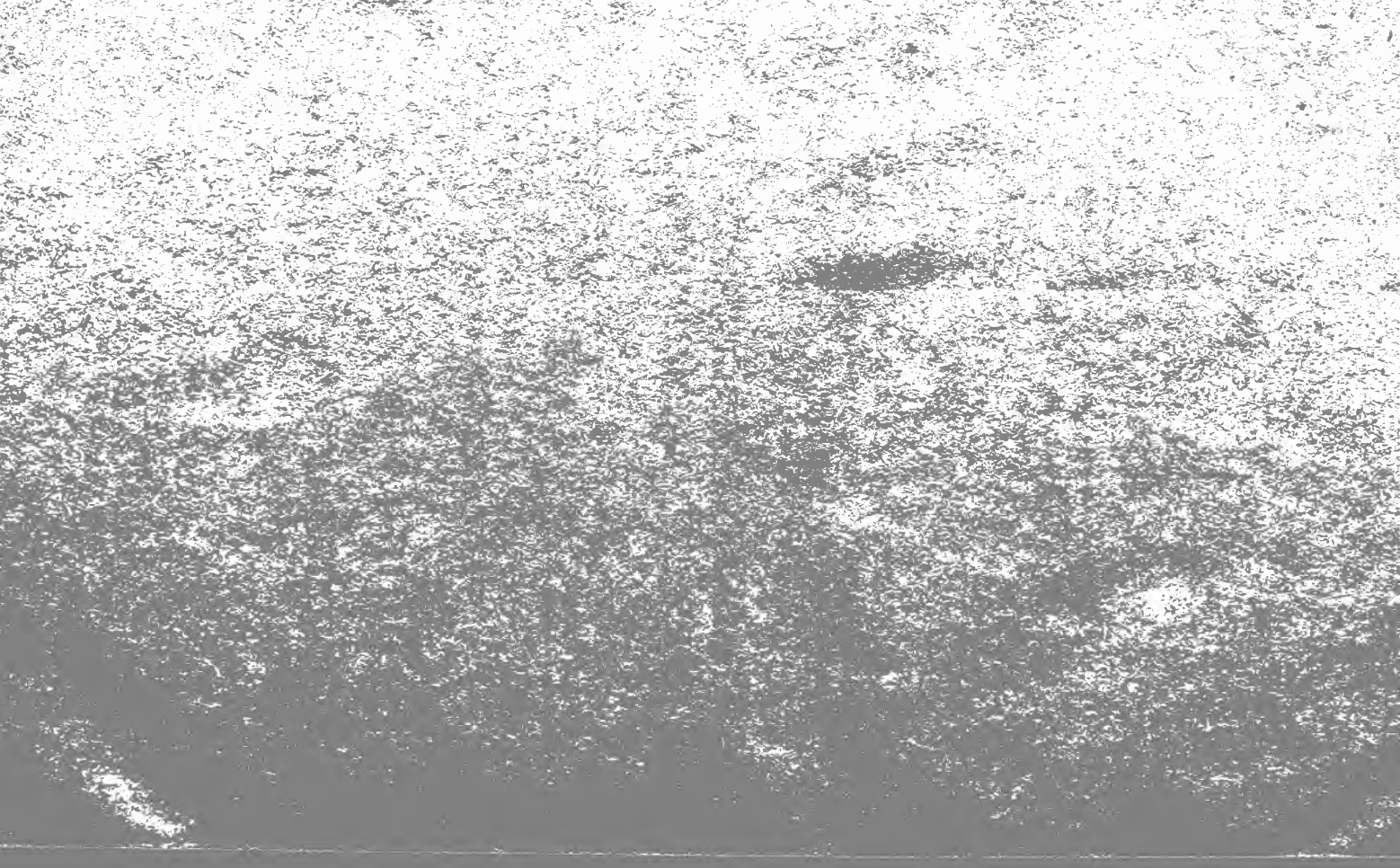

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MENTAL FATIGUE AND SCHOOL EFFICIENCY

An Experimental Study in Winthrop Training School and Other Schools in South Carolina

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PREFATORY NOTE.

In this study we have attempted to stick to facts as we found them whether they fit our preconceived notion of fatigue or not. If these facts as here presented give the reader a clearer view of the working ability of school children, or if they stimulate the teacher to more efficient service, or if they encourage the educator to present criticism or additional data for the improvement of this treatise the effort expended in its preparation will have been repaid.

I wish to thank President D. B. Johnson, of Winthrop College, and the teachers of classes in Winthrop Training School and in the Rock Hill and the Fort Mill schools where the tests were given, for their kind co-operation and assistance in securing data. Special credit is also due to Dr. Paul R. Radosavljevich, of New York University, for his constant aid in this investigation.

L. A. R.

CONTENTS.

INTRODUCTION.

Mental fatigue refers to the incapacity for doing mental work as a result of excessive effort. The subjective feeling of ennui or weariness is no longer accepted as an adequate measurement of fatigue. Frequently it happens that when we feel the least like work we are really quite capable of it. Upon the other hand the feeling of capability for a task is no absolute proof that we are able. Nearly every one has an opinion of fatigue based upon his own subjective feelings, and yet so varied are these opinions and so contradictory to objective facts that little reliance can be placed on them. This was shown by the publication of "Remarks on replies by teachers to questionaire respecting mental fatigue" in 1888 by Sir Francis Galton. This inquiry showed the need of objective measurements for determining mental fatigue. Such measurements may be classified as (1) physical tests, (2) psychophysical tests, and (3) mental tests.

(1) *Physical Tests.*—Many investigators have assumed or have sought to discover a direct relationship between muscular and mental efficiency, and upon this basis have attempted to measure mental fatigue. In this field Mosso (89) may be considered the pioneer. He and Maggiora carried on similar tests on students and lecturers before and after mental efforts. For this purpose Mosso had devised the ergograph for measuring the ability of the finger to persist in the lifting of an attached weight. Neither of these men found positive evidence of excessive fatigue. Extensive experiments have been carried on by German investigators with the ergograph, and some have claimed very positive indications of fatigue in school children. The more recent experiments of Ellis and Shipe, University of Texas (35), and other investigators, fail to indicate any school fatigue with the use of the ergograph. Under the present status of doubt in regard to the co-variation of physical strength and mental efficiency, it is impossible to

89. Mosso, A.—Fatigue. Translated by Drummond.
35. American Journal of Psychology, Vol. 14, 1903, pp. 232-245.

accept the ergograph as a means of measuring mental fatigue until verification of its value is made by further experimentation. The same may be said of the dynamometer, which has been used for a like purpose. That there is a physical basis for psychical activity has been indicated frequently enough, but just what the relation is has not been so easy to determine. Weichardt (25) and Lorenz (77) even claim a knowledge of the kenotoxin which produces fatigue as well as of anti-kenotixin which neutralizes or retards its effects. We can at present only await further developments in this line.

(2) *Psycho-Physical Tests.*—These tests are based on the assumption that mental fatigue always produces loss of nervous tension or tone, resulting in diminished functioning of the nervous end organs, as in reducing the sensitiveness of the skin. In such case the measurement of the sensitiveness of the skin with an instrument like the esthesiometer would furnish a good measure of the mental fatigue. This method has been highly favored by some of the German psychologists, but has been severely condemned by others.

Similar methods are those of pain-producing pressure measured with the algesiometer, and the tapping rate test with a telegraphic key or similar instrument. Wells has perhaps done the most thorough work in the tapping tests (135). Nevertheless, considerable doubt as to the value of this type of tests still remains; and we pass to the consideration of the mental tests.

(3) *Mental Tests.*—The method of the mental tests is more direct than the other methods considered, although it is attended with no fewer difficulties. In attempting to measure fatigue by the comparison of mental tasks done by pupils at different times of day there first appears the difficulty of setting the test. It must be homogeneous and of a difficultness and nature suitable for a test of real efficiency. The difficulty is increased by the fact that every task involves the consideration of both rate and quality of work. But besides these difficulties there are the serious factors of practice and sub-

25. Ped. Sem. (March, 1910), Vol. 17, pp. 29-39.
77. Zeit. f. Schulgesundheitspflege, Vol. 24, 1911, pp. 12-32 and 85-102.
135. Amer. Jour. Psych., Vol. 19, 1908, pp. 345-358 and 435-483.

jective attitude of the pupils, such as determination, interest, indifference, discouragement, ennui, and various stimulations. No surprise need be expressed that investigators arrive at different and sometimes contradictory conclusions. The contribution of each has in its way added to the resources for the solution of the important question of mental fatigue.

The large number of investigations by German psychologists may be briefly summarized as representing an increased rate of work with a corresponding increase of errors for the later periods of the day. In general they have given emphasis to the errors as representing an extreme mental fatigue. This conclusion is emphasized in the lower grades. It must, however, be borne in mind that the class periods in Germany are an hour long even in the elementary grades.

In 1900 Thorndike (121) gave a series of tests at half past nine in the forenoon and at half past three in the afternoon to intermediate and grammar grade classes in the Cleveland and the Scranton schools. His conclusions were that the children are as able to work in the afternoon as in the forenoon. They do not *feel* as able; but they do not lack one jot or tittle of *being* as able in the afternoon. He does not deny overpressure in school as a possibility, but claims that not one-tenth of the nervous breakdowns are due to the *amount* of work. Most of them, he says, are due to "worry, misery and strain of ill-directed effort and stupid lack of mental stimulus and healthy mental life, together with misuse of sense organs." He regards stupid teaching as a chief cause of nervous breakdowns in school. The doubt must still remain whether children *ought* to do as much work in the afternoon even if Thorndike has proved that by spurt effort they *can* do as much.

The remaining tests of special interest to us in this study concern themselves with the five-hour single session of school so common in Germany. Careful experiments were conducted in various schools for extended periods by Richter (102), Laser (70), Kemsies (62), and Ebbinghaus (34).

121. Psychological Review, Vol. 7, 1900, pp. 446-482 and 547-579.
102. Unterricht und geistige Ermuedung, Halle, 1897.
70. Ueber die geistige Ermuedung der Schueler, Berlin, 1905.
62. Arbeitshygiene der Schle auf Grund von Ermuedungsmessunger.
34. Zeit. f. Psychologie, Vol. 13, pp. 401-417.

While these investigators do not wholly agree as to the advisability of the five-hour session, none of them discover any direct influence from it which can be called especially bad. Upon the whole the evidence seems to favor the single session rather than oppose it.

This brief historical review indicates that the problem of fatigue in school is quite unsettled. It seems evident that the question of fatigue must be investigated in reference to special conditions and phases rather than as a whole.*

We now turn our attention to the special study of fatigue and efficiency in the school children of South Carolina.

