This publication is the report of the instructional program, "Measure and Find Out, A Quantitative Approach to Science," designed for grades four, five, and six. The basic rationale of the program is not to present any material which a child cannot observe, describe, and measure. The report is divided into five parts, each explaining different aspects of this project. These sections are: "Goals and Objectives," "Content and Materials," "Classroom Action," "Implementation: Requirements and Costs," and "Program Development and Evaluation." A short bibliography is provided. (PS)
Program Report

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Educational Research and Development
Far West Laboratory for Information/Utilization Division

Measure and Find Out
# Basic Information

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**Goals and Objectives**

1. Long-range goals
2. Terminal objectives
3. Detailed objectives

**Content and Materials**

1. Content focus
2. Content and organization of subdivision
3. Classroom action
4. Implementation: Requirements and Costs

**Intended Audience**

- Teachers
- Administrators
- Parents
- Community members

**Context of Use**

- Elementary schools
- Middle schools
- High schools

**Limitations**

- Limited to specific grade levels
- Not suitable for special education needs
5. Program Development and Evaluation

5.1 Rationale

5.2 Program development

5.3 Developer's evaluation

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Bibliography
BASIC INFORMATION

Program Name: Measure and Find Out, A Quantitative Approach to Science
Format: Series of three workbooks
Uniqueness: A quantitative approach to science stressing measurement and graphing
Content: General science
Suggested Use: Complete program or supplement
Target Audience: Fourth-, fifth-, and sixth-graders junior high students who need remediation
Length of Use: Once or twice weekly for one to two hour periods
Availability: Workbooks and materials available from the publisher
Teacher's notes available for each workbook
Aids for Teachers: 

Format: Measure and Find Out, A Quantitative Approach to Science
Measure and Find Out differs "quite radically" from other elementary science programs because it simply does not include treatment of any topic that a child cannot observe, describe, and measure. That is the view of Measure and Find Out developer Clifford Swartz, a college physics professor whose primary purpose in designing the program was to prepare children for success in science courses above the elementary level.

The program has not undergone extensive evaluation. An informal poll of teachers involved in Long Island field tests indicated general success for most lessons. Some teachers criticized the absence of material on zoology and ecology. An update down\textsuperscript{ upd }\textsuperscript{ p }

A lesson in Book Two (grade 5) instructs children to measure the mass and length of three dried beans, and a variety of other phenomena. Grams, kilograms, meters, and centimeters are then used to measure time, weather, plant growth, electricity, and a host of other phenomena. "Which way do the roots grow?" and "What happens to the root when a seed is planted upide down?" workbook questions, which are then answered with a magnifying lens, and diagrams illustrating the growth of roots. They are measured, looked at, their plasmatic tissues studied, and then soak them and four more seeds in water for a day. In the next lesson, students sit open the three seeds and soak them and four more seeds in water for a day. In the next lesson, students sit open the three seeds, diagram the growth of roots, look at the tiny plants inside with a magnifying lens, and answer workbook questions, "Which way do the roots grow?" and "What happens to the root when a seed is planted upide down?"

The program consists of three student workbooks, three teacher guides, and prepared laboratory equipment. Designed for use in grades 4, 5, and 6, the program encourages independent study and requires students to read. To use the program successfully, teachers must do exactly what part of the program title says: "measure and find out." In the first lesson, students are introduced to the metric system. Grams, kilograms, meters, and centimeters are then used to measure time, weather, plant growth, electricity, and a variety of other phenomena. Grams, kilograms, meters, and centimeters are then used to measure time, weather, plant growth, electricity, and a host of other phenomena. "Which way do the roots grow?" and "What happens to the root when a seed is planted upide down?" workbook questions, which are then answered with a magnifying lens, and diagrams illustrating the growth of roots. They are measured, looked at, their plasmatic tissues studied, and then soak them and four more seeds in water for a day. In the next lesson, students sit open the three seeds, diagram the growth of roots, look at the tiny plants inside with a magnifying lens, and answer workbook questions, "Which way do the roots grow?" and "What happens to the root when a seed is planted upide down?"
1.0. GOALS AND OBJECTIVES

1.1. Long-range goals.

The primary goal of Measure and Find Out is to prepare students for junior and senior high school science. According to the developer, the program was designed with specific secondary science programs in mind, especially Time, Space and Matter (Princeton Project) and International Science Curriculum Study.

