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MEASUREMENTS OF SOME ABILITIES IN SCIENTIFIC THINKING

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NEED.—Civilized society needs more scientific ability.

There is a most vexing scientific problem which arises daily in all our lives. Some circumstances there are amid which it is wise to rely upon competent authority; others, upon personal investigation; and yet others, upon both. How may our population distinguish among these? Amid what circumstances trust conclusions? Even slightly keener insight into this problem is valuable.

A distinction, vital, yet forming no defined part of these measurements has here to be made,—a distinction, in the sense to be defined, between primary and secondary data. Primary data are selected by the individual from immediate experience; secondary data, from representations of the immediate experience of other individuals. When I see James board the street-car, I am selecting a primary datum. When John tells me that James boarded the street-car, I am selecting a secondary datum. The primary are always the basis. To them is the final reference. They are more educative than the secondary. Their use in our schools is still too rare. Nothing so characterises the modern period of history as its insistence upon building its thought world when it can out of primary data, and its knowledge that secondary data are subjected consciously and unconsciously to certain streams of influence, such as prejudice and carelessness, not to mention greed, from which the sole escape is vigilant comparison with primary data. We in the school are still too exclusively mediaeval schoolmen, in the sense of depending too much upon secondary data for our conclusions, and of being too content to encourage our students to conclude upon the bases of secondary data alone. Too often we accept statements from books instead of those from life that could be found easily and used

convincingly. To let print pass as evidence when experience is both available and educative is to revert to attitudes which it was a function of the Renaissance to replace. For the middle ages Aristotle was a final authority; for this modern age no authority is final. In this age we must train children to rely much upon the testimony of their own senses, taken with their interpretation of the material furnished them by their senses. It is not scientific to rely habitually upon the conclusions of others without seeking primary data, for which the search is often feasible. This emphasis has been placed by some writers and teachers, but it is general neither in thought nor in practice.

When and how to investigate, when and how to recognize authority, when and how to combine investigation with authority,—these are problems of scientific method, of education, and of citizenship. It is sound educational policy to give them central importance in school. How many dismal errors of judgment at critical moments in public and private life could thus be averted,—errors in the choice of political candidates, of employment, of studies, of vocation and avocation, of national and individual friends and enemies, of dress, of residence, of attitudes, of schools, of courses of study, of food, clothing, shelter, education, and amusement,—of all,—everything,—that ever makes or mars our lives?

AIM.—The ultimate aim of this investigation is to aid in focusing attention sharply upon scientific method as the proper method of children's study, both in the eleven abilities tested, and in all other abilities which are at once important and feasible.

The immediate aim of this investigation is to increase the consciousness and effectiveness of the use of eleven scientific abilities.

Scientific ability is used daily both by adults and by children. It is used more or less consciously, accurately, effectively, and appropriately. When pupils make good use of method, their world of data and their education are ordered and relatively useful. The scientific method is the best method. In its highest reaches it is complexity itself. In its simplest forms its elements are employed unconsciously by children in the pre-school age. The published mathematical calculations of the position of the planet Neptune, before it had ever been seen, filled several volumes. A girl of three said: "Big engine says, 'Ding dong;' 'Pussy's in the Well' says, 'Ding dong;' many things say, 'Ding dong.'" She collected two facts and made an inductive conclusion. A child of five, who said,

"A pond is a little round place to sail boats in—with water in," defined imperfectly; nevertheless, to a certain extent, she employed ability number three. Her mental work falls within the concept of scientific method. It is such crudely elementary uses of method by the masses of children upon which we must erect the superstructure of more advanced and finished work. We must teach no less of the content of geography, but we must lay more stress upon teaching children to study, to handle problems, to work methodically, to plan independently their own ways of solving problems, to lay out their own work, to observe precisely, to remember exactly and fully, to think well, to expound clearly,—in short, to use the scientific method.

The ultimate aim of this investigation is wider than the present scope of the test.

DEFINITION.—The competent have never formulated even a tentative consensus of judgment in answer to the question: What is scientific method? In the absence of such an agreement concerning the living and developing complex of processes known as scientific method the following is a more vague and arbitrary statement, of which the first part expresses a general meaning, and the second a meaning narrowed by analysis and selection to the particular purposes of this investigation.

The aim of science is to explain the world. The aim of a science is to explain a limited portion of the world. The scientific method is that complex of processes used in the attempts to explain. It is a complex of processes which are never mutually exclusive. It is a complex into which its elements enter in ever varying frequency, order, and degree. While it can be analyzed usefully, it can be analyzed neither finally,—for scientists alter its use from age to age; nor universally,—for scientists alter its use from field to field.

The history of the theory of scientific method is suggested by such names as Francis Bacon, John Stuart Mill, W. Stanley Jevons, and Karl Pearson.

ANALYSIS.—From among the processes of which the total complex is scientific method, eleven, which have importance with reference to scientific work, and feasibility with reference to inclusion in this scientific method test, have been selected. While all of them together are very far from constituting the whole of scientific method, severally they fall quite within that concept. They are called more or less into play whenever a problem is to be solved carefully,—that

is, whenever the scientific method is to be used. Each **ability** is a process used in science. In the list following, each is designated by a catch-word. Each catch-word appears at the top of each of three exercises. Each exercise is intended as a partial measure of one ability. (The catch-words do not appear in the test as given to the students.) Following this list is an equal number of paragraphs, each devoted to the definition of one ability.