*As historical reference see "Mental Fatigue," by Max Offner. Translated by G. M. Whipple, Baltimore, 1911.

EXPERIMENTS IN SOUTH CAROLINA.

The Problem.

The aim of this study was to obtain knowledge of the working ability of children for different periods of the single session of the school day, and to determine the influence of mental fatigue on the working rate, together with the effects of recesses and recuperative exercises. The facts considered were obtained from single session schools of five and a quarter to five and a half hours, including thirty minutes for recess periods. The Winthrop Training School, where the most thorough tests were made, had sessions from Tuesday to Saturday, inclusive, beginning at 8:45 a. m. and ending at 2 p. m., with two fifteen-minute recesses. Short gymnastic and singing periods were included in the daily program.

Method of Procedure.

The methods used in obtaining the facts conformed as closely as possible to the regular school work. Nothing was said to the children about "experiment." They were simply told to do the work as well as they could. In all cases they worked earnestly, generally believing that their success would affect their term record. In the longer tests the work done was based directly upon the class exercises in the different subjects used.

In order to secure uniformity of procedure, it was considered best to give the tests myself; so that, except in a very few cases to be noted, the results are those obtained from tests conducted uniformly by the same person. In the case of the eighth and ninth grades in the Training School, where most of the tests were made, I had direct charge and could plan the procedure with great uniformity. Cautions were taken against allowing practice or undue stimulation effects to enter into the measurements. The method of equal ability groups was adopted as had been done before by Winch (142), and also by Thorndyke (121).

142. Jour. Educational Psychology, Vol. 1, Nos. 1 and 2, 1910.
121. Psychological Review, Vol. 7, 1900, pp. 547-576.

Each group worked upon a different kind of exercise from the other group; and in the second trial the type of work of the two groups was exchanged. The experiments thus became distinctly a measurement of group abilities at different times of day at which the tests were given. Individual variations appear, but are not the primary subject of consideration.

Even when the children do different work at each of the two tests, there is considerable suspicion that the first test has an influence on the second, due either to practice or to the attitude of the children. In order to provide for this possibility the first test was sometimes at the close of the day and sometimes at the beginning.

First Series of Short Tests.

Two series of printed tests in simple operations in arithmetic were used. The first series consisted of easy problems in addition, multiplication, subtraction and division, printed on separate slips of paper.

A class of twelve ninth grade girls (average age fifteen and one-half), and a class of eight eighth grade girls (average age fourteen and one-half), were used for preliminary trials with these tests. The first test, consisting of addition and multiplication, was given at 2 p. m. at the close of the school day, and the second, consisting also of addition and multiplication, was given at 8:50 a. m. at the beginning of the following school day. In order to avoid the influence of practice, the pupils were divided into two groups of equal average ability and each group had a different kind of work in the two tests. The group which had addition in the first test had multiplication in the second, and the group which had multiplication in the first test had addition in the second. So that each pupil worked addition and multiplication but did not repeat the work in either subject. Now, since the abilities of the two groups were approximately equal, the sum of the records in the two tests should be equal, except for variation due to mental fatigue or other disturbing factors. Following is a tabulation of these results. The columns headed "correct" indicate the amount of correct work on a basis of ten for each example.

The columns headed "errors" indicate the number of incorrect results.

TABLE I.

Ninth Grade, Winthrop Training School, Twelve Girls, Average Age 15.7.

	Friday, Nov. 11 1:57-2 P. M.		Saturday, Nov. 12, 1910 8:47-8:50 A. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	39.5	2.2	50.0	0.0
Multiplication	42.6	2.5	47.1	1.0

A. M. Averages: 48.5 correct, 0.5 errors.
P. M. Averages: 42.8 correct, 2.5 errors.
Mean variation 2.7 0.5

TABLE II.

Eighth Grade, Winthrop Training School, Eight Girls, Average Age 14.5.

	Friday, Nov. 11 1:57-2 P. M.		Saturday, Nov. 12, 1910 8:47-8:50 A. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	48.2	1.0	49.7	0.2
Multiplication	46.2	1.2	45.0	1.7

A. M. Averages: 47.4 correct, 1.0 errors.
P. M. Averages: 47.2 correct, 1.1 errors.
Mean variation 2.2 0.7

While Table 1 indicates better work for the morning hour both in quantity and quality for the ninth grade, still it is not sufficient basis for general conclusions, and we shall find the additional tests do not in general support this relation between the early and the late work.

By Table 2 it will be observed that the eighth grade girls do almost exactly as well at one time as at the other, both in quantity and quality of work.

The next thing done was to invert the order of the tests, giving the morning test before the afternoon test. This should enable us to eliminate any transfer of practice from

the first test which might affect the second test in favor of any particular time of day. Division and subtraction were used and the tests given in the same manner as in the first tests of the series. Only two minutes were allowed for each test.

Again the ninth grade do better in the early part of the day, but only a small degree better. The eighth grade do more at the late hour, but they make more mistakes. These results show no great difference between morning and afternoon working ability of pupils, and we shall need to examine the results of other tests in order to draw definite conclusions concerning the fatigue effects of a five-hour session of school.

TABLE III.

Ninth Grade, Winthrop Training School, Twelve Girls, Average Age 15.7.

	Thursday, Nov. 17 8:53-8:55 A. M.		Friday, Nov. 18 1:58-2 P. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Subtraction	48.7	0.5	47.8	1.2
Division	47.2	1.4	44.5	2.3

A. M. Averages: 48.0 correct, 1.0 errors.
P. M. Averages: 46.1 correct, 1.7 errors.
Mean variation 2.3 1.0

TABLE IV.

Eighth Grade, Winthrop Training School, Eight Girls, Average Age 14.5.

	Thursday, Nov. 17 8:53-8:55 A. M.		Friday, Nov. 18 1:58-2 P. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Subtraction	49.5	0.2	50.0	0.0
Division	34.7	1.0	43.0	3.7

A. M. Averages: 42.1 correct, 0.6 errors.
P. M. Averages: 46.5 correct, 1.8 errors.
Mean variation 2.6 0.5

Tests in Elementary Grades.

These easy tests in arithmetic were next given to other grades of the Training School in the same manner as described above. The two groups were made according to the regular seating of the pupils in the room. For example, as double desks were used those sitting in the west end of each seat composed one group, while those sitting in the east end constituted the other group. Three minutes were allowed the seventh and sixth grades for each part of the work. The tests were given in the seventh and sixth grades first at the late hour and second at the early hour of the following school day. Table 5 for the seventh grade shows over three points out of a possible fifty points, or over six per cent. more work in the first test; that is, in the one at the close of the school day. It also shows fewer errors in the afternoon. Table 6 for the sixth grade shows the same kind of results in a less degree. As in the eighth and ninth grade classes, so here, the effect of novelty or interest seems to be even more favorable to the first trial than practice is to the second. This same influence of stimulation through novelty may be noted throughout the investigation, and will be discussed later. It may be said, however, that a comparison of results of tests taken in different order indicate that the novelty and the practice approximately counteract each other, so that in general the records in tests at different times of day fairly represent the working ability for the particular time and may be directly compared for determining the effects of fatigue.

TABLE V.

Seventh Grade, Winthrop Training School, Seven Girls, Average Age 13.2; Two Boys, Average Age 13.

	Friday, Nov. 18 1:42-1:45 P. M.		Saturday, Nov. 19 8:45-8:48 A. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	49.6	0.2	47.5	1.5
Multiplication	46.2	1.2	42.8	2.4

A. M. Averages: 45.1 correct, 2.0 errors.
P. M. Averages: 47.9 correct, 0.7 errors.
Mean variation 2.1 0.6

TABLE VI.

Sixth Grade, Winthrop Training School, Eleven Girls, Average Age 12.2; Two Boys, Average Age 12.

	Friday, Nov. 18 1:42-1:45 P. M.		Saturday, Nov. 19 8:45-8:48 A. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	43.7	1.5	43.5	1.3
Multiplication	31.8	1.3	34.5	4.0

A. M. Averages: 39.0 correct, 2.7 errors.
P. M. Averages: 37.7 correct, 1.4 errors.
Mean variation 4.3 1.1

TABLE VII.

Fifth Grade, Winthrop Training School, Ten Girls, Four Boys.

	Thu. Nov. 10 1:45-1:50 P.M.		Fri. Nov. 11 9:55-10 A. M.		Thu. Dec. 1 9-9:04 A. M.		Thu. Dec. 1 2-2:04 P. M.	
Average.	Correct.	Errors.	Correct.	Errors.	Correct.	Errors.	Correct.	Errors.
Average	46.7	1.6	44.0	1.0	.....	.....	.....	.....
Multiplication	37.0	2.0	40.1	2.6	.....	.....	.....	.....
Subtraction	.....	.....	.....	.....	45.0	2.0	47.0	1.7
Division	.....	.....	.....	.....	31.2	7.7	28.7	13.7
A. M. Aver.	42.0 correct, 1.8 errors.				38.1 correct, 4.8 errors.			
P. M. Aver.	41.9 correct, 2.0 errors.				37.8 correct, 7.7 errors.			
Mean Var.	5.1		1.0		6.0		3.4	

TABLE VIII.

Fourth Grade, Winthrop Training School, Ten Girls, Thirteen Boys.

	Thu. Nov. 10 1:45-1:50 P.M.		Fri. Nov. 11 9:55-10 A. M.		Thu. Dec. 10 9-9:04 A. M.		Thu. Dec. 10 2-2:04 P. M.	
Average.	Correct.	Errors.	Correct.	Errors.	Correct.	Errors.	Correct.	Errors.
Addition.....	43.4	1.4	41.9	2.4	.....	.....	.....	.....
Multiplication..	24.8	3.8	26.9	2.0	.....	.....	.....	.....
Subtraction.....	.....	.....	.....	.....	41.7	4.2	45.1	2.5
Division.....	.....	.....	.....	.....	27.4	7.9	14.4	12.9
A. M. Aver....	34.4 correct, 2.2 errors.				34.5 correct, 6.0 errors.			
P. M. Aver...	34.1 correct, 2.6 errors.				29.8 correct, 7.7 errors.			
Mean Var....	6.8		1.6		5.9		3.7	

We shall next consider Tables 7 and 8 for the same kind of tests in other classes. These are double tables, in which the first parts show the result where the first test is taken in the afternoon while the last parts show the results where the first test is taken in the morning.

The indications of these tables are that the children of the fifth and fourth grades of the Training School are about as efficient at the close of a five-hour session as at the beginning.