The other major long-range goal was to get children off on the right foot in science learning. The units were therefore designed to prevent presentation of material that would be too difficult and thus lend itself to oversimplification.

Developer Swartz said he stayed away from complex concepts that could lead to a necessity for unlearning, damage future understanding, and breed an unfavorable attitude toward science.

The student will be able to draw a circuit diagram for a 1-1/2-volt battery, put in light and dark, parallel and series connections, etc., and to calculate the voltage of the battery.

The test question in Book Three could be paraphrased to come up with the following behavioral goal:

"A student will be able to draw a circuit diagram for a 1-1/2-volt battery, put in light and dark, parallel and series connections, etc., and to calculate the voltage of the battery."

In each of the closest things to clearly stated behavioral objectives are test questions in Books Two and Three. Detailed behavioral objectives for individual lessons are not listed in the teacher guides or elsewhere.

1.2. Terminal objectives.

Major goals for students include learning to organize data, to measure length, mass, time, and temperature; to plot data on a graph.

"A test question in Book Three could be paraphrased to come up with the following behavioral goal: "The student will be able to plot a graph. He will be able to read the data from such a graph."

In fact, the closest things to clearly stated behavioral objectives are test questions in Books Two and Three. Since Book One has no tests, detailed objectives must be abstracted from the lessons. A typical objective from Book One would be, "Given a table of data showing simple functional dependence of two variables, the student will be able to define a table of data showing simple functional dependence of two variables, the student will be able to draw a graph."

Although Book One has no tests, detailed objectives must be abstracted from the lessons.

A test question in Book Three could be paraphrased to come up with the following behavioral goal: "The student will be able to draw a circuit diagram for a 1-1/2-volt battery, put in light and dark, parallel and series connections, etc., and to calculate the voltage of the battery."

1.3. Detailed objectives.

Detailed behavioral objectives for individual lessons are not listed in the teacher guides or elsewhere. In fact, the closest things to clearly stated behavioral objectives are test questions in Books Two and Three.
2.0 CONTENT AND MATERIALS

2.1 Content focus. The program offers no organizing scheme of concepts or processes. Using Measure and Find Out, a child takes a quantitative approach to the physical sciences, earth science, botany, and astronomy. Measurement is the key work. There is no attempt to introduce generalized principles, broad concepts, or lofty universals—except in the case of electricity, where the lessons are grouped under general topics, and in Books Two and Three, lessons are grouped under general topics. In Book Two, the lessons are grouped under general topics, and there is a more or less evenly divided among earth science, chemistry, measuring plants, and measuring the moon. The 49 lessons in Book Three are more or less evenly divided among earth science, chemistry, and measuring plants. The 49 lessons in Book Three are designed to introduce the metric system, measuring the body, measuring the weather, measuring light, and measuring the moon. The lessons are grouped under general topics, and there is a more or less evenly divided among earth science, chemistry, measuring plants, and measuring the moon. The lessons are grouped under general topics, and there is a more or less evenly divided among earth science, chemistry, measuring plants, and measuring the moon. The lessons are grouped under general topics, and there is a more or less evenly divided among earth science, chemistry, measuring plants, and measuring the moon. The lessons are grouped under general topics, and there is a more or less evenly divided among earth science, chemistry, measuring plants, and measuring the moon.

