2	1	2	3	2	9	17	24
Drill	2	6	2	-	-	2	-	-	1	-	1	1	-	1	-	-	1	-	-	-	-	2	9	6
Visual	-	-	1	-	1	-	-	1	-	-	-	2	-	-	2	-	-	5	1	-	2	1	4	10
Tests	-	-	4	-	-	2	-	1	4	-	-	-	-	-	-	-	1	-	-	1	-	-	3	10
Review	-	2	3	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	2	5
Individual report	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Problems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

By observing the last four tables discussed, it will be found that demonstration and laboratory rank first and second in all tables as methods of teaching physics. This is no doubt, due to the fact that it is easier to bring about a more thorough understanding of the principles of physics if the student sees the principle in actual operation and has an opportunity to try the principles. No doubt laboratory would be more widely used if sufficient apparatus and time were available so that the student could be given more freedom in the laboratory and the use of guide sheets and laboratory manuals could be used to much smaller extent, if not entirely eliminated.

It is found that drill, lecture, recitation and discussion are the next four ranking methods of teaching in all classes of schools, although not always in this order. This order of choices can be accounted for, because by these methods the principles illustrated by the demonstration and laboratory work can be further explained and clarified for and by the students. These methods are commonly used in leading up to the demonstration and laboratory work.

Visual aids rank seventh in all classes of schools. By this method the general application of the principles in every day life can be shown, especially where it is impossible to do this by means of inspection trips.

The remaining methods of teaching are only occasionally used in any of the classes of schools and it is particularly interesting to note that the problem was chosen by only the teachers of the high schools in first class cities, and then in only a few instances.

Tables 15, 16, 17 and 18 are concerned with the various types of visual aids as chosen by the physics teachers in the high schools of first class cities, high schools of second class cities, community high schools and third class city and rural high schools respectively. The visual devices are ranked in each table according to frequency of use. Physics is divided into the same phases as in the preceding four tables. The first, second and third choices are given for each phase of physics and each class of high school. It will be observed that demonstration, diagrams, movies and blackboards are the four high ranking devices in each class of high schools, while charts, slides, film strips and graphs are chosen only occasionally. Accordingly, the first four devices will receive discussion as they are ranked in each table, while the latter or the occasionally chosen four will not be discussed separately for each table.

In Table 15 it is shown the first, second and third choices by the teachers of physics in high schools of first class cities that demonstration apparatus is most widely used, being the first choice 34 times, second choice ten times and third choice four times. Diagrams rank next, being first choice five times, second choice 13 times and third choice 11 times. Movies and blackboard rank third and fourth in usage; movies being first choice seven times, second choice seven times and third choice six times, while blackboards are first choice two times, second choice 11 times and third choice ten times.

Table 15. Visual aids in the teaching of physics in high schools in first class cities.

Divisions of physics	Choice	Visual aids: Demonstration apparatus	Diagrams	Movies	Blackboard	Slides	Charts	Graphs	Film strip
Fundamental concepts	1st.	3	1	1	2	1	-	-	-
	2nd.	1	1	-	1	1	-	3	-
	3rd.	-	3	-	1	-	3	1	-
Mechanics of fluids	1st.	5	1	-	-	1	-	-	1
	2nd.	1	2	-	3	-	-	1	-
	3rd.	1	2	1	-	-	2	-	-
Mechanics of solids	1st.	4	2	1	-	1	-	-	-
	2nd.	3	-	-	3	-	-	1	-
	3rd.	1	3	-	1	-	1	1	1
Heat	1st.	6	1	-	-	1	1	-	-
	2nd.	-	3	2	2	1	-	2	-
	3rd.	1	2	-	1	-	1	1	-
Electricity and magnetism	1st.	5	-	2	-	2	-	-	-
	2nd.	2	3	-	-	1	1	-	-
	3rd.	-	-	2	2	-	2	1	-
Sound	1st.	6	-	1	-	2	-	-	-
	2nd.	1	1	4	1	-	-	-	-
	3rd.	-	1	1	4	-	-	-	-
Light	1st.	5	-	2	-	1	-	-	-
	2nd.	2	3	1	1	-	-	1	-
	3rd.	1	-	2	2	-	-	1	-
Total	1st.	34	5	7	2	9	1	-	1
	2nd.	10	13	7	11	2	1	8	-
	3rd.	4	11	6	10	-	10	5	-

Table 16 furnishes similar information concerning the high schools in second class cities. Demonstration again is the most widely chosen by the teacher being the first choice 97 times, second choice 44 times and third choice 37 times. Movies rank second in choice, being the first choice 71 times, second choice 21 times and third choice 28 times.