Table 9 shows the result of a test given by a teacher in the Rock Hill Graded Schools to a group of fourth grade boys. The school session in this school lasts from 9 a. m. to 2:30 p. m., with two fifteen-minute recesses, so that the afternoon test is nearly half an hour later than those in the other schools. It is probable that the strain of the last half hour is rather severe on the younger children, and there is little doubt that it is sufficient to cause the five per cent. decrease in ability indicated in the table.

TABLE IX.

Fourth Grade, Rock Hill Graded School, Eighteen Boys, Average Age 10.

	Wednesday, Nov. 23 9:25-9:30 A. M.		Wednesday, Nov. 23 2:25-2:30 P. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	44.2	1.6	43.9	3.9
Multiplication	33.9	7.5	31.4	8.6

A. M. Averages: 39.1 correct, 4.5 errors.
P. M. Averages: 37.6 correct, 6.2 errors.
Mean variation 7.2 3.9

Second Series of Arithmetical Tests.

We shall next consider a second series of tests in the arithmetical operations, longer and more difficult than the ones already presented.

(See Appendix for sample tests.)

The tests of the second series were given in the same manner as those of the first except that the time allowed was extended to from five to ten minutes, according to the ability of the class.

Tables 10, 11, 12 and 13 are results for high school classes. Table 10 indicates that the ninth grade pupils of the Training School have about the same ability in the morning and in the afternoon; Table 11 shows that the eighth grade pupils are abler in the afternoon; while Table 12 shows that the ninth and tenth grades in the Fort Mill School have more ability in the morning, and Table 13 indicates equal abilities in the morning and afternoon for the eighth grade. Table 13 shows the results of three tests taken at different times of the day. While the first and last tests indicate about equal ability for the forenoon and the afternoon, the middle test indicates a distinct dropping off in ability between 12 and 1. It will later be further indicated that the working ability of classes increases in the morning till 10 or 11 a. m., and then drops off slightly to rise again before the close of school at 2 p. m.

TABLE X.

Ninth Grade, Winthrop Training School, Twelve Girls.

	Saturday, Dec. 10, 1910, 1:57-2:02 P. M.		Thursday, Dec. 22 8:50-8:55 A. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	90.7	3.2	88.8	1.3
Division	81.5	5.5	73.2	4.6

A. M. Averages: 86.0 correct, 3.1 errors.
P. M. Averages: 86.1 correct, 4.4 errors.
Mean variation 6.6 1.7

TABLE XI.

Eighth Grade Girls, Winthrop Training School.

	Saturday, Dec. 10 1:57-2:02 P. M.		Thursday, Dec. 22, 1910 8:50-8:55 A. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	93.5	1.5	81.5	0.5
Multiplication	87.0	0.5	86.0	0.0

A. M. Averages: 83.8 correct, 0.2 errors.
P. M. Averages: 90.2 correct, 1.0 errors.
Mean variation 7.5 0.3

TABLE XII.

Ninth and Tenth Grades, Fort Mill Graded School.

	Monday, Dec. 12 10:10-10:15 A. M.		Monday, Dec. 12, 1910 1:50-1:55 P. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	79.0	4.0	73.2	5.4
Subtraction	89.8	5.2	92.2	5.8

A. M. Averages: 84.4 correct, 4.6 errors.
P. M. Averages: 82.6 correct, 5.6 errors.
Mean variation 6.3 3.3

TABLE XIII.

Eighth Grade, Fort Mill School, Twelve Girls, Eight Boys, December 12, 1910.

	10:50-10:57 A. M.		12:38-12:45 P. M.		1:45-1:52 P. M.	
Average.	Correct.	Errors.	Correct.	Errors.	Correct.	Errors.
Addition	76.4	10.2	70.5	7.0	74.6	5.6
Subtraction...	70.6	8.4	79.7	10.3	93.0	5.3
Multiplicat'n..	57.0	3.2	61.2	3.0	48.8	4.8
Division.....	77.4	8.2	64.2	9.4	64.8	3.3
Total Av....	70.3	7.5	68.9	7.4	70.3	4.7
Mean Var...	11.7	2.6	11.7	4.3	11.3	4.0

TABLE XIV.

Fourth Grade, Fort Mill School, Nine Girls, Average Age 11; Three Boys, Average Age 11.6.

	9:55-10:03 A. M.		1:42-1:50 P. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	47.0	9.6	52.3	5.0
Multiplication	27.0	26.3	41.2	13.8

A. M. Averages: 37.0 correct, 18.0 errors.
P. M. Averages: 46.7 correct, 9.4 errors.
Mean variation 8.9 7.9

TABLE XV.

Third Grade, Fort Mill School, Four Girls, Average Age 9.2; Eight Boys, Average Age 9.8.

	9:55-10:03 A. M.		1:42-1:50 P. M.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	28.2	12.1	28.7	4.2
Multiplication	33.0	12.2	31.0	10.7

A. M. Averages: 30.6 correct, 12.2 errors.
P. M. Averages: 29.9 correct, 7.5 errors.
Mean variation, 6.7 5.6

The foregoing tables refer to all the grades of school children from the third grade (average age nine and one-half years) to the tenth grade (average age sixteen years), and indicate the comparative quality and quantity of work in the arithmetical operations at the beginning and at the close of the school day. For convenient comparison, a summary of these tables for the various tests may be shown as in Table 14, p. 22.

A careful inspection of this summary shows that the results are as good for the late period of 2 p. m. as for the early period of 9 a. m., and this is as obvious in the lower grades as in the higher. In other words, there is no indication of a falling off in efficiency due to the fatigue of the school day. In fact, these results show somewhat more favorably for the afternoon work, as is indicated by the per cent. gain, or loss, for the early and for the late periods of the day. For in the seven grades considered, only three—ninth, sixth and third—show a total quantity of correct work greater in the morning, while only the ninth and fifth grades show fewer mistakes at the early hour. The conclusion, therefore, is inevitable that if there is mental fatigue due to the work of the school day these tests fail to show it either by quantity or quality of the work done.

These results seem to correspond well to Thorndike's (121) conclusions regarding the relative efficiency of the children at the beginning and at the close of the day, based on his tests in the Cleveland and Scranton schools. He found the children just as efficient at the close of a double daily session between 3 and 4 p. m. as at the beginning between 9 and 10 a. m. This is also in agreement with the results of an investigation by Ebbinghaus (34) on the fatigue of a five-hour daily session of school in the district of Breslau, Germany. In a series of brief tests he discovered but little indication of fatigue in the children.

Importance of Tests of Continuous Effort.

So far the tests considered have been short, usually not exceeding ten minutes. There is evidently a great difference between the energy required for these and that required for

121. Psychological Review, Vol. 7, 1900, pp. 547-576.
34. Zeit. f. Psychologie, Vol. 13, pp. 401-417.

TABLE XIV.

Summary of Tables. Figures (1) and (2) Under "Order" Indicate whether Test was First or Second.

Grade.	School.	Table.	A. M. Work.			P. M. Work.		
			Order.	Correct.	Errors.	Order.	Correct.	Errors.
Ninth	Winthrop	Table 1	(2)	48.5	.5	(1)	42.8	2.3
Ninth	Winthrop	Table 3	(1)	48	1	(2)	46.1	1.7
Ninth	Winthrop	Table 10	(2)	86	3.1	(1)	86.1	4.4
Ninth and Tenth	Fort Mill	Table 12	(1)	84.4	4.6	(2)	82.6	5.6
Totals for Ninth and Tenth Grades				266.9	9.2		257.6	14
Eighth	Winthrop	Table 2	(2)	47.4	1	(1)	47.2	1
Eighth	Winthrop	Table 4	(1)	42.1	.6	(2)	46.5	1.8
Eighth	Winthrop	Table 11	(2)	83.8	.2	(1)	90.3	1
Eighth	Fort Mill	Table 13	(1)	70.3	7.5	(2)	70.3	4.75
Totals for Eighth Grade				243.6	9.3		254.3	8.65
Seventh	Winthrop	Table 5	(2)	45.1	2	(1)	47.9	.7
Sixth	Winthrop	Table 6	(2)	39	2.7	(1)	37.7	1.4
Fifth	Winthrop	Table 7	(2)	42	1.8	(1)	41.9	2
Fifth	Winthrop	Table 7	(1)	38.1	4.8	(2)	37.8	7.7
Totals for Fifth Grade				80.1	6.6		79.7	9.7
Fourth	Winthrop	Table 8	(2)	34.4	2.2	(1)	34.1	2.6
Fourth	Winthrop	Table 8	(1)	34.5	6	(2)	29.8	7.7
Fourth	Rock Hill	Table 9	(1)	39.1	4.5	(2)	37.6	6.2
Fourth	Fort Mill	Table 14	(1)	37	18	(2)	46.7	9.4
Totals for Fourth Grade				145	30.7		148.2	25.9
Third	Fort Mill	Table 15	(1)	30.6	12.2	(2)	29.9	7.5

continuous effort extending through an hour or more. It is evident that each pupil possesses an energy reserve to be drawn upon in cases of need. It is then apparent that the source of energy supply may furnish support for ten minutes of efficient work, but not for forty minutes of equally good work. This consideration may give rise to confusion in the definition of fatigue. May not fatigue mean loss of efficiency to persist in continuous work rather than loss of efficiency for short trials? It may be claimed, for example, that a pupil can be well nigh exhausted from fatiguing effort, and yet under stimulus may rally and produce a high record for a few minutes. It seems probable then that the continuous mental work covering an hour may be a better measure of the conditions of fatigue in the schoolroom than the shorter tests.

In consideration of the above probability I undertook to measure the working efficiency of the pupils of the ninth and eighth grades during nearly an hour at different times of the day. But my aim was not only to determine the fatigue of the different parts of the school hour, as was done by Burgerstein (8) and Miss Holmes (54), but to find it for different times of the day and under different known conditions.

By comparing the nature of the efficiency curves for the different hours of the day it seemed possible to draw conclusions concerning the relative conditions of fatigue for the various periods.

Tests for Continuous Effort.

The tests used were class reviews in algebra, history and Latin. The tests consisted of four parts on different phases of the subjects and approximately of equal length and difficultness. Each part was intended to be long enough to require not less than ten minutes by the best pupils. In very few cases did any pupil finish the work in the ten minutes allowed for it. The attempt to make each part of equal difficultness for the pupils in the algebra tests was not successful. The pupils were not thorough on part of the work gone over in the test,

8. Educational Rev., Vol. 25, p. 364.
54. Ped. Sem., Vol. 3, 1905, pp. 213-234.

and were especially weak in the solving of the concrete problems.