In Books Two and Three, lessons are grouped under general topics. In Book Two, topics featuring between 8 and 20 lessons each include the metric system, measuring the body, measuring the weather, measuring light, and measuring the moon. The lessons are not sequenced in the above order. Lesson 40 deals with measuring objects made of different metals, and lesson 44 with measuring the body. Lesson 49 with measuring objects made of different metals, and lesson 44 with measuring the body. Lesson 49 with measuring objects made of different metals, and lesson 44 with measuring the body. Lesson 49 with measuring objects made of different metals, and lesson 44 with measuring the body.

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2.2 Content and organization of the subdivisions. Some of the more flashy areas of science are not really suited for the elementary classroom. This is further evidenced by the fact that there is no attempt to introduce the metric system, measuring the body, measuring the weather, measuring light, and measuring the moon. The lessons are not sequenced in the above order. Lesson 40 deals with measuring objects made of different metals, and lesson 44 with measuring the body. Lesson 49 with measuring objects made of different metals, and lesson 44 with measuring the body. Lesson 49 with measuring objects made of different metals, and lesson 44 with measuring the body. Lesson 49 with measuring objects made of different metals, and lesson 44 with measuring the body.

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Students take from 15 minutes to two hours to complete lessons. Grade 4 lessons are typically completed in less time than grade 6 lessons.

Most teachers report using the program twice a week.

In Book One the child learns the metric system, makes simple measurements, and frequently uses graphs.

The pupil grows bean plants, studies insects that are brought to class, constructs simple machines using magnets, and uses a simple electric circuit. Measurements are made in all activities and observations are recorded.

In Book One the child learns to make a weather observation chart.

The following lessons are grouped under the weather measurements section:

- "How to Read a Cloud" Observing and classifying clouds.
- "Mood in the Willows" Constructing a wind vane and classifying wind speeds.
- "The Heart of It, Is the Humidity" Using wet-bulb and dry-bulb thermometers to make a psychrometer.
- "The High for Today" Setting up a graph to record temperatures.
- "Into Each Life Some Rain Must Fall" Constructing a rain gauge and keeping a daily rainfall chart.
- "Weather or Not" Setting up a weather observation chart.

In the Grouping of Lessons in Book Two, the pupil learns to measure the weather by building basic weather forecasting instruments. The following lessons are grouped under the weather measurement section:

- "The Dense Earth" Measuring the density of rocks.
- "A Model World" Making a scale drawing of the school building.
- "The Earth Science Grouping in Book Three Features This Sequence:"

The following lessons are grouped under the weather measurements section:

- "How to Read a Cloud" Observing and classifying clouds.
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- "The High for Today" Setting up a graph to record temperatures.
- "Into Each Life Some Rain Must Fall" Constructing a rain gauge and keeping a daily rainfall chart.
- "Weather or Not" Setting up a weather observation chart.
"Hard as a Rock."

Observing erosion of rocks.

"Late to Bed and Early to Rise."

Setting up a chart to record time of sunset and sunrise.

"East of the Sun."

Graphing the direction in which the sun rises and sets.

"A Heavenly Course."

Measuring the path of the sun across the sky.

"The World Around."

Observing and measuring, using a globe.

"Circling the Pole."

Using a protractor to observe stars.

"West of the Moon."

Observing the moon.

"Here Come the Planets."

Setting up a scale model of the solar system.

"West of the Moon."

Observing the moon.

"Next to Bed and Early to Rise."

"Setting up a chart to record time of sunset and sunrise."

"Hard as a Rock."

Observing erosion of rocks.

Materials include two basic kits, called the Start-a-Lab and Expand-a-Lab, for each of the three levels.

Laboratory materials include two basic kits, called the Start-a-Lab and Expand-a-Lab, for each of the three levels.
Many of the items supplied by the publisher are commonly available or may already be on hand at schools. Because of the open stock procedure, such items need not be bought from the publisher.