1. <i>Value</i>	5. <i>Statistics</i>	9. <i>Classification</i>
2. <i>Feasibility</i>	6. <i>Relevancy</i>	10. <i>Arrangement</i>
3. <i>Definition</i>	7. <i>Recording</i>	11. <i>Sufficiency</i>
4. <i>Clarity</i>	8. <i>Comparison</i>	

1. *Value.* The ability of pupils to judge as to the relative values of different problems. Whenever a problem is suggested for solution, this question should arise first: Is the problem worth solving? Will its solution be of enough value to pay for the work it will take? Will the conclusions of the investigation be of worth?

2. *Feasibility.* The ability of pupils to judge whether problems can or cannot be solved. When one has decided that it would be valuable to solve a certain problem, the very next question is: Can it be solved? Can suitable methods be devised? Can enough relevant data be found?

3. *Definition.* The ability of pupils to distinguish good definitions from bad. When one has decided to try to solve some problem, the need of defining some of its terms often arises. Pupils need to know the differences between good and bad definitions. A definition of a thing usually states a class in which the thing belongs, and a mark or marks by which the thing may be distinguished from differing things in the class.

4. *Clarity.* The ability to distinguish sentences which contain no ambiguity from those which contain ambiguity; to locate ambiguity; to recognize clarity of expression.

5. *Statistics.* The ability to know when statistics are needed in the proof of a statement or in the solution of a problem.

6. *Relevancy.* The ability to select facts that relate to the problem and to reject those that do not; to stick to the point. When one has chosen his problem and made clear its meaning, one must know how to select data that will aid in its solution, and to reject those that will not.

7. *Recording.* The ability to select the better from among the poorer methods of recording the facts relevant to a problem.

8. *Comparison.* The ability to distinguish good from bad comparisons. Comparison involves the likenesses and the differences of two or more things.

9. *Classification.* The ability to distinguish between a class containing something foreign to it and a class not containing something foreign to it; to recognize the presence of something foreign in a class.

10. *Arrangement.* The ability to arrange the members of a class in useful sequence; to distinguish between good and bad arrangements. When one has placed the relevant objects or data each in its own class in accordance with some purpose, the members of each class should usually be set one after the other in some sequence. The sequence may be dominated by any one of a great variety of ideas, according to the purpose, such as number, size, color, or degrees of importance, of difficulty, or of obviousness.

11. *Sufficiency.* The ability to judge whether the data are sufficient for the purpose. Having the relevant data thus classified and arranged, no conclusion may be drawn until the question of sufficiency has been answered: Are the data of enough combined weight to prove the point? Are they adequate to solve the problem? One method of proof is never considered sufficient for a proposition of much difficulty or importance, but must, when possible, be supplemented, that is, substantiated, checked, verified, by one or more other methods. Only a verified proof is sufficient. Verification is somewhat the same idea as sufficiency.

The test as given to students is printed on an eight page folder in eight point type. On the first page are blanks for name, date, address, grade, class, teacher, scores, and a sample exercise which is explained and solved. There are also the following:

DIRECTIONS TO STUDENTS

These exercises are given to see how well you can think. On the following pages you will find other exercises like the sample above. Do the first, then the second, and then the others in order, until you have done all you can. You will have all the time you need. Work all the time. Look over each exercise, after you have done it, to be sure you have done it right. If you make any mistake, correct it. Ask no questions. Let no one help you.

After you have done all the exercises you can, take them to the teacher at once. Take your pencil with you. As soon as the teacher has written down how long it took you to do the test, write the answers to the two questions below:

Did you get any help on any exercise on the following pages? Answer "Yes," or "No.".....

If you did, what help did you get?

THE TEST

1. Classification

Put a cross on the line before the word that is in the wrong group of words; but if there is no such word, put a cross here.....

<i>Animals</i>	<i>Buildings</i>	<i>Foods</i>	<i>Fruits</i>
..... cat	house	meat	apple
.....cow	 barn	bread	dog
..... horse	store	butter	cherry

2. Clarity

Put a cross on the line before the sentence that is not clear; but if there is no such sentence, put a cross here

..... Some lakes are small, some lakes are large, and some are very large.

..... Some ponds are small, and some are large.

..... Men are not all the same height, for some are taller than others.

..... Some men are short, and some men are very tall.

..... Some women are short, and some women are very tall.

..... Women are not always of the same height as men.

..... Many ponds are small.

..... Many lakes are large.

..... John and James went fishing, and he was drowned.

..... Some mountains are larger than others.

..... Some lakes are larger than others

..... Some men are taller than others.

3. Relevancy

Put a cross on the line before the fact that helps show that the air is colder high up than it is low down; but if there is no such fact, put a cross here.....

..... Tables have four legs, braces, and tops, and are very useful for many purposes.

..... Chairs have four legs.

..... Some houses are colder than others.

..... Cradles sometimes rock.