The result was that very low grades were made on the problems in the algebra, and the mean variation in the scores was very great. But since the pupils were carefully divided into groups of equal ability and since the complete score for each ten minutes was the sum of the four groups working on all four parts of the test, the total results probably represented fairly well the relative working rate for each of the four ten-minutes.

(For sample tests see Appendix.)

Results of Tests in the Ninth Grade.

The class of twelve girls was considered in four groups of three each. The ability of the groups were approximately equal. Part A of the test was given to one group of three; part B, to another group; part C, to another group, and part D, to the last group of the girls. All worked just ten minutes, and then we used two minutes in collecting papers and changing questions. Then all worked again for ten minutes, when the papers were again collected. In this manner forty-eight minutes were required to complete the work, giving every pupil ten minutes' time on each part of the test.

The test was regarded as regular work upon which the term grades in the various subjects would in part depend. No suggestion of experiment was made to the pupils. They used all the time and worked earnestly.

In Tables 17 and 18 the children show a constantly increasing efficiency throughout the four ten-minute periods. These grades are based upon a possible 100 per cent. for each ten minutes. The test proved very difficult for the pupils, who in some cases show low grades and tremendous variability for the different parts of the work. All the pupils worked earnestly throughout each part of the test, as they also did in the other tests. The scoring was as uniform as possible on such imperfect papers, some credit being allowed for every correct statement. Here the increase in results is so decided in quantity that it cannot fail to indicate the continued increase in

working efficiency throughout the forty-eight minutes. It shows that the warming-up process in ninth grade children continues during the most of the first hour of the school day.

The tests upon which Table 19 is based was given three weeks after that for Table 18. The children had improved somewhat and showed more regularity and a better working ability. The averages for the four parts of the test show different variations, indicating, first, an increase in ability, then a marked decrease, and finally, an increase. This form of variation becomes quite significant throughout the tests of the same type.

TABLE XXII.

Summary of Tables 17-21, Ninth Grade (Continuous Work), Winthrop Training School.

(Table 17)	*Algebra*, January 25, 1911.			
Time	9:02- 9:12	9:14- 9:24	9:26- 9:36	9:38- 9:48
Averages	65.6%	71.0%	79.2%	81.9%
(Table 18)	*Algebra*, September 23, 1910.			
Time	9:00- 9:10	9:12- 9:22	9:25- 9:35	9:37- 9:47
Averages	22.7%	29.2%	35.0%	38.0%
(Table 19)	*Algebra*, October, 1910.			
Time	11:20-11:30	11:32-11:42	11:45-11:55	11:57-12:07
Averages	39.9%	40.9%	35.0%	36.9%
(Table 20)	*Algebra*, December 1, 1910.			
Time	1 15- 1:25	1:27- 1:37	1:39- 1:49	1:51- 2:51
Averages	37.7%	47.5%	37.7%	38.7%
(Table 21)	*History*, December 22, 1910.			
Time	11:15-11:25	11:27-11:37	11:39-11:49	11:51-12:01
Averages	64.0%	74.3%	68.7%	71.7%

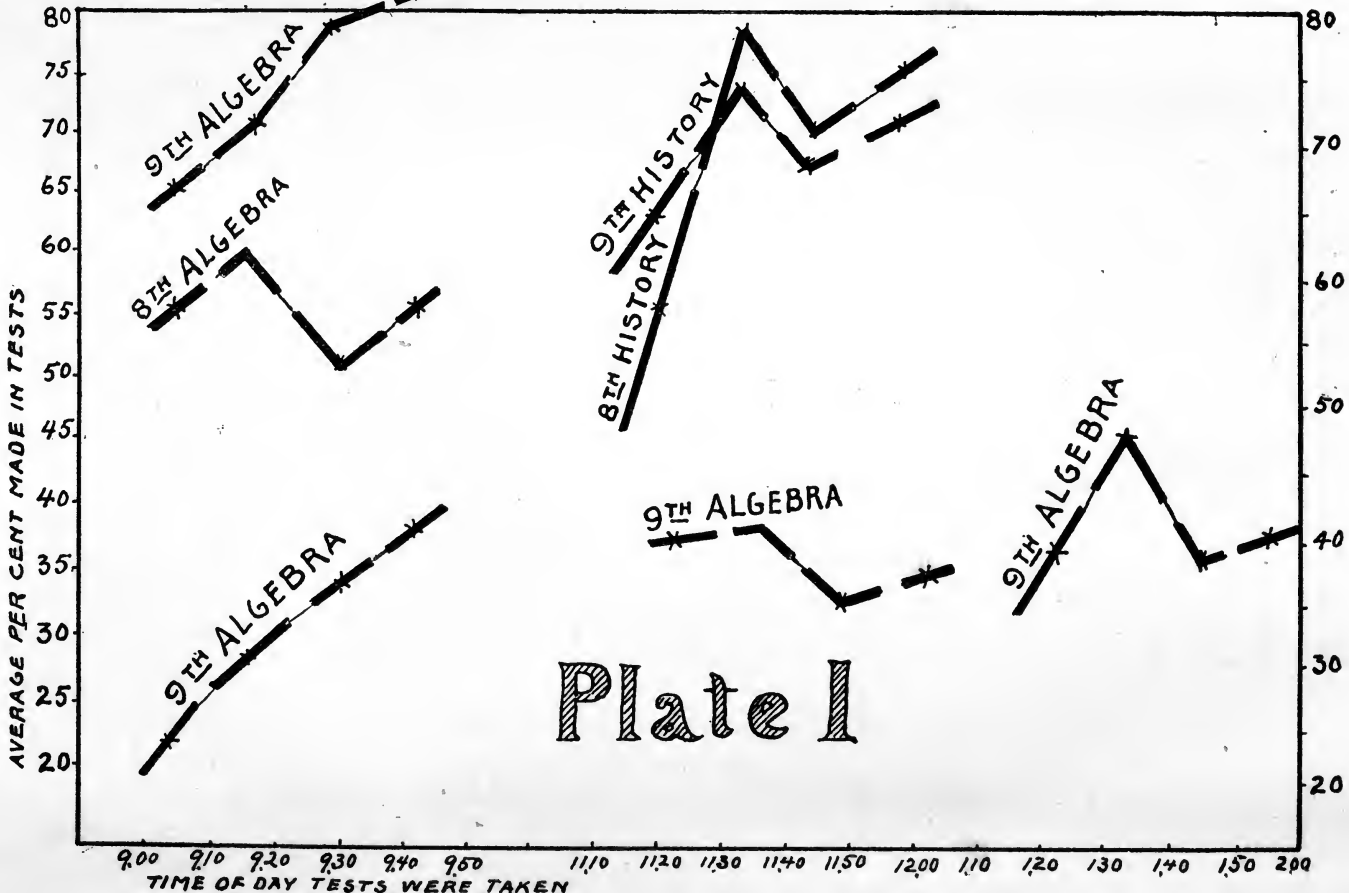
Tables 22 and 23 show a summary of results in these continuous tests for the ninth and eighth grades. The interesting variations indicated in these tables are shown by the diagram in Plate I.

TABLE XXIII.

Eighth Grade (Continuous Work).

	Algebra, Friday, September 23, 1910.			
Time	9:00- 9:10	9:12- 9:22	9:25- 9:35	9:37- 9:47
Averages	56.6%	61.5%	52%	56%
	History, Thursday, December 22, 1910.			
Time	11:15-11:25	11:27-11:37	11:39-11:49	11:51-12:01
Averages	57.6%	78.8%	71.2%	76%

Mean variation for Tables 22 and 23 is approx. 9. per cent.


9TH ALGEBRA
8TH ALGEBRA
9TH HISTORY
8TH HISTORY
9TH ALGEBRA
9TH ALGEBRA
9TH ALGEBRA
Plate I
AVERAGE PER CENT MADE IN TESTS
80
75
70
65
60
55
50
45
40
35
30
25
20
9.00
9.10
9.20
9.30
9.40
9.50
11.10
11.20
11.30
11.40
11.50
12.00
1.10
1.20
1.30
1.40
1.50
2.00
TIME OF DAY TESTS WERE TAKEN

Rhythmic Fluctuations in Efficiency.

Plate I distinctly indicates a wave-like rise and fall in efficiency. And this occurs in every hour of the uninterrupted work except with the ninth grade in the first hour. The rhythmic recurrence of high and low efficiency is very evident. In these cases the complete period of the wave of efficiency is twenty minutes. This certainly gives an interpretation to the appearance of fatigue during the working hours of the school day. Evidently the fatigue of the first hour in the ninth grade is not great enough to cause a cessation of the working rate. In every other case fatigue seems to occur and to be relieved by a temporary slowing up in the rate of work. Apparently the descending lines in the diagrams represent a resting period in the pupils, while the ascending lines show more strenuous effort.

The conclusion that a rhythmic alternation of high and low efficiency always occur in continuous work may need further verification. However, this conclusion seems to harmonize well with known facts of life. The physiological processes are largely rhythmical as, for example, the pulsations of the heart and the movements in respiration. There are many cases where a periodical alternation of rest and increased activity occur in the physical body.

Pillsbury (100) and others have found that the attention can be sustained at a maximum for only a few seconds. It seems probable that the efficiency curve is made up of short fluctuations within a longer wave. Perhaps the curve is very complex, being composed of several different lengths of waves.

Efficiency at Different Periods of the Day.

As has been found by many experimenters the working capacity as indicated by mental tests does not fall off regularly during the day, but varies from one period to another with irregularity according to the individual. In no case is the efficiency curve from morning till evening a straight line. This fact necessitates comparisons of ability between every two periods in order to construct the curve for the day.

100. Amer. Jour. of Psch., Vol. 14, 1903, pp. 276-288.

It has already been indicated by the summary of the tests (Table 16) that children do as well in their tests at the close of the session at 2 p. m. as they do early in the day. A closer examination of the tables indicates that the pupils do better work at 10 to 11 a. m. than they do either earlier or later in the day. The eighth grade in Table 13 does decidedly better work both at 11 a. m. and at 2 p. m. than at the intervening period between 12 and 1 p. m. A sixth grade class in the Rock Hill Schools made an average in the arithmetical tests of 41.8 per cent. at 10 a. m. and only 38.3 per cent. at 2 p. m., with .7 more errors per pupil at the late hour. This indicates about 9 per cent. better work at the 10 o'clock hour.

The ninth grade class in the Training School made an average grade of 73 per cent. in a dictation test at 1:35 p. m. and an average of 76 per cent. in a similar test at 11:20 a. m., with an average of 1.8 errors per pupil in each test. Again the result is in favor of the forenoon work. These results indicate a maximum working ability at from 10 to 11 a. m. and a depression or falling off for the period from 12 to 1 p. m. followed by a rise in ability before the dismissal at 2 p. m. But in all cases the average working rate increases after the opening of school in the morning.