The publisher offers all necessary steps for the program. Not sold by the publisher are the necessary lab kit materials. Many lab kit materials are made of plastic which is described as "sturdy." In accordance with the wishes of the developer, calibrations and scales are no more exact than is required for the basic lesson activities. The developer has stated that school science equipment is often more exact than necessary, resulting in student frustration and a waste of money.

Teacher materials. Separate teacher's guides are published for each of the three levels. The guides include a list of materials needed for each lesson. Tips on where to obtain supplementary materials, instructions for use of lab materials, and background information on principles involved are published for each of the three levels. The guides are not written in scientific jargon, and do not presume much scientific understanding on the part of the teacher. The books do point out what the author considers pitfalls in elementary science.

For example, one instruction to the teacher in Book Three (grade 6) reads:

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Students have been plagued for a couple of generations by the requirement of knowing which are simple machines and which are compound machines. Is the screw, for instance, merely an inclined plane wrapped in a circle or is it also a wheel-and-axle? This sort of semantic problem is strictly a schoolbook substitute for doing some real science learning. The problem of machine classification is unknown outside of schoolbooks. For example, one instruction to the teacher in Book Three (grade 6) reads:
```
Teaching/learning strategy. The quantitative approach teaching/learning strategy is well summed up in a report from developer Clifford Swartz: "The theme of our whole attempt is measurement and functional dependence. It should be emphasized, neither is creative independent inquiry. The program stresses elementary procedures. The teacher is to act only as a guide and organizer for most of the lessons. Whole class activity is not important. Students, with or without help from the teacher, measure and graph things to which they are directed by the workbooks. When new concepts are introduced or the entire class is required to participate in an activity, teacher instruction is necessary. Otherwise, students can do workbook lessons by themselves. The approach requires students to be able to read at the level of the workbooks. This has been something of a controversial matter in field trials. Some teachers have complained that the reading is too difficult, others say there is no problem. A certain order, or may allow them to skip from lesson to lesson. A certain order, or may allow them to skip from lesson to lesson. Teachers may require students to do the exercises in a certain order, or may allow them to skip from lesson to lesson. The approach requires students to be able to read at the level of the workbooks. This has been something of a controversial matter in field trials. Some teachers have complained that the reading is too difficult, others say there is no problem.

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3.2 Typical lesson.

In most lessons, students are introduced to the measurement to be done by one or two tersely written paragraphs, followed by specific instructions for making one, two, or several measurements. Students then record their measurements and the lesson is finished.

Evaluation of students is left almost entirely to the ingenuity and judgment of the individual teacher. Like the one described above, many lessons take more than one class hour to complete, and may require short snatches of time throughout the day. Other lessons will require students to spend a few minutes every day for weeks or even months.

3.3 Evaluation of students.

Evaluation of students is left almost entirely to the ingenuity and inclination of the individual teacher. The developer does state some broad criteria for evaluation, and tests are included in Books Two and Three. A lesson in Book One (grade 4) begins by asking the pupil if he is taller or shorter than his shadow. "Let's find out," the workbook entices. The student is instructed to make the room dark by pulling the shades and turning off the lights. A floor lamp is used to cast the student's shadow on the floor.

The teacher's guide urges that children be instructed to notice that their shadow does not totally disappear under their feet at noon. Therefore, the student is to be told, the sun is not really directly overhead.