..... Some men are colder-blooded than others.

..... The animals give us much food and clothing.

..... Horses are larger than dogs.

..... Mountain peaks are cold.

..... Animals usually have ears.

..... Animals usually have eyes.

..... Some animals are colder-blooded than we.

..... Some chairs rock.

4. *Definition*

Put a cross on the line before the best way of telling what a pond is; but if there is no such way, put a cross here

-A thing with water all the way around it.
- Something useful to boys and girls who like to swim.
- Something surrounded by people who are talking.
- A small body of water surrounded by land.
- A house surrounded by a large forest in this country.
-A street.
- A number.
- A book.
-Lands.
- Water and land.
- A body of water, large or small, and almost surrounded by land.
-A body of land.

5. *Feasibility*

Put a cross on the line before the statement that would be too hard to prove true; but if there is no such statement, put a cross here.....

-Some children are taller than others.
-Some women are older than others.
-Some old men are smaller than others.
- Some children are larger than others.
- Some children have better homes than others.
-Some children know more than others.
- Some children know less than others.
- The brightest child lives in Boston.
-Children go to school, at least in this part of the world.
-Grown people do not.
- Some men know more than others, and the same is true of women.
- Some men know more than some women.

6 *Arrangement*

Put a cross on the line before the group of things that come in the best order; but if there is no such group, put a cross here

- baby, boy, young man, old man
- baby, young man, old man, boy
- old man, boy, baby, young man
- baby, boy, old man, young man
- old man, young man, baby, boy
- boy, old man, young man, baby
- boy, baby, young man, old man
- young man, old man, boy, baby
- young man, baby, boy, old man
- boy, old man, young man, baby
- baby, boy, old man, young man
- old man, young man, baby, boy

7. Clarity

Put a line under the word that makes the following sentence not clear; but if there is no such word, put a cross here.....

Boston and New York are both large cities, but it is smaller than the other.

8. Recording

Put a cross on the line before the best way of keeping facts in geography until you are ready to use them; but if there is no such way, put a cross here....

- Write them down, put the paper in your book, and lose the book.
- Talk plainly to someone who knows how to keep the facts he will want to use.
- Write your name.
- Write a friend's name, then your mother's, and then your father's.
- Speak.
- Speak loud.
- Go somewhere.
- Write the facts down, using just a few words for each.
- Write.
- Write your name fast; then write it again and again without stopping.
- Write your name slowly.
- Write your name well; then try to write it better and better.

9. Sufficiency

Put a cross on the line before the way by which you could surely find out how much rain falls in New York City in a year; but if there is no such way, put a cross here.....

- Ask any one you meet.
- Think about it hard.
- Look in the right book.
- Ask some friend who lives far away.
- Ask two friends who live near.
- Guess at it.
- Guess at it and have two or three friends guess at it.
- Sit still.
- Do not whisper; always do what your teacher tells you to do.
- Be good.
- Sit still and think hard.
- Write about it to your friends.

10. Arrangement

Put a cross on the line before the best order of things; but if there is no such order, put a cross here.....

.....cloud rain river brook ocean
 rain cloud brook river ocean
ocean rain cloud brook river
river ocean rain cloud brook
cloud brook river ocean rain
brook river ocean rain cloud
brook rain cloud river ocean
 rain cloud river ocean brook
cloud river ocean brook rain
cloud rain brook river ocean
river ocean brook rain cloud
 ocean brook rain cloud river

11. *Value*

Put a cross on the line before the question that is most important to the greatest number of persons; but if there is no such question, put a cross here.....

.....Is your father ill?
Does Mr. Jones own his house?
Is your pencil sharp?
Can you run a mile without stopping?
Will the earth continue to have enough light?
Does a pound of feathers weigh as much as a pound of lead?
Does candy ever cost eighty-five cents a pound?
Does candy ever cost thirty-five cents a pound?
Are some fire-places built of brick?
Are some of the very best stoves made of iron?
Have tables four legs each?
Do some chairs rock?

12. *Definition*

Put a cross on the line before the best way of telling what a pond is; but if there is no such way, put a cross here....

.....A body of water wholly surrounded by land.
A body of water surrounded by land.
Water which is of use to boys and girls.
Water surrounded by land.
A small body surrounded by land
Still water.
A small body of water surrounded by land.
A body of land surrounded by water.
A large body of water surrounded by land.
A small body of land surrounded by water.
A body of land fitted for man to live on.
Land and water.

13 Feasibility

Put a cross on the line before the statement that can be proved true; but if there is no such statement, put a cross here.....

-The telephone is just as useful as the telegraph.
-The heat of summer is harder to bear than the cold of winter.
-It is better for all persons to live in valleys than upon hills.
-Next summer will be hotter than last summer.
-There is always too little rain.
-Dogs never do harm.
-Iron-making is the most useful industry.
-Canada is farther north than the United States.
-Sometimes two persons are just alike.
-Sometimes two blades of grass are just alike.
-A pound of lead weighs more than a pound of feathers.
-Sometimes two Americans are just alike.

14. Relevancy

Put a cross on the line near the statement that helps show that air is colder high up than it is low down; but if there is no such statement, put a cross here.....