This gives emphasis to the mental inertia in school children and shows the importance of the warming-up process. It will be shown later in this discussion that not only is the mental warming-up a feature of the first hour of the school day, but that it takes place after every extended recess or long continued diversion from the regular school work.

Mental Inertia.

The mind does not change from one state of consciousness to another. New associations have to be formed and the mind has to get up momentum in its new activity. This adjustment requires time. The tendency of the mind to persist in the same attitude or activity is known as mental inertia. The persistence in consciousness corresponds to the persistence of sensation in the sense organs after the stimulus has been removed; the sensation of a flash of

lightning, for example, persists several times as long as the duration of the flash itself. The condition in which the mind tends to persist may be one of lassitude or passive indifference, or of strenuous effort, but in all cases it requires time to adapt itself to new attitudes. Stout says: "The incessant change which is essential to the very existence of conscious life always possesses some degree of momentum" (Stout, Analytic Psychology, I, p. 147). For example, one may feel the need of writing a letter to a friend, but finds it much easier to sit and muse in idleness than to begin the writing. But suppose the letter begun, the interest in the activity may be so great that it may be as hard to stop writing as it was to get started at first.

The importance of mental attitude for the accomplishment of a task was illustrated by the junior class in psychology in Winthrop College. Two sections of the class had been given tests in habit-substitution for the same number of days. A variation was made by introducing into one section five minutes of hard work in mental arithmetic between the parts of the substitution test; and by showing the other section a funny picture at a corresponding time which caused all the students to burst into laughter. The result was, that upon resuming the substitution test after the interruption, the section of the class which had worked at the mental arithmetic showed twice as much improvement in the work of the substitution as the section whose minds had been diverted by the funny picture. It required time for the students to resume a mental attitude for work after the diversion caused by the comical picture, while the mental poise of those who worked the arithmetic was less disturbed.

It is evident that some individuals warm up to their maximum ability much more quickly than others. The variations depend upon age, sex, temperament and mental attitude of the pupils. Certainly the inertia varies for different grades. It seems that according to the results of these tests the inertia of the eighth grade class is less than that of the ninth grade. It takes the eighth grade less time to warm up to their maximum in the morning, but also the fatigue waves begin sooner. In

Table 23 it will be seen that they reach their maximum efficiency in the second ten minutes of work, while the ninth grade continue their gain throughout the four ten-minute periods.

The test in history on December 22 (Table 23), indicates that the eighth grade make a very rapid gain for the first twenty minutes and then suddenly fall off, though not in an extreme degree.

In taking up their work after recess as well as in the morning the eighth grade indicate a promptness in reaching their maximum, which is only equalled by the promptness with which they show the depression of fatigue. Why should this grade of pupils differ so much from those of the ninth grade? Partly on account of being a year younger, partly on account of being a year less experienced in school studies, but, perhaps, chiefly on account of their mental attitude toward school work. They were distinguished for their enthusiasm and thoroughness. They had high ideals and entered upon all their tasks with much spirit. Evidently they were more susceptible to fatigue than the slower ninth grade and their variation from period to period was greater. The comparison between the two classes must, however, afford a strong suggestion of smaller inertia in the younger children. As will be pointed out later, the ability of the younger children to sustain prolonged attention is more limited.

Mental Stimulations.

Mental stimulations are extremely varied in type, but all of them are related to interest and secure their results through different degrees of attention. The stimulations of importance for our consideration here are (1) purposive attainment, or expectancy, (2) pleasure in accomplishment, (3) novelty, or interest in the new.

1. *Purposive Attainment.*—Strong purpose is a powerful stimulus in the performance of work. The most disagreeable tasks become interesting if there is sufficient purpose in doing them, and there is no doubt that to impart to the child a proper purpose in life is the most important duty of the teacher whose

business it is to make better men and women. It may generally be expected that the child's attainments will vary in exact accord with the strength of his purpose. It is this variation which destroys the validity of a great deal of pedagogical experimentation. If, for example, a task consists of nonsense to the child he will not work well at it after the novelty wears off. The importance of the factor of purpose is so self-evident to educators that it needs no specific demonstration here. In order to keep this factor as uniform as possible the tests of the eighth and ninth grades were generally confined to the tasks required in their regular school work. And special effort was made to maintain a constancy of purpose in the minds of the pupils throughout these experiments.

Expectancy which is closely allied to purpose in the completion of a task has much influence in all tests. In the tests here considered it probably has much to do with the rhythmic rise of efficiency in the last part of the test, as well as the rise in efficiency at the close of the day.

2. *Pleasure in Accomplishment.*—The very fact of being able to do a difficult task affords an incentive for doing it. The pleasure is increased when the accomplishment can be definitely seen and recognized. This is realized in children working problems for the right "answer."

A large class of college students in psychology had been trying a habit-substitution test with various encouragements to improve at a better rate. The work was evidently not interesting to them. Finally, I showed the class the practice curve which represented their progress, and with no further encouragement than the explanation of the curve the class doubled the rate of improvement over their previous trials. The fact that they recognized their accomplishments gave the students an incentive to do the work better.

Doubtless this factor entered into some of the arithmetical tests. For example, the eighth and ninth grades showed interest and rapid improvement on difficult mental operations with numbers called out by the teacher. The problems increased in difficulty and yet the ninth grade made on successive days averages of 85 per cent., 86 per cent., and 92 per

cent., respectively, while the eighth grade made corresponding averages of 76 per cent., 85 per cent., and 88 per cent. on the same tests. On less agreeable tasks like dictation work the children showed much less improvement.

3. *Novelty.*—Finally, novelty or interest in the new is a great stimulation to effort. However, due to its nature, it does not remain long a constant, and its variability is a troublesome factor in experimentation. The difficulty may be illustrated in part by a carefully performed experiment with the eighth and ninth grades of the Training School for the determination of efficiency in dictation at different hours of the day. A selection on Socrates found in Brooks' Eighth Reader (taken from Historical Tales, by Charles Morris), was divided into four parts approximately equal. The work was introduced by telling the chlidren that they were to learn something about Socrates and that it was hoped that they would be interested in this great man. They were then asked to attend carefully to the reading. Twenty-one lines were read to them and the children were given ten minutes to write down as much of it as they could remember. The average grades were based upon the number of ideas correctly reproduced. The other portions of the selection were given in the same manner on successive weeks at different hours of the day. The grading was done in the same way and gave the following results for the four tests:

1. Friday, September 23, 12:55-1:05 p. m.: Ninth grade 65 per cent., eighth grade 62 per cent.

2. Thursday, September 29, 9-9:10 a. m.: Ninth grade 44 per cent., eighth grade 49 per cent.

3. Thursday, October 6, 10:40-10:50 a. m.: Ninth grade 44.4 per cent., eighth grade 48 per cent.

4. Thursday, October 20, 1:20-1:30 p. m.: Ninth grade 45 per cent., eighth grade 48 per cent.

How can we account for the remarkable drop between the first and second test and the constancy of the last three tests? Certainly not by the time of day, because the last test was at about the same time as that of the first but with an average grade very much lower.

The fact is that the children hated this particular work after the first trial of it. It was drudgery to them and they appeared bored whenever they had to resume the task. They hated the name of Socrates so that when the thrilling account of his death was finally read to them, they sighed and in suppressed whisper said, "Thank God, he's dead!" Under such conditions it is easy enough to account for the sudden drop in the average grade. It was due merely to a drop in interest. This attitude indicates a sharp contrast with that of the same children toward the mental arithmetic referred to above; and it is proper to note that none of the other tests were accompanied by a similar attitude of repugnance. It has already been noted that in order to eliminate the factor of novelty as well as the disturbing factor of practice the order of the tests was varied so as to have the first test sometimes in the afternoon and sometimes in the forenoon. This seems to have been worth while, for the novelty effect was in some cases greater than the practice influence. There is no doubt that many fatigue experiments are worthless, due to the interference of stimulation through novelty. This criticism applies to nearly all the earlier investigations on fatigue, and is perhaps a more difficult factor to estimate than the influence of practice.

Effects of Interruptions.

What are the influences of recesses, lunch periods, singing and gymnastic exercises on the daily school work? It is generally agreed that these interruptions relieve the nervous strain, and give rest to the children. But to what extent? What is the relative efficiency of pupils before and after such pauses? The following tables indicate the results of introducing the various interruptions between the parts of the work.

Table 24 shows the result of a test in Latin similar to the previous tests except that an interval of twenty-one minutes occurred between the first and second parts of the test. Ten minutes of this twenty-one minutes were used for gymnastics and the balance for recess. It will be observed that the drop in efficiency was quite marked after this recess and continued

for two ten-minute periods. It is only during the last ten minutes that the pupils rally and show an improvement in work, even then they fall distinctly below their accomplishment for the period before the intermission.

In Table 25 the test was again interrupted by intermissions. After the first part of the test there was a ten-minute recess of entire freedom, during which the pupils walked around and talked, but did not engage in any organized game. It will be seen that the children made a better record after this ten-minute recess than before, while in the test of Table 24 they made a poorer record after the twenty minutes of gymnastics and recess combined. After the third part of the test there was an intermission of twenty-eight minutes, during which the pupils engaged in folk dancing under the supervision of the physical director. This exercise was provided for once a week (Tuesday) and was regarded by the children as a great privilege. They evidently enjoyed it better than any exercise either in school or out of school. Consequently they entered into the dancing with real interest and returned from it with a glow of pleasure and apparent vigor. In the fourth part of the test after the dancing the children resumed their work promptly and with earnestness, but instead of showing a gain in efficiency as heretofore in the final effort they fell off and showed a lower average than on any other part of the test. The energy of the children had been used up, or their minds diverted so that they could not resume their work with their usual high efficiency for the final ten minutes of the test.

In the tests so far considered the time allowed was ten minutes to each part. In all cases the tasks were too long for many of the pupils to complete in the given time. We may now consider the result of a test given at the end of the term in which double the time (twenty minutes) was allowed for each of the four parts. The children employed all of the time and worked earnestly.

The work for the second twenty minutes (Table 26) shows an improvement over that of the first part. A free recess of ten minutes was given at the end of the second twenty-minute period. After this the children fell off about five per cent. in

their work during the third twenty minutes. Then ten minutes were used for singing under the direction of the music teacher. Following the singing, which consisted of familiar songs, the records show an improvement indicating an efficiency almost equal to that for the first twenty minutes. It will be noted that the variations showing increase, decrease and a second increase in working efficiency are of the same order as for the tests of half the length. (See Plates I and II.)