Blackboards and diagrams rank third and fourth respectively with blackboards being chosen first ten times, second 61 times and third 45 times while diagrams were first choice ten times, second choice 25 times and

Table 16. Visual aids in the teaching of physics in high schools in second class cities.

		Visual aids							
Divisions of physics	Choice	Demonstration apparatus	Movies	Blackboard	Diagrams	Charts	Film strip	Slides	Graphs
Fundamental concepts	1st.	9	10	4	2	4	-	-	-
	2nd.	7	1	8	2	6	2	1	2
	3rd.	6	3	7	5	3	3	2	-
Mechanics of fluids	1st.	17	10	2	-	1	-	2	-
	2nd.	3	4	11	6	3	3	-	-
	3rd.	9	3	5	3	5	1	2	-
Mechanics of solids	1st.	15	11	2	1	-	-	-	-
	2nd.	4	1	12	3	3	4	-	1
	3rd.	8	4	5	4	5	1	1	-
Heat	1st.	14	10	2	-	1	2	1	-
	2nd.	5	2	10	4	3	2	1	1
	3rd.	4	5	5	3	4	-	2	2
Electricity and magnetism	1st.	16	10	-	1	5	1	1	-
	2nd.	9	6	5	2	-	3	-	-
	3rd.	3	5	9	8	3	1	1	-
Sound	1st.	14	11	-	2	2	2	1	1
	2nd.	7	4	7	4	-	4	1	1
	3rd.	5	3	8	4	3	2	-	-
Light	1st.	12	9	-	4	4	2	2	-
	2nd.	9	3	8	4	1	2	1	1
	3rd.	2	5	6	4	7	1	-	-
Total	1st.	97	71	10	10	17	7	7	-
	2nd.	44	21	61	25	16	20	4	6
	3rd.	37	28	45	31	30	9	8	3

Table 17 shows the first, second and third choices of visual aids

Table 17. Visual aids in the teaching of physics in community high schools.

Divisions of physics	Choice	Visual aids: Demonstration apparatus	Movies	Blackboard	Diagrams	Slides	Graphs	Charts	Film strip
Fundamental concepts	1st.	1	3	2	2	-	1	1	-
	2nd.	4	-	3	3	-	-	-	-
	3rd.	3	-	2	1	-	1	-	-
Mechanics of fluids	1st.	4	5	1	-	2	-	1	-
	2nd.	2	1	4	2	1	-	-	-
	3rd.	2	-	3	1	-	-	1	-
Mechanics of solids	1st.	5	6	-	-	-	-	-	-
	2nd.	-	1	6	1	2	1	-	-
	3rd.	3	-	3	-	2	-	1	-
Heat	1st.	3	5	1	-	1	-	1	-
	2nd.	1	-	3	1	2	3	1	-
	3rd.	2	1	2	2	-	-	2	-
Electricity and magnetism	1st.	3	6	-	-	-	-	1	-
	2nd.	1	2	3	-	1	1	1	1
	3rd.	2	-	1	2	-	2	-	2
Sound	1st.	4	5	1	-	-	1	-	-
	2nd.	2	1	2	3	1	1	1	-
	3rd.	2	-	4	-	1	1	-	1
Light	1st.	2	6	1	1	1	-	-	-
	2nd.	4	-	2	2	2	1	-	-
	3rd.	3	-	3	2	-	-	-	1
Total	1st.	22	36	7	3	4	2	4	-
	2nd.	14	3	23	12	9	7	3	1
	3rd.	17	1	18	8	3	4	4	4

ranking second is movies, being first choice 36 times, second choice three times and third choice one time. Blackboards and diagrams rank third and fourth respectively. Blackboards being the first choice seven times, second choice 22 times and third choice 18 times while diagrams were first choice three times, second choice 12 times and third choice eight times.