-Too little rain hurts plants.
-Men can sail in the Arctic Ocean only a small part of the year.
-There is snow in summer on some mountains.
-Plants grow fast in warm, wet places.
-Dogs have saved many persons lost in the snow
-The North Pole was discovered.
-It is cooler in the shade than in the sun.
-Snow lasts longer in the shade than in the sun.
-There are railroads on the sides of some high mountains.
-Men should be strong to climb some high mountains
-Too great cold hurts plants.
-Frost hurts some plants

15 Comparison

Put a cross on the line before the sentence that shows a difference between two things; but if there is no such sentence, put a cross here

-The Mississippi River is long, winding, and beautiful.
-Some rivers are short, rapid, and almost useless.
-The Mississippi River carries boats of many kinds.
-The boats carry cotton, wheat, and other things, besides passengers.
-China makes 15 million pounds of silk a year, Japan 7.
-Many boats carry passengers up and down the Mississippi River.
-Many of the boats have water-wheels to make them move.
-The water-wheels are placed at the ends of the boats.
-The water-wheels turn because they are driven by the engines
-The turning makes the boats go.
-The boats have engines.
-The engines make the wheels turn.

16 *Statistics*

Put a cross on the line before the statement that could be more surely proved by using numbers than in any other way; but if there is no such statement, put a cross here

-Some boys use boats well; some build boats well, too.
-Both girls and boys go to school in this country.
-Men and women in this country sometimes work to earn a living.
-Schools are made for teaching; they are sometimes used for public meetings
-Children go to school to study
-Children go to school to learn to study; they do not always succeed.
-There are teachers who do not teach children to study.
-There are beautiful children who go to school.
-This country contains some wildcats.
-A pound of sugar costs more than a pound of flour.
-Some houses are built of brick.
-A most important thing about school is learning to study.

17. *Classification*

Put a cross on the line before the best grouping of things; but if there is no such grouping, put a cross here

-house lion wildcat cat tiger school-house store
-house store cat lion tiger store wildcat
-lion cat store house tiger store wildcat
-tiger store wildcat lion cat store house
-tiger store wildcat house store cat lion
-tiger lion wildcat cat house school-house tiger
-house wildcat store tiger store wildcat
-house store wildcat tiger wildcat store
-lion house cat store tiger wildcat store
-house school-house store tiger lion wildcat cat
-tiger wildcat store lion store house cat
-house store cat lion tiger wildcat store

18 *Value*

Put a cross on the line before the question that is most important to the greatest number of people; but if there is no such question, put a cross here.....

-Will the sun continue to rise every morning?
-Are evergreens found in many parts of the earth?
-Is coal found in Alaska?
-Do rivers always flow from higher to lower ground?
-Do some mountain ranges run from north to south?
-Do some mountain ranges run from east to west.
-Was tobacco discovered in this country?
-Has the telephone been used for many years?
-Is coal mined in this country?
-Does water freeze in very cold weather?
-Does the moon go around the earth in about twenty-eight days?
-Is oil found in the earth with coal in this country?

19. *Value*

Put a cross on the line before the question that is most important to the greatest number of people; but if there is no such question, put a cross here

-Does man raise enough wheat?
-Do the forests yield enough wood?
-Do the strongest nations have the best schools?
-Do our cows and goats yield enough milk?
-How much coal is there left in the earth?
-Are the fur-bearing animals in danger of being killed in too great numbers?
-Are inland countries well connected with the sea by means of rivers?
-Are the continents well connected with each other by means of the oceans?
-Will the earth continue to have a good supply of heat?
-How much is the telephone used in the country?
-In what languages are the best books likely to be printed?
-How many more automobiles have been sold during the last year than during the year before that?

20. *Statistics*

Put a cross on the line before the statement that could be more surely proved by using numbers than in any other way; but if there is no such statement, put a cross here.

-Manufacturing is of great financial importance in Germany.
-Chairs are made of wood, nails, screws, glue, cloth, tacks, and paint.
-Swings are made of wood, nails, screws, chains, and other things.
-Mining is an interesting work.
-Iron and steel are in some ways alike and in some ways different.
-Mountains are beautiful.
-Lakes and mountains make beautiful scenery when seen together.
-Islands, lakes, and mountains make beautiful scenery.
-The United States, Canada, and Mexico contain beautiful scenery.
-To the people of the United States the camel is a strange animal.
-The Chinese have customs that are strange to us.
-The Indians have strange customs.

21. *Definition*

Put a cross on the line before the sentence that tells best what a river is; but if there is no such sentence, put a cross here.

-A river is a body of water; the body of water is in motion; the body of water is sometimes blown upon by the wind.
-A river is flowing water.
-A river is a large stream of water flowing through the land toward some other stream or body of water.
-A river is a stream of water flowing rapidly through the land, and finally reaching the ocean.
-A river is a stream of water flowing in a channel on land toward some other stream or body of water.
-A river is water.

- A river is a large stream of water flowing through a channel toward some other stream or body of water.
- A river is a stream flowing in such a way as to be of use to man.
- A river is a current of water.
- A river is a large current of water.
- A river is a current of water flowing through the land.
- A river is a stream of water flowing through the land; it is used for carrying boats.