TABLE XXVII.

Summary of Tables 24-26, Ninth Grade, Winthrop Training School.

(Table 24)	*Latin*, December 21, 1910.			
Time	10:10-10:20*	10:41-10:51	10:53-11:03	11:05-11:15
Averages	55.4%	50.4%	49.6%	52.1%

*20 minutes recess and gymnastics.

(Table 25)	*Algebra*, January 17, 1911.			
Time	10:15-10:25*	10:35-10:45	10:47-10:57†	11:25-11:35
Averages	39.5%	41.8%	39.3%	39.1%

*10 minutes recess. †25 minutes folk-dancing.

(Table 26)	*History*, January 24, 1911.			
Time	11:03-11:23	11:25-11:45*	11:58-12:18†	12:30-12:50
Averages	77.9%	80.8%	75.4%	77.3%

*10 minutes recess. †10 minutes singing.

TABLE XXVIII.

Summary of Eighth Grade (Interrupted Work).

Latin, Wednesday, December 21, 1910.

Time	10:10-10:20*	10:41-10:51	10:53-11:03	11:05-11:15
Averages	75.4%	77.8%	71.4%	77.8%

*20 minutes gymnastic and recess.

Algebra, Tuesday, January 17, 1911.

Time	10:15-10:25*	10:35-10:45	10:47-10:57†	11:25-11:35
Averages	60.7%	73.8%	74.7%	73.6%

*10 minutes recess. †25 minutes folk-dancing.

History, Tuesday. January 24, 1911.

Time	11:05-11:45*	12:00-12:20†	12:30-12:50
Averages	66.9%	70.3%	

*10 minutes recess. †10 minutes singing.

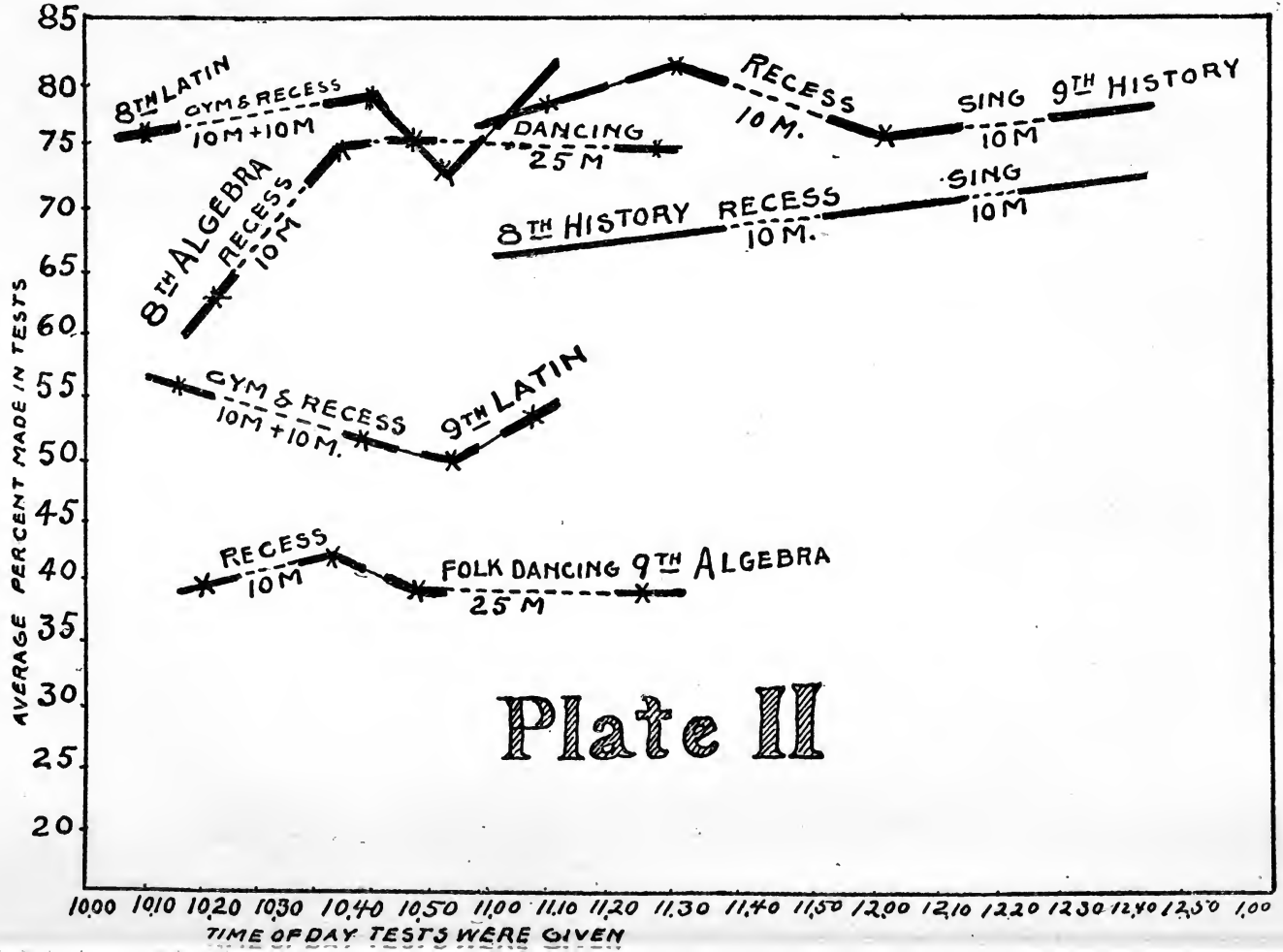

AVERAGE PER CENT MADE IN TESTS
85
80
75
70
65
60
55
50
45
40
35
30
25
20
8TH LATIN
GYM & RECESS
10M + 10M
DANCING
25 M
RECESS
10 M.
SING 9TH HISTORY
10M
8TH ALGEBRA
RECESS
10M
8TH HISTORY RECESS
10M.
SING
10M
GYM & RECESS
10M + 10M.
9TH LATIN
RECESS
10M
FOLK DANCING 9TH ALGEBRA
25 M
10.00 10.10 10.20 10.30 10.40 10.50 11.00 11.10 11.20 11.30 11.40 11.50 12.00 12.10 12.20 12.30 12.40 12.50 1.00
TIME OF DAY TESTS WERE GIVEN

Plate II

TABLE XXIX.

Seventh Grade, Winthrop Training School, Saturday, January 14, 1911.

	11:55-12 A. M. Before Gymnastics		12:10-12:15 P. M. After Gymnastics.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	71.1	1.0	82.6	0.3
Subtraction	86.0	6.4	89.6	1.6

Before Gymnastic Averages: 78.5 correct, 3.7 errors.
After Gymnastic Averages: 86.1 correct, 2.3 errors.
Mean variation 6.5 . 1.9

TABLE XXX.

Sixth Grade, Winthrop Training School, January 14, 1911.

	11:55-12 A. M. Before Gymnastics		12:10-12:15 P. M. After Gymnastics.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	66.0	2.6	84.0	3.4
Subtraction	77.2	3.2	82.3	1.3

Before Gymnastics Averages: 69.6 correct, 2.9 errors.
After Gymnastics Averages: 77.1 correct, 2.3 errors.
Mean variation 7.7 3.2

Effects of Gymnastics.

According to the records in Table 24, the ninth grade lose rather than gain efficiency by twenty minutes of gymnastics and recess. The eighth grade which in uninterrutped cases make a very large gain in the second ten minutes show in Table 28 only a very slight gain after the gymnastics and recess of twenty minutes, while the seventh and sixth grades each show an improvement of five per cent. or more in addition and subtraction after ten minutes of gymnastics (Tables 29 and 30). The longer period of twenty-five minutes in the pleasant exercise of dancing proves disadvantageous to the work following it in both the ninth and eighth grades. As further evidence

upon the effect of the folk-dancing the ninth grade were tested upon work in simplifying complex fractions in algebra upon a day when there was dancing and upon another day when there was no dancing. The results were as follows:

After dancing Tuesday, December 6, at 11:22-11:27 a. m., average 50.9 per cent.

No dancing Saturday, December 17, at 11:45-11:50 a. m., average 60.6 per cent.

Thus we see that on Saturday when there was no dancing the children did much better than at approximately the same time upon Tuesday just after twenty-five minutes of dancing.

It is apparent that the greater distractions due to inertia prevent the pupils from regaining their working poise at once. The conclusions are obvious. (1) The short gymnastic period improves the work following it, while the longer period in gymnastics lowers the work, all of which tends to favor the short gymnastic period not exceeding ten minutes in preference to the longer one. (2) The benefits of the gymnastics are more apparent in the sixth, seventh and eighth grades than in the ninth grade. It is natural to infer that the lower grades in general have more need of gymnastics and physical activities.

Effects of Singing.

In one long test in history ten minutes of singing of well known songs were introduced into the test as a rest factor. (Tables 26 and 28.) It seems that the singing had a beneficial effect in improving the work following it. At least the singing had no bad influence, as the ninth grade showed improvement after the work, and the eighth grade made a better combined average on the work immediately preceding and following than on the work in an uninterrupted period of the same time. The effect of singing in this case is not different from that of a free recess. It is doubtful whether the effort to sing at sight from printed notes would have the same beneficial influence.

Effects of Recesses.

Plate II indicates the efficiency of pupils influenced by different kinds of intermissions introduced into their extended periods of work. In order to get the full meaning of the intermissions it is necessary to compare the curves with those of Plate I, in which no interruptions were introduced. It will be seen that the ten-minute intermissions do not affect the results unfavorably. However, a close comparison with Plate I shows that the comparative results for the period following are about the same as when no intermission is allowed. The definite benefits probably appear later, and it may be noted here that in the algebra test the third ten minutes of work (*i. e.* the second ten minutes after the recess) shows less falling off than usual for this period. Indeed the eighth grade after recess show a continued improvement in the algebra as they do also in the long history test. It is evident that this grade have a greater need of recess than the ninth grade. This is further indicated by the fact that in the history test the eighth grade make a better average in two twenty-minute periods each preceded by ten minutes of relaxation than in forty minutes of continuous work (70.3 per cent. to 66.9 per cent.), while on the other hand, the ninth grade do decidedly better in the forty minutes of uninterrupted work.