Table 18 again shows demonstration to be the most widely chosen visual aid, being first choice 54 times, second choice 49 times and third choice 21 times. Movies are next in rank of choice, being first choice 42 times, second choice 14 times and third choice 19 times. Blackboards and diagrams rank third and fourth in choice; blackboards being first choice 13 times, second choice 17 times and third choice 38 times while diagrams were first choice 13 times, second choice 21 times and third choice 20 times.

It is interesting to note that demonstration apparatus was the most widely chosen teaching aid in visualizing the principles of physics, which indicates that seeing the principle in actual operation in a simple way is the most satisfactory method of teaching it.

Movies rank second in choice as a visual aid and this is no doubt due to the fact that through the movies the students visualize processes and operations more definitely than by any other device.

Diagrams and blackboards no doubt represent an economy and convenience measures. Charts, slides, graphs and film strips cost considerable; while the instructor is able to make his own diagrams, and can vary them so as to make more effective his instructional areas.

Table 18. Visual aids in the teaching of physics in third class city and rural high schools.

Divisions of physics	Choice	Visual aids: Demonstration apparatus	Movies	Blackboard	Diagrams	Charts	Slides	Graphs	Film strip
Fundamental concepts	1st.	3	6	4	2	4	1	1	-
	2nd.	7	1	2	2	4	4	-	-
	3rd.	4	1	9	2	1	2	-	-
Mechanics of fluids	1st.	9	7	1	2	2	-	-	-
	2nd.	5	1	4	3	-	5	1	1
	3rd.	5	3	7	1	1	-	1	-
Mechanics of solids	1st.	8	7	-	2	1	-	2	-
	2nd.	8	1	3	1	-	5	-	-
	3rd.	2	4	7	2	1	2	-	-
Heat	1st.	9	3	2	5	2	-	1	-
	2nd.	7	2	2	5	2	2	2	-
	3rd.	1	4	5	3	3	3	-	-
Electricity and magnetism	1st.	8	5	2	2	3	-	-	-
	2nd.	9	3	2	2	-	2	1	-
	3rd.	1	3	4	4	4	-	-	-
Sound	1st.	8	7	1	-	3	-	-	-
	2nd.	7	4	2	5	1	2	1	-
	3rd.	4	1	3	6	3	1	-	1
Light	1st.	9	7	3	-	3	-	-	-
	2nd.	6	2	2	3	-	4	2	1
	3rd.	4	3	3	2	4	1	1	-
Total	1st.	54	42	13	13	18	1	4	-
	2nd.	49	14	17	21	7	24	7	2
	3rd.	21	19	38	20	17	7	2	1

Table 19 gives information concerning the average cost per student per year for apparatus and laboratory supplies in the different classes of high schools. In the high schools of first class cities the minimum spent for apparatus and laboratory supplies is 50 cents per student per year and the maximum is $6.50 per student per year. In the high schools of second class cities the minimum cost for physics supplies is 15 cents per student per year and the maximum is $5.00 per student per year. In the community high schools the cost per student per year varies from $1.00 to $7.00 for equipment and supplies. In the third class city and rural high schools the greatest variation exists as the cost per student per year ranges from 25 cents to $15 for apparatus and supplies.

There are several factors that cause these great variations to exist. Most important, no doubt, is the amount and condition of the equipment on hand and possibly the small number enrolled in some schools is bound to increase the expense per student.

Table 19. Maximum and minimum cost per student per year for apparatus and supplies for teaching physics.

Class of schools	Maximum cost	Minimum cost
High schools in first class cities	$ 6.50	$ .50
High schools in second class cities	$ 5.00	$ .15
Community high schools	$ 7.50	$ 1.00
Third class city and rural high schools	$15.00	$ .25

Table 20 shows to what extent inspection trips are used in showing the practical application of the principles of physics. In the high schools in first class cities nine or 90 per cent of the high schools make use of inspection trips; 23 or 63.89 per cent of the high schools in second class cities make use of inspection trips. Of the community high schools nine or 64.29 per cent make use of inspection trips. Of the third class city and rural high schools 22 or 70.97 per cent use inspection trips. Considering all schools, it is found 63 or 69.23 per cent use inspections.