22. *Recording*

Put a cross on the line before the best way of keeping facts in geography until you use them; but if there is no such way, put a cross here .

- Remember them even when it is hard to do so.
- Copy them from books.
- Copy sentences from books.
- Keep a note-book.
- Keep several note-books.
- Think hard and carefully as you work.
- Think hard and carefully as you find the facts.
- Let your teacher do it for you.
- Remember everything you read.
- Write each fact briefly and correctly.
- Try to remember the best of what you read.
- Always try to remember the best of what you read.

23 *Sufficiency*

Put a cross on the line before the way by which you could surely find out how much rain falls in New York City in any one night; but if there is no such way, put a cross here

- Ask your best friend.
- Ask your teacher at some time when she has not too much to do, so that she will have time to answer you carefully and fully.
- Ask your mother at night when you have reached home after school, at some time when she is not too busy, and when she is not too tired.
- Ask your father.
- Walk one mile alone, so that you may think about it without anyone to talk to you.
- Ask a friend.
- Walk two miles alone, dressed for the weather, so as to be free to think hard about the rain.
- Eat dinner at six, after a long walk in the open air with your best friends
- Guess at it.
- Ask your father at night, after he has come from work and has finished his dinner.
- Catch rain all night in the right cup rightly placed
- Sit in a chair, quietly thinking all the time about the weather and the rain

24. Feasibility

Put a cross on the line before the statement that could be proved true; but if there is no such statement, put a cross here

-The United States will always be the richest nation in the world.
- The United States will not always be the richest nation in the world.
-The theatre helps educate the world.
-The theatre does not help educate the world.
- China will some day rule the world.
- China will never rule the world.
-All great men are Europeans.
-No great men are Europeans.
-Europe will always be the richest continent.
- Europe will never be the richest continent.
- Asia will sometime give the world the richest men.
- Asia will never give the world the greatest men.

25. Recording

Put a cross on the line before the best way of keeping facts of geography until you are ready to use them; but if there is no such way, put a cross here.....

-Remember them by using your own best way of remembering facts.
-Copy them fully from books. Copy the whole of each sentence. Save these copies until you need them.
- Remember where they are so that you may be able to find them again easily whenever you want them.
-Copy sentences from books, leaving out words like "the" and "a," and any other words that have little meaning.
-Keep a note-book in which you write down everything you wish to keep, whether it was found in reading or in observing.
-Keep a note-book. Write each fact.
-Keep each fact you need by writing it in few and chosen words in a note-book.
-Keep a note-book. Use a sentence for each fact.
-Find the true connections among the facts; memorize these, and talk from memory.
-Memorize everything you read.
-Try to remember the important facts you read.
- Always try to memorize the more important facts you read.

26. Clarity

Put a cross before the sentence that is not clear; but if there is no such sentence, put a cross here

-Some rivers flow into rivers, and some flow into the ocean.
-Many rivers flow into the ocean, but not all flow into the ocean.
-Many brooks flow into lakes, and many brooks flow into rivers.
- Does water always flow down hill?
-Does water ever flow up hill?

-Two plowmen were talking to two other plowmen about their land.
-Flames usually go up, not down or to the side.
-The sun gives us light and heat every day.
- ... The earth turns around in exactly 24 hours.
- Some years are longer than others, and the longer years are called leap-years.
-Cows give milk, but the milk they give is not all alike; some milk is better than other milk
-Men milk cows

27 Arrangement

Put a cross on the line before the best arrangement of things; but if there is no such arrangement, put a cross here . . .

- ..valley hill mountain; ice steam water; drop brook river
- ..steam ice water; drop brook river, hill valley mountain
- ..hill mountain valley; steam ice water; drop brook river
- ..mountain hill valley; drop brook river; steam ice water
- ..hill valley mountain; steam ice water; drop brook river
- ..mountain valley hill; drop brook river; steam ice water
- ..ice steam water; drop brook river; hill mountain valley
- ..water steam ice; valley hill mountain; drop brook river
- ..steam water ice; brook drop river; valley hill mountain
- ..brook drop river; steam water ice; valley hill mountain
- ..brook river drop, ice water steam; hill mountain valley
-valley hill mountain; ice water steam; drop brook river
-brook river drop; ice water steam; hill mountain valley

28 Comparison

Put a cross on the line before the sentence that best shows a difference between the Pacific Ocean and the Atlantic Ocean; but if there is no such sentence, put a cross here

- .. One ocean is larger than the other.
- .. The Atlantic Ocean is smaller than the Pacific Ocean.
- .. The Pacific is much larger than the Atlantic.
- .. Both oceans have currents of water flowing through them.
- .. Both oceans are large bodies of water
- .. The Pacific has more square miles than the Atlantic.
- .. The Pacific contains many thousands of square miles.
- .. The Atlantic contains many thousands of square miles.
- .. Both bodies of water contain salt.
- .. The Atlantic ocean connects us with far-off lands.
- .. The Pacific connects us with far-off lands.
- .. Both oceans are useful, both are large, both carry ships, both have storms, and both are beautiful.