Shadow was during various times of the day. Shadow lengths are recorded in the workbook. Finally, the student draws pictures (graphs) to show where his shadow was during various times of the day. When the shadow is large, next, he takes turns with other students in measuring a shadow outside in the sun. The teacher's assistance would obviously be needed in this point. The student can proceed on his own. A field test showed teachers used a wide variety of grading and evaluation methods. Often, teachers are given ideas in the teacher's guides for additional activities, or for special points to make. Additional activities, or for special points to make to the class. A lesson in Book One (grade 4) begins by asking the pupil if he is taller or shorter than his shadow. "Let's find out." The workbook mentions that the program has inherent in it the possibility of testing.

It is possible to specify certain tasks of measurement that a student must be able to do. The pupil must, furthermore, be able to record data in appropriate ways, and interpret graphical information of specified complexity.
Despite the developer's contention that evaluation should be based on the measurement skills a student has acquired, the tests in Books Two and Three are called "How Much Do You Remember?" and test for memory as much as measuring skills.

A test at the end of a grouping of lessons on measuring the child's own body asks the student to graph from memory the breathing rates for resting and vigorous exercise. Other graphs in the test are also to be constructed from memory without doing any original measurement.

The teacher's guides provide answers for doing the test questions, but no numerical scales for grading are suggested. Teachers who answered questions after using Measure and Find Out materials listed a variety of evaluation methods ranging from administration of traditional quizzes to no grading at all. One teacher evaluated students by having them give demonstrations before the class. Another had them draw pictures of the lesson activities they set up. Another teacher used grades, but found out after giving a traditional textbook test that some lessons in the textbook were already covered in the class. Another had students draw pictures of the lesson activities and the teacher evaluated students on their drawings. Other methods included giving students a variety of out-of-class preparation to evaluate.

### 3.4 Out-of-Class Preparation

**Teacher.** Since most lessons are designed for students to do independently or in small groups, and the student is asked at the beginning of each lesson to graph sunrise and sunset over a long period of time, if measuring and finding out is used as a complete program, the developer suggests supplemental readings. Reading lists are included in Books Two and Three.

**Student.** For some lessons students will have to make measurements at home. Lessons in Book Three (Grade 6) have to be located. Audiovisual equipment is seldom required. Preparing activities might include a maximum of five minutes reading the teacher's guide, a few minutes setting up the room, and varying amounts of time spent finding materials. For other lessons, a trip to the grocery store to buy fresh fruit, a trip to the library for photos, a flashlight, or a sheet of graph paper might be required.

Preparation activities might include a maximum of five minutes reading the teacher's guide, a few minutes setting up the room, and varying amounts of time spent finding materials. For other lessons, a trip to the grocery store to buy fresh fruit, a trip to the library for photos, a flashlight, or a sheet of graph paper might be required.
IMPLEMENTATION: REQUIREMENTS AND COSTS

4.1 School facilities and arrangements.

A variety of schoolroom conditions are suitable for the program. It is optimal to have available running water, storage space, movable furniture, and a friendly janitor. Given them in a field test had proven extremely valuable in helping them understand the developer's rationale.

Teachers responding to inquiries about the program indicated that special training in quantitatively approaching the measurement itself.

"Teaching quantitative science in this manner," says the teacher's guide, "does not require special training. With Measure and Find Out, says the developer, "the source of information is the measurement itself."

"Teaching quantitative science in this manner," says the developer, "does not require special training. With Measure and Find Out, says the developer, "the source of information is the measurement itself."

4.2 Student prerequisites.

Otherwise, students need no special preparation.

4.3 Teacher prerequisites and training.

"Teaching quantitative science in this manner," says the developer, "does not require special training. With Measure and Find Out, says the developer, "the source of information is the measurement itself."

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4.4 Training course is currently available from the publisher or developer.

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4.5 Teacher prerequisites and training.

Otherwise, students need no special preparation.

"Teaching quantitative science in this manner," says the developer, "does not require special training. With Measure and Find Out, says the developer, "the source of information is the measurement itself."