Table 20. Schools using inspection trips.

Class of schools	Schools reporting	Schools using inspection trips		Schools not using inspection trips	
	No.	No.	Per cent	No.	Per cent
High schools in first class cities	10	9	90.00	1	10.00
High schools in second class cities	36	23	63.89	13	36.11
Community high schools	14	9	64.29	5	35.71
Third class city and rural high schools	31	22	70.97	9	29.03
Total	91	63	69.23	28	30.79

Results of this study indicate that physics as it exists in the high schools of our state satisfies the regulations set up by our state and also the standards of the surrounding and selected states studied. The rating would be higher were it not for the lack of adequate laboratory apparatus and supplies. Table 19 furnishes the evidence to support the preceding statement in that if sufficient material were available for the laboratory, there would not be such a variance in its cost nor would it become so high per student per year.

In general the regulations set up by the various state departments concerning the content and teaching of physics consisted of a list of required experiments that must be worked and also a list of the apparatus that was necessary for carrying on the demonstration and laboratory work. In a few cases some suggestions were made as to the time that should be spent in the study of the various phases of physics.

In only one case, that being Iowa, was anything at all completely worked out as a course of study. In this case an entire pamphlet was devoted to the teaching of physics in the secondary schools. It was based on information obtained from some of the very successful teachers and accordingly contained very useable suggestions. It set the entire course up on the problem-project basis. The course was divided somewhat differently than in our state but this is no doubt due to the use of a different textbook. It not only gave methods and ideas for teaching but went so far as to suggest ways for testing for mastery. Besides this it contained all the essential information found in the regulations set up in the other states. The outstanding features of this course of study were its detail and completeness.

In comparing the status of physics in Kansas with the regulations set up in Iowa, it is evident that Kansas would compare favorably; but with a teacher's guide such as Iowa publishes the teaching of physics in Kansas would be made more effective and made more attractive to the learner.

SUMMARY

Ninety-one and eighty-two hundredths per cent of the high schools of Kansas reporting offer physics in their curriculum.

On the average about one-half of the high schools require some mathematics as a prerequisite to physics. The mathematics requirement is more rigid in the smaller schools which can no doubt be accounted for by the fact that such schools do not offer a wide choice of subjects in their curriculum.

The high school teachers of physics, as a group, do not consider physics as a necessary prerequisite to chemistry.

Physics is in general a free elective where prerequisites have been met, and in other cases selection is based on interest and general intelligence.

The time allotted for laboratory is two hours per week and three hours per week for recitation.

Standardized tests are used in about one-half of the high schools of Kansas with those of the author of the state approved text being used in practically all of the cases.

Approximately 50 per cent of the high schools use general intelligence tests for the purposes of grouping and comparison.

About 50 per cent of the high schools exploit vocational possibilities.

State adapted texts are used in all schools.

The number of weeks allotted for the teaching of the various divisions of physics varies but little in all classes of Kansas high schools.

About 65 per cent of the high schools use inspection trips.

Only in the high schools of the cities of the first class is more than one instructor employed in the physics department.

Variation in cost per year exists because of many new departments and the necessity of re-equipping old ones.

In all classes of schools, demonstration is by far the most widely chosen teaching device with laboratory and lecture next in the first and second class city and community high schools; while in rural and third class city high schools laboratory and recitation are second and third choice.

As for devices chosen for visual education, demonstration apparatus again leads by a large margin in all classes of high schools. Slides and charts are second and third choices in first class city high schools and both are chosen to about the same extent. In the other high schools of the state, movies are a second choice by a wide margin.

CONCLUSIONS

One year of general mathematics of the high school level should be required as a prerequisite for physics.

Standardized tests should be used more extensively and comparisons made so as to check efficiency and progress.

Intelligence tests should be used for selection, grouping and comparison.

Greater use of inspection trips should be encouraged to show illustrations of the practical application of physics and to increase vocational interests.

A greater degree of vocational and professional information touched upon in the course should be included.