29. Comparison

Put a cross on the line before the best comparison; but if there is no such comparison, put a cross here . . .

-Lake Huron is larger than Lake Michigan
-Lake Michigan is deeper than Lake Huron.
-Both lakes are very large.
-Lake Michigan and Lake Huron are two lakes in the same water system; they are of nearly the same size; both carry much traffic; both carry many of the same boats. But the former has 22,322 square miles of area and 750 feet of depth, while the latter has only 21,729 square miles of area, but 870 feet of depth.

	Area	Elevation	Greatest Depth
.....Huron	22,322	582	750
.....Michigan	21,729	582	870

	Area in square miles	Elevation in feet	Depth in feet
.....Huron	22,322	582	750
.....Michigan	21,729	582	870

- These lakes show both likenesses and differences. The following are likenesses: (1) Both are in the same water-system. (2) Both carry much of the same traffic. (3) They have the same elevation, 582 feet. (4) Their areas are nearly equal, Huron having 593 square miles more than Michigan. (5) The lakes are much alike in shape, Huron being about three times as long as wide, and Michigan about four.
-These lakes show both likenesses and differences. The following are likenesses: (1) Both are in the same water-system. (2) Both carry much the same same traffic. (3) They have the same elevation above sea-level, 582 feet. The following are differences: (1) Huron has 22,322 square miles of area, and Michigan 21,729. (2) The lakes differ in shape, Huron being about three times as long as wide, Michigan about four. (3) The greatest depth of Huron is 750 feet, Michigan 870
-Huron and Michigan are nearly the same size.
-Huron is shorter than Michigan.
-Lake Huron does not have Chicago upon its shore.
- Both lakes are useful.

30 Classification

Put a cross on the line before the best grouping of things; but if there is no such grouping, put a cross here. . . .

	cat horse crab man fish dog		cat horse crab man fish dog
	tree bush wood man apple		tree bu:h wood apple fruit
	stone iron lead tin steel		stone iron man lead tin

cat horse crab man fish dog	cat horse crab man dog
.....tree bush wood apple fruit	tree bush wood apple fruit
stone iron lead tin steel	stone iron lead tin man
cat horse crab man fish dog	cat horse crab man fish dog
.....tree bush wood apple fruit	 tree bush wood apple fruit
stone iron bush tin steel	stone iron lead man steel
cat horse crab man fish dog	cat horse crab man fish dog
.....tree bush man wood apple	 tree bush iron wood fruit
stone iron lead tin steel	stone iron lead tin steel
cat horse crab man fish dog	cat horse crab man fish dog
.....tree bush tin wood apple	 tree bush stone apple fruit
stone iron lead tin steel	stone iron lead tin steel
cat horse crab man tin dog	cat horse crab man fish fruit
.....tree bush wood apple fruit	tree bush wood apple fruit
stone iron lead tin steel	stone iron lead tin steel

31. Relevancy

Put a cross on the line before the fact that helps show that air is colder high up than it is low down; but if there is no such fact, put a cross here

- More snow fell in the spring of 1888 in New England than for many springs before.
- Northern people moving to the south can live best in the high regions.
- Men who fly in flying machines must sometimes dress warm.
- It is colder in a well than at the top of it.
- It is much colder in the northern part of Alaska than in the southern.
- High towers have been blown down by the wind in many parts of the world.
- The Washington Monument is 555 feet high.
- Trees will not grow at the north pole, nor will they grow at the south pole.
- Bears sleep through the winter.
- Many birds that live in the north during the summer fly south for the winter.
- A mountainous country is more beautiful than a flat one.
- It often feels colder out of doors than in a room with windows and doors shut.

32. Statistics

Put a cross on the line before the statement that would need the most numbers to prove it; but if there is no such statement, put a cross here.....

- Many plants grow fast in warm, wet places.
- Many men raise wheat in the upper Mississippi valley.
- Wheat is the chief crop of the upper Mississippi valley.

-Canada raises more wheat and corn than the United States.
-Large quantities of corn and oats grow in the United States.
- The United States is a great manufacturing nation.
-Water covers two-thirds of the earth's surface.
-More rain falls on the western coast of this country than upon the eastern.
-China makes 15 million pounds of silk a year, Japan 7 million.
-It is sometimes cold in Canada.
-It is sometimes cold in England.
- It is sometimes cold in the United States.

33. *Sufficiency*

Put a cross on the line before the way in which you could surely find out how much rain falls in any one year in New York; but if there is no such way, put a cross here.....

- Save the newspaper reports.
- Ask a good weather-man.
- Catch rain in a dish every time it rains; measure the amount; save the records.
-Take the government statement of the average rainfall per year.
-Watch the rains yourself, carefully guessing the amount each time it rains, and saving the records.
- Catch rain all the time it rains in a dish carefully made for that purpose.
- Read rainfall reports from all the important cities of the United States.
- Take the daily weather report of the newspapers, save the figures, and add up at the end of the year.
-Read newspapers and reports.
- Ask a good teacher in geography.
-Read all the New York papers.
-Discuss the matter carefully with a group of friends.