It has already been pointed out that the twenty minutes given to gymnastics and recess combined proved of doubtful value to the work following in both the eighth and ninth grades, while the twenty-five minutes of dancing proved decidedly damaging. At the same time it was noted that ten minutes of formal gymnastics showed favorably for the sixth and seventh grades. In tests of rapid work in mental arithmetic taken at 12:05 p. m. before recess and at 12:30 after a twenty-minute recess, the ninth grade made an average of 94.2 per cent. before recess and of 96 per cent. after recess, while the eighth grade made an average of 94.3 per cent. before recess and 100 per cent. after recess. In this case the twenty-minute free recess seems to be valuable for both grades, but its value is greater in the eighth grade. This all seems to

point to the conclusion that the short intermissions of all types are better than the long ones. We may now consider the effect of recess upon the lower grades. Table 31 shows for a test in addition and subtraction in the fifth grade of the Training School an improvement of about 5 per cent. after a fifteen-minute recess at 12:30 p. m.; while Table 32 shows approximately the same for the fourth grade. The number of errors in both cases were fewer after recess.

We may next consider in Tables 33 and 34 the effects of a thirty-minute recess upon children of the sixth and fifth grades in the Fort Mill Schools. The children exercised moderately during the thirty minutes at playing ball and in various running games. They came into school after recess glowing with pleasure from their play. They entered upon their work with eagerness and worked hard throughout the time of the test. The results indicate in both classes about 5 per cent. increase in quantity of correct work, but the errors increased tremendously, showing in both classes more than twice as many errors after recess as before. The work after recess as compared to that before recess was unreasonably bad in quality. The children apparently failed to get the prompt mental adjustment required for accurate work. The case of more errors after recess certainly indicates that it is not safe to rely on number of errors alone, as Friedrich (36) and others have, for determining the degree of fatigue. Neither does the rate of work alone seem adequate for the determination. The final judgment must be based upon an estimation including both quantity and quality of work. This gives doubtful interpretation to the effects of the long recess. To count the wrong work simply as zero would indicate better ability after recess than before. But wrong results are worse than no results and should be counted as a negative value. How much negative value should be given to wrong results? Nothing but an arbitrary answer can be given, and every person can formulate his own answer. My judgment is that in this case the work after recess deserves a lower rating than before recess notwithstanding its increase in quantity.

36. Zeit. f. Psychologie und Physiologie der Sinnesorgane, Vol. 13.

This indicates again that the shorter recess of fifteen minutes is better than the thirty-minute recess, and confirms the general conclusion against the use of the long recess as well as against all extended intermissions. The evidence, however, is not complete, for we are unable at this time to determine the persisting physiological and mental effects of the more perfect relaxation due to long intermissions. This topic deserves further consideration than can be given to it at this time.

TABLE XXXI.

Fifth Grade, Winthrop Training School, January 12, 1911.

	12:25-12:30 P. M. Before Recess.		12:48-12:53 P. M. After Recess.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	66.7	3.0	64.0	2.2
Subtraction	64.0	8.0	75.3	7.2

Before Recess Averages: 65.3 correct, 5.5 errors.
After Recess Averages: 69.65 correct, 4.7 errors.
Mean variation 7.7 3.2

TABLE XXXII.

Fourth Grade, Winthrop Training School, January 12, 1911.

	12:25-12:30 P. M. Before Recess.		12:48-12:53 P. M. After Recess.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	62.1	3.0	57.6	3.0
Subtraction	56.0	18.0	67.2	13.0

Before Recess Averages: 59.0 correct, 10.5 errors.
After Recess Averages: 62.4 correct, 8.1 errors.
Mean variation 9.5 4.2

TABLE XXXIII.

Sixth Grade, Fort Mill School, Ten Girls, Average Age 12.8; Four Boys, Average Age 14, December 12, 1910.

	11:18-11:25 A. M. Before Recess.		12:12-12:19 P. M. After Recess.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	52.5	2.4	64.7	8.8
Subtraction	65.0	5.8	59.4	22.8

Before Recess Averages: 58.7 correct, 4.1 errors.
After Recess Averages: 62.1 correct, 15.8 errors.
Mean variation 10.3 4.1

TABLE XXXIV.

Fifth Grade, Fort Mill School, Eight Girls, Average Age 11; Nine Boys, Average Age 10.6; December 12, 1910.

	11:18-11:25 A. M. Before Recess.		12:12-12:19 P. M. After Recess.	
Average.	Correct.	Errors.	Correct.	Errors.
Addition	50.4	2.0	59.8	6.0
Subtraction	71.7	7.7	71.2	15.3

Before Recess Averages: 61.0 correct, 4.8 errors.
After Recess Averages: 65.5 correct, 10.6 errors.
Mean variation. 10.1 5.0

Effect of Lunches.

The time for eating their lunches and regular meals is a serious question for the children in the single session schools of the South. Generally they take but little lunch to school, and do not get their dinner till 3 o'clock. In some cases the family have their dinner at the same time, and in others the family eat an hour or two earlier and the children get a separate dinner when they come home—sometimes it is a cold one, sometimes it is "warmed over," and sometimes it is cooked fresh. In defense of this practice it should be said that the question resolves itself into a problem of local condi-

tions, (1) on account of the servants who do the cooking in the Southern homes and frequently live some distance from the family for whom they work. These servants want to go home about the middle of the afternoon. This makes the 6 o'clock dinner impracticable at present for people who depend upon servants, and this class constitutes a large proportion of the white citizens. (2) The hot weather of spring and fall makes it undesirable for the children to go home for dinner at the middle of the day and return for a school session in the afternoon.

The question naturally comes up in regard to the children bringing their lunches to school and eating them during intermissions. This is just what they might be expected to do, but, strange to say, there seems to be small practice of it. Through observation and inquiry I found that very few children brought anything to eat at recess except an apple or some other fruit.

In discussing the effects of the custom of the school children with other educators I found many of them critical in regard to it, but none had any definite conclusions to offer nor any data from which to derive conclusions.

I began by offering a longer recess of twenty to twenty-five minutes between 12 and 1 o'clock and at the same time suggested to the children that this would give them a better opportunity to eat their lunches. The children appreciated the longer recess, but the lunches did not come. I inquired of the parents whether their children did not get very hungry before they got their dinner, and told them that I had provided a longer recess in which to eat their lunches. "Yes," said the parents, "our children come home nearly starved, and we've kept after them to take lunch to school, but they won't do it." Occasionally the children prearranged for a "feast" at the recess period; then each would bring some part to school and they would spread it out in picnic fashion. These feasts, however, detracted from the quality of the school work following them. This was indicated in the remark of one of the student teachers, who said: "I do not mind teaching at any time of day except the period just after recess on picnic days. I wish

the children would not have any more 'feasts.' They are so hard to get settled to their work afterwards."

The custom in regard to the time of eating is so well established that people are slow to consider any change. It may be remarked, however, that an established custom is not always the best custom, even though it may be accepted as satisfactory to those habituated to it; and I believe that there should be a better arrangement provided by which school children could have their dinners at an earlier hour. My opinion is that such an arrangement can most practically be provided in connection with domestic science as a school subject belonging to the regular curriculum. But we have no time or space to devote to the discussion of plans in detail. All we care to claim is that the extra attention to eating would be, not better mental work, but better physical nutrition for the growth of the children.

Question of Overpressure.

Do these tests indicate that there is overpressure of work on the pupils? Evidently not. And while one may conclude that there is some falling off during a part of the day, still it does not seem sufficient for alarm. The periodic depression of ability is probably just a phase of the process of recuperation.

In further support of the fact that no serious fatigue was realized we found by observation of the quality of the regular recitations that the pupils were about equally efficient at all times of the day. The different subjects—algebra, history, etc.—were shifted to various places in the daily program, and each pupil-teacher was asked, after a trial at different hours, which period she preferred for teaching her subject. No choice was expressed, the teachers all declaring that the children did just as well at one time as at another, except at the period just after the second recess on days when the children had a picnic feast at this recess. The teachers expressed their disapproval of these luncheons, claiming that the children did not do good work in the recitations following them.

Likewise the advanced grades of the Training School showed no special fatigue for any particular day of the week,

from Tuesday to Saturday, inclusive. This was evidenced in a concrete way by the amount of supplementary reading done on different days of the week. The reading was entirely optional, but the pupils had access to a good library and as an encouragement in the use of the available books, they were asked to keep a record of their daily reading and report upon it. Their reports showed almost an equal amount of reading for each day of the week, slightly more being done on Saturday. This would certainly indicate no excessive fatigue at the end of the school week.

It may be claimed that the children of the eighth and ninth grades of the Training School did not work under the strain usually experienced by pupils in the first year of the high school, and I grant that this is probably true. The children of the Training School had study periods alternating with their recitation periods throughout the day, and were allowed thirty minutes of recess in the five and one-fourth hour session, but upon the other hand, they worked earnestly and accomplished their tasks in a satisfactory manner.

The fact that there is no indication of nervous strain or overpressure in the children included in these experiments does not exclude the probability that children are frequently injured by overwork and too long hours in school. The need of shorter hours, more recesses, and a greater variety of work applies especially to the younger children in school. It must be admitted, however, that we still lack data by which to establish this fact. There is now a need of more data on the fatigue of children in the primary grades.

SUMMARY OF CONCLUSIONS AND PEDAGOGICAL APPLICATIONS.

1. *Overpressure.*—The foregoing data do not indicate extreme fatigue or overpressure for the daily work in school children. There may be apparent exceptions, but usually they are the result of worry instead of work. In general there is more *weariness* than *fatigue* in the children; and mental activities are more necessary than complete idleness. Here then is the teachers problem: How provide the proper mental stimulations for keeping up the interest in school?

2. *Mental Stimulations.*—Purpose, pleasure of accomplishment, and interest in novelty and variety are strong stimulations to effort, and are very valuable for increasing the rate of working. If a boy sees no purpose in learning he will not learn. The teacher needs to establish and deepen the purpose of his pupils in securing knowledge; also he must provide work that they can do, so that they may get the encouragement of progress and accomplishment; and he must provide a variety of work that will break up the humdrum drudgery of school work and take away the tired feeling. Occasional change creates new life in the school, and greatly increases the work.

3. *Mental Inertia.*—Pupils are not at their highest efficiency at the beginning of the session. The warming-up process seems to be especially important in older children. It requires time to get into the swing of the work. Low working rate frequently results from lack of proper mind set or proper swing in the performance of the task. When the mind gets completely off a given line of thought it takes time to get back to it. This fact requires a caution against extended interruptions and too frequent changes, especially in the upper grades.

4. *Recesses.*—Recesses are especially valuable for the younger children. The short recesses of ten minutes to

fifteen minutes show an improvement in working ability in all grades, and are better than the long intermissions for the work immediately following. The longer recess evidently distracts the attention from the lessons, and the mental inertia of the older pupils requires considerable time for them to get readjusted to their work. The longer recess has a value in affording complete relaxation and relief from nervous strain, but is opposed to immediate mental efficiency.