The State Department of Education should publish and put in the hands of physics teachers a more complete guide for the teaching of physics. They could well follow, as a model, the one published by the State Department of Education in Iowa.

ACKNOWLEDGMENT

The writer takes this opportunity of thanking the high school administrators and physics teachers for their aid in gathering the information for this study. Without the cooperation of these the study would have been impossible.

Special thanks are given to Dr. C. V. Williams for his untiring efforts and efficient guidance in directing the study of this problem. The writer also feels indebted to the other members of the education department, who have given many helpful suggestions.

Appreciation is also given to the state departments of the surrounding and selected states, that so generously furnished data for this study.

REFERENCES

1. Black, N. Henry and Davis, Harvey N.
Practical physics, rev. ed. New York. Macmillan. 555 p. 1922.

2. Buckley, H.
A short history of physics. New York. D. Van Nostrand. 254 p. 1927.

3. Bossing, Nelson L.
Progressive methods of teaching secondary education. New York. Houghton Mifflin. 693 p. 1935.

4. Cajori, Florian.
A short history of physics. New York. Macmillan. 322 p. 1899.

5. Crawford, Claude C.
The technique of research in education. Los Angeles. The University of Southern California. 320 p. 1928.

6. Crew, Henry.
The rise of modern physics, ed. 2. Baltimore. Williams and Wilkins. 434 p. 1935.

7. Douglass, Harl R.
Modern methods in high school teaching. New York. Houghton Mifflin. 544 p. 1926.

8. Downing, Elliott R.
An introduction of the teaching of science. Chicago. University of Chicago. 240 p. 1935.

9. Einstein, Albert.
The evolution of physics. New York. Simon and Schuster. 319 p. 1938.

10. Freeman, Frank Nugent.
Visual education. Chicago. University of Chicago Press. 391 p. 1924.

11. Henderson, William D.
The new physics in every day life. New York. Lyons and Carnahan. 797 p. 1935.

12. Hoban, Charles Francis.
Visualizing the curriculum. New York. The Cordon Company. 300 p. 1937.

13. Holley, Charles Elmer.
High school teachers' methods. Champaign, Illinois. The Garrard Press. 414 p. 1937.

14. Houston, W. V.
Philosophy of physics. Science News, 85:415-19. Apr. 30, 1937.

15. Hull, Gordon Ferrie.
An elementary survey of modern physics. New York. Macmillan. 457 p. 1936.

16. Jeans, J. H.
New world picture of modern physics. Science News, 80:213-22. Sept. 7, 1934.

17. Kendall, Calvin Noyes and Mirick, George A.
How to teach special subjects. New York. Houghton Mifflin. 310 p. 1918.

18. Lynde, Carelton John.
Physics of the household. New York. Macmillan. 313 p. 1914.

19. McClenny, George L.
Handbook on organization and practices for secondary schools of Kansas. Topeka, Kansas. Kansas State Printing Plant. Oct. 1939.

20. Markham, W. T.
Kansas state educational directory. Topeka, Kansas. Kansas State Printing Plant. 1938.

21. Melne, E. A.
Some points in the philosophy of physics, time, evolution and creation. Smithsonian Institution Annual Report. 219-38 p. 1933.

22. Monroe, Walter S. and Engelhart, M. D.
The scientific study of educational problems. New York. Macmillan. 504 p. 1936.