THE RIGHT ANSWERS

Each exercise is either right or wrong. Mark wrong all cases of crosses on more than one line. Mark wrong all cases of really ambiguous placing of a cross. Any mark which clearly indicates an answer here designated as a correct answer, should be marked correct. Some children mark with a slanting or vertical line. This should be counted correct. The right answers are below. No other answers may be counted correct.

- 1 x dog
- 2 x John
- 3 x Mountain
- 4 x A small
- 5 x The
- 6 x baby, boy, young
- 7 x it
- 8 x Write the facts
- 9 x Look

- 10 x cloud, rain, brook
- 11 x Will
- 12 x A small body of water
- 13 x Canada
- 14 x There is snow
- 15 x China
- 16 x A pound
- 17 x house school-house
- 18 x Will
- 19 x Will
- 20 x Manufacturing
- 21 x A river is a large stream of water flowing through the land
- 22 x Write
- 23 x Catch
- 24 x The theatre helps
- 25 x Keep each fact
- 26 x Two
- 27 x valley hill mountain; ice water
- 28 x The Pacific is
- 29 x These lakes Michigan 870.
- 30 x (The second group at the left)
- 31 x Northern
- 32 x The United
- 33 x Ask a good weather man.

MEANS.—The means is found in the analytical diagnosis of classes and of individuals afforded by the test. This is illustrated in the case of one class and of one pupil below:

This illustration suggests that L. S. needs improvement in the abilities here named recording, comparison, and sufficiency. She seems especially good in her judgment of the feasibility of problems, and about average in her other abilities. The individual graph is, of course, less reliable than the grade graph would be. Suppose, however, that the ability of L. S. to tell good from bad comparisons were really near the median of her class instead of far below it, as indicated by her graph. If this fact is discovered, the graph has served its purpose. Taken with the extended observations of a teacher, and perhaps of a principal, the graph will constitute a real value, will offer a tentative analysis of the child's ability, and will suggest means of improvement.

At the outset two courses were open: to study one ability intensively, or to survey in a preliminary way a field made up of several abilities; to investigate, for instance, judgments as to the values of different problems (ability 1), or to look more broadly and less

SCHOOL A; PUPIL L. S.; AGE 11; CLASS 6A; DATE, MARCH 14 1917

Graph showing the performance of a sixth grade class and of individual L. S. The vertical scale at the left is of P. E. units of difficulty. The horizontal row of numbers and letters is read thus: Ability 1, value; ability 2, feasibility; etc. (See page 5.) The variations of L. S. above and below her class appear. T means time.

deeply upon judgments involved in the exercise of the eleven abilities. The more inclusive scope was selected, the test in the present form being the result. Through this test conclusions as to the group standing of a class of pupils in each of the eleven abilities may be drawn. This preliminary survey of portions of the great field of scientific ability may properly be followed by a more searching one composed of a series of tests, one or more for each of the eleven abilities and for other abilities. Through such a series conclusions could be drawn regarding the abilities of individual pupils,—conclusions which would possess a degree of reliability not contemplated in the present work.

RELIABILITY.—The reliability of conclusions expressed, upon the basis of the present test, by graphs for classes of pupils, would be sufficient; for individuals, usefully suggestive. Consider, however, the case for the reliability of the individual graph. Exercise number one calls for at least twelve classification judgments before the right answer can be made with confidence. Since there are

thirteen possible places for a cross, the chance for getting an exercise right without thinking is about eight per cent. The probability, therefore, that a cross on the line before the word *dog* is placed there as the result of careful thought is great, while the probability that three crosses on the right lines in the set of exercises labelled *classification* are placed there as the result of careful thought is very great. Students getting all three right really know something about classification. There would be of course a negligible number of exceptions in a large number of cases. It is true that an exception is not negligible for the individual that happens to be concerned, but the frequency would be low with which more than one or two of the ability scores of an individual would be much wrong. This graph is a usefully suggestive conclusion. It is at the same time the most vital and the least reliable conclusion. It will be important to develop at a later time two commensurate series of scaled exercises for each ability, in order to obtain very accurate graphs for each child.

A precise measurement of one trait in one individual by means of the present test is not contemplated, for such a measurement could not be based upon responses to three exercises. Four scores only are possible: none right, one right, two right, and three right.

CLASSIFICATION OF THE TEST.—This is a test of method, not of content. One class of mental measurements concerns the subjects of the curriculum, as spelling, reading, writing, and arithmetic. It deals with the content of subjects. Another class studies capacities and abilities each of which is used in several or in all of the subjects of the curriculum. In this class belong measurements of intelligence, memory, and reasoning. In this class also belongs this scientific method test, which aims to measure the abilities of students to use certain elements of the scientific method. All the content of this test falls within the subject of geography, but the aim is to measure the ability to use scientific method in geography, not the ability to remember geographical content.

Both method and content are of worth. To whatever extent an ability to employ a method may be transferred from field to field by students,—and even if it may not be transferred at all, it is still an essential to progress within the field. Content is the other essential. It is the whole world. Its study broadens the view. It is the material upon which we use method. Yet it means relatively little to our matriculating boys and girls without some conscious mastery of method.