4.6 Other elements.

The program is well suited for nongraded classrooms.
4.4 Cost of materials, equipment, services

<table>
<thead>
<tr>
<th>Item</th>
<th>Source</th>
<th>Per Item</th>
<th>Replacement Rate</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Student workbooks:</td>
<td>Scott, Foresman</td>
<td>$1.02-1.35</td>
<td>Yearly</td>
<td>1 per pupil per year</td>
<td>Scott, Foresman</td>
</tr>
<tr>
<td>Book One, Two, Three*</td>
<td>Scott, Foresman</td>
<td>$57.00-117.00</td>
<td>5 years</td>
<td>Minimum 1 per classroom</td>
<td>Scott, Foresman</td>
</tr>
<tr>
<td>Items such as knife, clock, apple, hot plate, spider</td>
<td>Scott, Foresman</td>
<td>$0.75</td>
<td>Reusable</td>
<td>Several per classroom</td>
<td>Teacher</td>
</tr>
<tr>
<td>Items (kits of materials)</td>
<td>Scott, Foresman</td>
<td>$57.00-117.00</td>
<td>5 years</td>
<td>Minimum 1 per classroom</td>
<td>Scott, Foresman</td>
</tr>
<tr>
<td>Teacher's Notes:</td>
<td>Scott, Foresman</td>
<td>$0.00</td>
<td>Reusable</td>
<td>1 per teacher</td>
<td>Scott, Foresman</td>
</tr>
<tr>
<td>Supplementary Item</td>
<td>Scott, Foresman</td>
<td>$42.00-96.00</td>
<td>5 years</td>
<td>1, 2, 3*</td>
<td>Scott, Foresman</td>
</tr>
</tbody>
</table>

*Any item in kit can be purchased separately. All are pictured individually in publisher's order.
PROGRAM DEVELOPMENT AND EVALUATION

5.0 Program Development and Evaluation

Thus, the program is designed to avoid the complexities of science and provide units that are realistic for the elementary school.

...
The development is not a greater believer in the value of objective evaluation. In Long Island schools, Swartz made no attempt to collect statistical information on student performance. Instead, he asked teachers to give anecdotal, subjective evaluations. Swartz became involved in a personal investigation, the asked teachers to give anecdotal, subjective evaluations. Swartz became involved in a personal investigation, the...
that the reading was too difficult. Swartz revised some of the lessons to make them easier to read.

However, he contends that the lessons are readable, and that some teachers are simply poor judges of their students' abilities. He cites the example of the teacher who insisted that her children would not be able to understand the word "graph" even though it was identified in a lesson as the name of an object on the board. The teacher explained the word to the students, but then told them only after the test that a graph is the opposite of an object on the board. The teacher's explanation in a lesson was thoroughly incorrect.

From observing the program in use, Swartz says that "in general, what is going on is very close to what I had in mind. Teaching of Measure and Find Out is closer to my actual intent than is the teaching of any of the other major elementary science programs." Swartz also reports that students are enthusiastic users of the program. Several teachers who have used written evaluations have stated that students are enthusiastic users of the program. Several teachers who have used written evaluations agree.

Here are observations of teachers who have used Measure and Find Out:

- "I noticed nothing spectacular over and above the science I taught in previous years."
- "I observed growth in confidence that I don't think is only related to a year's growth."
- "Nothing spectacular over and above the science I taught in previous years."
- "Students are aware of need for documented observations, necessity for pre-planning, acceptance of failure.

At present, there are no known statistically recorded data regarding the success of failure of the program.

5.4 Anecdotal Evaluation

While there are no known statistically recorded data regarding the success of the program, anecdotal evidence from several teachers who have used written evaluations agrees.

It did not understand what a graph was, according to one student who referred to it as a "chart," since they explained the word to the students, but told them they could call the object on the board a chart, since they understood the word "chart" even though it was thoroughly incorrect. The teacher's explanation in a lesson was thoroughly incorrect. The teacher referred to the teacher's misunderstanding of the teacher's instruction that her children would not be able to understand what a graph was, too difficult. Swartz revised some of the lessons to make them easier to read. However,
They became involved with considerable enthusiasm with little direction or aid from me.

With the quantitative approach we had additional alternatives. The children could select which alternatives they might do alone, partners, or in groups.

Interest breeds learning.

Definite progress in understanding and use of metric system.

Gradual improvement in working independently.

They became involved with considerable enthusiasm with little direction or aid from me.
BIBLIOGRAPHY