23. Moore, F. J.
A history of chemistry, ed. 2. New York. McGraw-Hill. 324 p. 1931.

24. Mueller, A. D.
Principles and methods in adult education. New York. Prentice-Hall. 428 p. 1937.

25. Parker, Samuel Chester.
Methods of teaching in high school. Boston. Ginn and Company. 529 p. 1915.

26. Preston, Carelton E.
The high school science teacher and his work. New York. McGraw-Hill. 272 p. 1936.

27. Ruediger, William Carl.
Teaching procedure. New York. Houghton Mifflin. 471 p. 1932.

28. Rusk, R. D.
New frontiers of science. Scribners, 98:210-15. Oct. 1935.

29. Samuelson, Agnes.
Physics, course of study for high schools. State of Iowa. 70 p. 1930.

30. Schluter, W. C.
How to do research. New York. Prentice-Hall. 137 p. 1926.

31. Schmitz, R. Morel.
Preparing the research paper. New York. Richard R. Smith. 94 p. 1931.

32. Science in general education. New York. D. Appleton-Century Company. 591 p. 1937.

33. Waples, Douglas and Tyler, Ralph W.
Research methods and teachers problems. New York. Macmillan. 653 p. 1930.

34. Whitney, Fredrick Lamson.
Methods in educational research. New York. Appleton. 335 p. 1931.

APPENDIX

A Study of Physics as Taught in the High Schools of Kansas

Questionnaire

____________________High School _________________Kansas

1. Is Physics offered in your curriculum every year? __________
If not offered every year, how often? __________
Is the course required or elective? __________
In what year of the curriculum is it placed? __________

2. In what courses of your curriculum is Physics a required subject?
____
____

3. Do you offer a course in Household Physics? __________
If such a course is offered, of what students is it a required subject? __________
____

4. Do you require any High School Mathematics as a prerequisite for Physics? _____ If Mathematics is required, how much? __________
____
If required, what courses? __________
____

5. Do you consider Physics a necessary prerequisite for Chemistry?
____

6. Is the course a free elective for those who wish to take it? _____
If not upon what do you base your selection? __________
____

7. How many do you have enrolled in physics? __________

8. How much time is allotted per week for recitation? __________
How much time is allotted per week for laboratory? __________

9. In weeks, how much time do you spend in the study of the following:

   Fundamental Physical Concepts.................. __________
   Mechanics of Fluids............................ __________
   Mechanics of Solids............................ __________

Heat.......................................______________
Electricity
Magnetism..................................______________
Static Electricity.........................______________
Current Electricity........................______________
Magnetic and Heating Effects of a Current....______________
Electromagnetic Induction and Alternating
Current....................................______________
Sound......................................______________
Light......................................______________

10. Please list what you consider the three leading teaching devices of the following: (1) Lecture (2) Drill (3) Demonstration (4) Review (5) Laboratory (6) Testing (7) Recitation (8) Visual (9) Discussion (10) Individual Reports: in their relative importance in the following divisions of physics:

Fundamental Physical Concepts....I_______ II_______ III_______
Mechanics of Fluids..............I_______ II_______ III_______
Mechanics of Solids..............I_______ II_______ III_______
Heat.............................I_______ II_______ III_______
Electricity and Magnetism........I_______ II_______ III_______
Sound............................I_______ II_______ III_______
Light............................I_______ II_______ III_______
(You may use numbers in denoting selections)

11. From the standpoint of visual education, please list your first, second and third choices of the following: (1) Moving Pictures (2) Slides (3) Charts (4) Graphs (5) Diagrams (6) Demonstration Apparatus (7) Film Strip (8) Blackboard; in teaching the various divisions of Physics:

Fundamental Physical Concepts....I_______ II_______ III_______
Mechanics of Fluids..............I_______ II_______ III_______
Mechanics of Solids..............I_______ II_______ III_______
Heat.............................I_______ II_______ III_______
Electricity and Magnetism........I_______ II_______ III_______
Sound............................I_______ II_______ III_______
Light............................I_______ II_______ III_______
(You may use numbers in denoting selections)

12. Do you make inspection trips?______________________________

13. Do you use standardized achievement tests?____________________

If standardized tests are used, what ones?____________________

How often and when are they given?____________________

14. Do you use the Emporia State tests that are available?__________

15. Do you make use of the scores obtained from general intelligence tests?________ If so how?____________________

16. Do you exploit the vocational possibilities of the course?________
In what ways? 1. ____________________
2. ____________________
3. ____________________

17. Do you use the State approved texts?____________________
If the approved text is used, do you use the accompanying laboratory manual and workbook?____________________
If the approved texts are not used, what texts are used?__________

18. Do you teach other subjects besides Physics?____________________
If so, please list.____________________

19. How many do you have employed in the Physics Department?__________
Are they employed full time in that Department?__________

20. What is the average cost per year per student for demonstration and laboratory equipment and material?____________________

21. Remarks: (Other suggestions and information would be appreciated)