THE HISTORY OF THE TEST.—The test is in its third edition. After an experiment with a brief first edition on October 31, 1916, all the exercises were for one reason or another discarded. It had consisted of nine exercises somewhat similar in form to those of the present edition. A second edition of forty exercises was then prepared. There were three or four exercises to measure each of the eleven abilities. These exercises were submitted to six judges for two purposes: to determine the validity of the answers and the fitness of each exercise as a measure of a specified ability. For instance, numbers 3, 14, and 31 are intended to measure relevancy judgments. Do they do this, or do they do something else? Are the students who score high in these three exercises the ones whose relevancy judgments are usually good? The question is a fair one. Within limitations there is an answer. The six judges were chosen for mental acumen and for their long study of scientific method. One is the head of a department of philosophy, of which two others are members; one is a member of a department of history, and one of a department of mathematics,—all these in a university; and one is an engineer and a teacher of mechanical drawing in a high school. Each spent from two to five hours upon the exercises. They worked separately, and except in one case had not seen the exercises before doing the work. To each were presented the forty exercises and the list of abilities substantially as defined above. Each stated which, if any, of the abilities was tested by each exercise. Not even at first was there a discouraging amount of disagreement. Some exercises were discarded, some modified slightly, and some rebuilt. At last the judges came to a practical agreement. Below is a tabulation of the responses of the judges, (a, b, c, d, e, f,) to the question: Does each exercise test that which it is designed to test? As to the correctness of the answers, each judge passed upon that point for each exercise as a preliminary to the tabulated judgment above. Each exercise needing it was modified until it met the approval of each judge before whom it came. The v's serve therefore as a tabulation of this judgment also. Every exercise has only v's because each one not at first receiving them was modified until it did.

	a	b	c	d	e	f		a	b	c	d	e	f
1	v	v	v	v	v		18	v	v	v	v	v	
2	v	v	v	v	v		19	v	v	v	v	v	
3	v	v	v	v	v		20	v	v	v	v	v	
4	v	v	v	v			21	v	v	v	v		
5	v	v	v	v	v		22	v	v	v	v		
6	v		v	v	v	v	23	v	v	v	v	v	v
7	v	v	v	v	v		24	v	v	v	v		
8	v	v	v	v	v		25	v	v	v	v	v	
9	v	v		v	v	v	26	v	v	v	v	v	
10	v	v	v	v	v	v	27	(v)	v	v	v	v	
11	v	v	v	v	v		28	v	v	v	v	v	
12	v	v	v	v	v		29	v	v	v	v		v
13	v	v	v	v	v		30	v	v	v	v	(v)	v
14	v	v	v	v	v		31	v	v	(v)	v		
15	v	v	v	v	v		32	v	v	v	v		
16	v	(v)	v	v	v		33	v	v		v	v	v
17	v	v	v	v	(v)	v							

v . . . Judge gave the opinion that the exercise would test the use of the ability with which it is labelled.

v . . . Judge gave such an opinion after some modification of the exercise, which was then submitted to the other judges indicated.

(v) . . . Judge agreed with the label after a brief discussion.

The exercises have also been through the processes of renovation and rebuilding as the result of two trials, one with the first and one with the second edition. It would be too much to state that each set of three exercises measures all that which is defined under its catch-word and nothing more; but it is hoped that each set of three is a significant measure of some considerable portion of that which is defined and of little else.

In March, 1917, the forty exercises of the second edition were submitted to 140 grade school pupils and to 141 high school pupils. So far as could be seen most of the exercises were good ones. Seven were discarded, leaving three for each of the eleven abilities,—thirty-three in all. The text of the test seemed now to have been fitted for a more extended use. About 1800 grade pupils took the test in May, 1917, and others will soon take it in grade schools, high schools, and colleges.

Throughout the building of the test, it has been the aim to reduce toward a minimum the difficulties of the directions found at the beginning of each exercise, of the wording, and of the content of

the test. Yet the trite, but pertinent question: What is measured? is sure to make its appearance. The safe answer is: Responses to the thirty-three exercises of the test, as printed, are measured. The question: Does the test measure abilities as defined? must, in the last analysis, be answered by those who read the statistics and conclusions to be published at some future time.

CONCLUSION.—Our schools now confront a danger arising from an embarrassment of riches. They are to be felicitated on having in their stock-rooms splendid supplies of measuring tests, which are being put to excellent use,—tests in the four fundamental processes and the reasoning of arithmetic, in punctuation, in spelling, in language, in oral and silent reading, in handwriting, and in drawing. But it happens to be generally true that those human abilities which it seemed proper to measure first, perhaps because they could be measured easily, did not happen to be those of the greatest value socially. Such measurements as those of ability in silent and rapid reading, of intelligence, of thinking, and of judgments are of the utmost value. Coupled with the tendency to measure first that which seemed most feasible, there has been, fortunately, some tendency to measure first that which seemed most important,—provided it seemed also feasible. The latter tendency is right. Together with the further development of tests which involve mainly memory, we need a proportionate production of tests of the highest mental qualities,—so far as these may be measured. While the measurement of scientific ability is beset with difficulty, still it is dealing, not mainly with memory, nor addition, nor spelling, nor punctuation,—important as these are,—but with the noblest intellectual function, judgment.