5. *Gymnastics.*—Ten-minute periods of gymnastic exercises are beneficial to the work following them; but twenty-five minutes of folk-dancing prove decidedly damaging on the immediate mental efficiency. The short periods seem to furnish rest and relief from nervous strain without causing distraction from the mental work in hand. In the long periods perhaps considerable fatigue is produced, and also the mental inertia prevents immediate resumption of the work after the long gymnastic exercises.

6. *Lunches.*—Lunches in the five-hour school session are of no immediate benefit to the mental work. Indeed, the indications are that the lunches are quite the reverse of beneficial. When considered physiologically this is the thing to expect, for, after eating, the blood is demanded in the digestive organs until the food is absorbed. Even the attempt to study immediately after eating does an injustice to the digestion by tending to draw a large blood supply to the brain. Such facts do not, however, take away the responsibiltiy of providing good nutrition for the children at school as well as at home. It would be cruel and foolhardy to neglect the food supply required for the child's growth and development even at the expense of a little immediate mental efficiency.

7. *Singing.*—Singing for ten minutes increases the mental efficiency.

8. *Daily Variations.*—There is a small variation of efficiency for different times of the day. The working ability appears to reach its maximum from 10 to 11 a. m. and then drops off somewhat till between 12 and 1 p. m., to rise again till the close of school at 2 p. m. The advantages of the early periods

of the day are not so great as some would claim for them. One period seems about as good as another for any particular subject, like algebra. The alternation of easy and difficult subjects in the daily program is, however, valuable for the change and relaxation which it affords.

9. *Rhythmic Fluctuations.*—In continuous work high and low efficiency alternate in a kind of rhythmic flow. These waves of effort provide for a rest and recuperation and in this way prevent the fatigue from becoming excessive. This is a very important fact for teachers, who should provide for the up and down swing in the working ability of their pupils. Every one knows the difficulty of attending for an hour to a sermon or lecture which moves in the even tenor of its way, with no variation to break the monotony. The attention swings away and then comes back to the subject. Blessed is the preacher, teacher or lecturer who has the power of bringing back to his line of thought the wandering minds of his audience! And some of them can do it. Observe the rise and fall of intensity in the successful lecturer and the occasional interspersion of anecdote and joke with more serious matter. He needs to get his discourse and his audience to swing together and make his climaxes on the rising tide of attention. It is not required that teachers practice this degree of art, but it is important that they diversify their teaching and thus provide for the natural swing of attention in their pupils.

10. *Length of Recitations.*—While variation in teaching must be encouraged, the power of prolonged attention must also be cultivated. The recitation periods must be long enough in the advanced grades to allow full swing of the pupil's ability for a time on the lesson, and must not be broken up by too many interruptions. The facts of rhythmic movement and of mental inertia indicate the need of considerable continuity of work. It is impossible now to tell just what length and variation of periods is best adapted to the needs of the children. From the data shown in Plate I it would seem that in high school girls the fatigue depressions occur at

twenty-minute intervals, and this would suggest the need of at least one recuperative variation in a forty-minute recitation period. It is evident that younger children have less power of prolonged continuous attention, and consequently in the lower grades the recitation periods should be very much shorter than in the upper grades.

SAMPLE TESTS.

APPENDIX I AND II.

Subtraction

1. 9 4 7 3 8 5 6 8 2 5
   -2 1 5 3 3 5 2 4 0 3

2. 8 4 3 5 7 6 2 9 6 4
   -5 3 3 2 3 5 2 7 0 4

3. 4 4 3 2 5 6 4 2 1 7
   -1 4 4 1 6 5 2 0 2 4

4. 7 0 3 2 1 5 9 4 1 0
   -2 0 7 1 1 6 9 1 3 7

5. 6 9 5 4 0 0 4 5 3 1
   -1 4 6 0 0 5 5 5 5 5

6. 4 5 5 5 0 0 1 1 1 2
   -2 5 9 0 0 4 7 0 1 7

7. 9 1 9 8 8 9 9 5 9 1
   -7 0 9 9 8 1 9 9 1 9

8. 5 5 5 4 4 3 3 0 2 2
   -2 4 5 3 9 0 9 0 7 7

9. 8 8 8 7 7 7 6 5 3 4
   -1 0 8 8 8 1 4 6 7 9

10. 8 9 7 4 4 3 2 5 5 0
    -1 6 9 4 3 9 0 4 5 7

Multiplication

1. 1 3 7 9 2 4 2 3 1 2
   X 4

2. 1 6 0 7 2 3 5 4 1 3
   X5

3. 6 7 2 4 3 9 5 8 1 4
   X3

4. 6 2 1 0 5 9 3 7 4 2
   X8

5. 3 2 7 4 0 1 3 5 8 9
   X9

6. 2 7 0 3 5 6 1 4
   X27

7. 1 8 4 0 6 3 2 5
   X26

8. 1 2 9 5 7 4 0 9
   X49

9. 2 3 4 5 9 6 5
   X58

10. 1 4 7 9 0 7 3
    X47

Addition

1. 4 3 7 5 3 4 3 6 2 4
   5 2 1 2 6 2 5 3 7 3

2. 5 9 3 7 5 6 7 5 3 4
   2 5 2 5 6 6 2 3 4 4

3. 5 2 8 3 8 9 6 9 6 7
   4 6 1 8 9 7 8 5 8 4

4. 3 5 1 2 3 2 6 3 5 2
   5 1 3 2 4 0 1 1 1 3
   1 2 3 4 1 4 1 2 4 2

5. 3 4 1 4 2 5 6 4 6 5
   2 4 6 5 2 9 2 3 3 4
   3 4 2 5 2 2 2 5 3 2

6. 9 2 3 5 5 3 6 7 2 6
   8 6 4 7 8 9 4 3 5
   7 5 8 6 9 4 3 9 4

7. 5 4 0 9 7 5 2 8 5
   6 8 2 9 5 3 7 4 3
   3 2 5 5 6 7 6 7 9

8. 2 6 7 3 5 9 4 7 2 9
   1 7 9 2 3 5 9 5 7 8
   4 4 8 3 4 3 8 6 6 9

9. 5 6 4 9 3 2 7 1 8
   7 2 9 8 8 4 9 3 7
   4 4 5 6 3 1 8 9 2
   7 5 3 4 9 8 5 3 6

10. 8 9 7 4 1 1 7 9 5
    9 1 6 9 7 4 7 3 9
    4 9 7 3 9 2 8 4 4
    7 4 8 4 8 1 5 5 3

Division

1. 3 | 6 0 9 3 9 6 0 1 2 6

2. 2 | 6 1 0 5 4 3 7 4 9 8

3. 6 | 6 7 8 5 4 3 6 8 6 4

4. 7 | 9 2 8 2 4 8 3 1 4

5. 8 | 9 2 8 7 3 4 4 4 0

6. 12 | 1 3 2 8 8 8 5 6 4 2 4

7. 11 | 1 5 4 3 5 2 6 6 7 8 1

8. 15 | 3 0 4 5 6 1 8 0 1 5

9. 18 | 5 8 1 4 5 6 2 2 3 6

10. 24 | 5 2 0 2 1 2 2 4 9 6 0

APPENDIX III.

NINTH GRADE ALGEBRA TEST, SEPTEMBER 23, 1910.

Part A—Ten Minutes.

1. Find the rate if the interest on $750 for 6 months is $22.75.

2. Find the time if the amount of $640 at 6% is $1,000.

3. A man is now 4 times as old as his son; in 20 years he will be only twice as old as his son. Find age of each.

4. A & B have together $8; A & C $10; B & C $12. How much has each?

5. The difference of two numbers is 7, and their sum is 63. Find the numbers.

Part B—Ten Minutes.

If a=1, b=2, c=3, d=4 find value of:

(1) $ab+bc-ac$.

(2) $\sqrt{6bc-b-c}$.

(3) $\sqrt[3]{6b^2c^2}-\sqrt{b^2c^2d}$.

(4) $7(a^2+b^2)-2(c^2-d^2)$.

(5) $d^2-c^2\div b+\frac{1}{2}$.

Part C—Ten Minutes.

Factor: (1) $64a^2-b^2$.

(2) $16a^4-b^4$.

(3) $8a^3-b^3$.

(4) $x^4-(y+z)^4$.

(5) $x^3-y^3-3xy(x-y)$.

Part D—Ten Minutes.

1. Multiply: $x^5-41x-120$ *by* x^2+4x+5.
2. Multiply: $3x^2-2y^2+5z^2$ *by* $8x^2+2y^2-3z^2$.
3. Multiply: $4x+3+5z^2-6x3$ *by* $4-6x^2-5x$.
4. Divide: $x^2-4y^2-9z^2+12yz$ *by* $x+2y-3z$.
5. Divide: $5x^3-x+1-3x^4$ *by* $1+3x^2-2x$.

APPENDIX IV.

GENERAL HISTORY TEST, DECEMBER 22, 1910.

(A) Name 10 ancient cities. Locate each. Give an important date and event connected with each.

(B) Name 10 rulers. Tell where and when each lived and something for which he was noted.

(C) Name 10 ancient battles, giving place, date and result of each.

(D) Name 10 ancient military leaders. Tell where and when each lived and something for which he was noted.

APPENDIX V.

NINTH GRADE LATIN TEST, DECEMBER 21, 1911.

Part A—Ten Minutes.

1. Conjugate *veniō* in the imperfect and pluperfect active, indicative and subjunctive.

2. Give the principal parts and all the infinitives of *landō,* and conjugate it in the present tense indicative and subjunctive.

Part B—Ten Minutes.

1. Decline: (1) *Pōculum,* (2) *rēs,* (3) *animal,* (4) *brevis,* (5) *totus.*

2. What classes of nouns belong to the i- stems? Illustrate with 5 examples.

Part C—Ten Minutes.

Give meaning:

1. In English—

(1) Sōl, sōlio
(2) porta-æ
(3) cantus-ūs
(4) virtium-ī
(5) miror
(6) circumveniō
(7) spērō
(8) sentiō
(9) ūtor
(10) credō

2. In Latin—

(1) Ambassador
(2) peace
(3) shout
(4) reward
(5) republic
(6) give
(7) see
(8) enjoy
(9) use
(10) go forward

Part D—Ten Minutes.

Translate Latin into English, and the English into Latin:

(1) Dux, cum castra mūnita essent, ad hostīs prosperāvit.
(2) Cōnsul, pāce factá, Rōmans vēnit.
(3) The boy is so lazy that he cannot learn.
(4) He stays at home that he may not learn.