APPENDIX A

PROCESS SKILLS IN THE CLASSROOM

Randolph J. Schenkat
Project Director
Dennis Battaglini
Science Education Specialist

COLLEGE OF SAINT TERESA

During the first year of PRISE, the project director realized, while auditing the courses in the Unified Science sequence, that a close parallel exists between the thinking underlying the scientific method and that leading to the development of special education methodology. Other educators also have remarked on the use of the scientific method in special education research and development. For example, Haring (1977) wrote,

> Special education has in the last dozen or so years become the one component of the overall educational system that relies most heavily on the scientific method and experimental research to improve instruction and to provide ways to change developmental learning and behavior problems. Basic research and application in learning, instruction, social reinforcement, behavior modification, curriculum analysis, and sequencing, have evolved from attempts to find the best methods of teaching handicapped persons. (p. 8)

In fact, whether it is so recognized or not, the scientific method can be a basic tool in the practice of all education. For example, it is the method by which the need for and provisions of IEPs can be determined and it is the method which can be used to ascertain whether a prescribed instructional plan works for the pupil.

The parallel between the work of child study teams in designing and writing IEPs and the competencies science education teachers are expected to attain in the Unified Science sequence strongly indicates that special education teachers and, indeed, all members of child study teams would do well to acquire the process skills. For convenience, the Unified Science competencies are listed next and then they are compared with the actions taken by child study teams.

1. **Observing**
   - A. Identify and name properties of an object or situation by using at least four of the senses.
   - B. Distinguish between statements of observation and inferences.
   - C. State observations in quantitative terms whenever possible.
   - D. Describe observable changes of an object.
   - E. Describe an object so that another person can identify the object in a set of similar objects.

2. **Inferring**
   - A. Construct one or more valid inferences from a set of observations.
   - B. Identify observations that support an inference.
   - C. Describe additional observations needed to test alternative inferences.
   - D. Distinguish inferences that should be accepted, rejected, or modified on the basis of additional observations.

A form of this article appeared as:
Schenkat, R.J. & Battaglini, D. Special education as a great experiment. **Education Unlimited**, 1980, Vol. 5, pp. 18-21.

3. **Measuring**
   A. Order objects by comparing a property that objects have in common, including length, area, mass, and volume.
   B. Describe objects quantitatively using arbitrary units to measure length, area, mass, and volume.
   C. Using appropriate units from the metric system, describe objects quantitatively by measuring their length, area, mass, and volume.

4. **Classifying**
   A. Identify and name observable properties of objects in a set which could be used to classify the objects.
   B. Construct a one, two, or multi-stage classification of a set of objects.
   C. Construct a classification of a set of objects which can be used by another person to identify each of the objects in the set.

5. **Using Numbers**
   A. Work out and discuss proportion problems drawn from a collection of such problems.
   B. Read and write numbers in scientific notation.

6. **Using Space/Time Relationships**
   A. State and apply rules for finding linear speed of various systems, for example, find the linear speed of a rolling wheel given its angular speed and its diameter or circumference.
   B. Describe motions and positions of objects using various reference frames.
   C. Describe places on a map using rectangular and polar coordinate systems.

7. **Communicating**
   A. Construct a graph from a collection of data.
   B. Interpret graphs verbally and be able to interpolate and/or extrapolate points on these graphs.
   C. Write a description of observations made on a phenomenon of your choice.

8. **Predicting**
   A. Make a prediction by extrapolating and interpolating from a self-made graph which describes a set of variables of a self-designed investigation.
   B. State qualitatively the limitations of the reliability of your predictions.

9. **Formulating Hypotheses**
   A. Select from a set of alternative statements those which are hypotheses (as defined by SAPA).
   B. Distinguish between statements which support a given hypothesis and those which do not.
   C. Construct a testable hypothesis from a given set of observations.
   D. Construct more than one hypothesis from a given set of data.

10. **Defining Operationally**
   A. State the meaning of an operational definition.
   B. Operationally define various materials from a set of your observations concerning tests of those materials.
   C. Select a common object and formulate an operational definition that would enable a person unfamiliar with the object to identify it from your definition.

11. **Interpreting Data**
   A. Make and interpret two types of frequency distribution graphs.
   B. Determine measures of central tendency from a set of data.
   C. Use slope to interpret a graph.
   D. Construct sentences that describe relation between two variables.

12. **Controlling Variables**
    A. List a series of variables that have a probable effect on the outcome of an investigation.
    B. Set up an experiment and identify which variables are manipulated variables, which are controlled variables, and which are responding variables.
13. **Experimenting**
    A. Design and carry out an experiment using all of the aforementioned processes that are pertinent.
    B. Defend your conclusions or lack of conclusions regarding your experiment.

"SCIENTIFIC" SPECIAL EDUCATION

Pre-IEP Activities

A critical teacher behavior is the ability to observe. Like scientists, special educators are asked to "state observations in quantitative terms whenever possible." (How rapidly does the child read when he reads this material at 95% accuracy?)

Rigorous classroom experiments often include a description of interrater reliability, that is, the measure of agreement between the observations of two or more people. The scientific analogy is "describing an object so that another person can identify the object in a set of similar objects." Special educators are cautioned not to allow biases to "distort their observations and inference" and only "describe observable changes in an object."

In the initial referral of a child with a possible handicap, the specialist gathers observations in the child's learning environment guided by the reason for referral. Rather than taking a shotgun approach, the specialist starts with the materials used in the classroom and then goes on to "identify and name observable properties of objects in a set which could be used to classify the objects." From the data collected by observation, the specialist is able to classify specific reading errors (i.e., the child misread twelve medial vowel sounds).

Almost simultaneous with the classifying, the specialist begins to make inferences regarding the various observations and classes. In the scientist's language, he/she "constructs one or more valid inferences from a set of observations and identifies observations that support an inference." Going beyond observation (the child misread 12 medial vowel sounds), the specialist now infers that the child reads poorly because he cannot make the symbol-sound match for vowels.

The specialist most likely will not be satisfied with only a tentative inference; he/she will look for other ways of gathering observations (perhaps other formal and informal assessments) to support the medial-vowel and other inferences which may have been made. Again in the scientist's language, the specialist has "described additional observations needed to test alternative inferences and distinguish inferences that should be accepted, rejected, or modified on the basis of additional observations."

The specialist, of course, is not operating in isolation. Some of or all other members of the child study team (psychologist, social worker, nurse, principal, speech and language clinician, regular classroom teacher, and parents) bring the observations they have made and their inferences. This team then examines all these data and reaches consensus on the observation-based inferences. Given the diversity of backgrounds among the team members, the difficulty of this task can be appreciated.

Given the California prohibition of the use of IQ data in placement decisions and the Schenck and Levy (1979) report of Connecticut practices, it seems reasonable to predict that educational specialists in the near future will be expected to employ the true scientific method of observation by directly studying a child's functional disabilities in his usual learning/social environment rather than by using the standardized measures that have enjoyed considerable vogue.

IEP Development

If a handicapping condition is found to be present in the child, then the observation-based inferences now begin to be converted into provisions of the IEP. The latter is very similar to an experimental design. It has the following components: (a) over-all goals; (b) short-term enabling objectives; (c) specification of objective mastery criteria; (d) listing of materials that will be used; and (e) staff responsibility. Again, very direct parallels can be drawn with the process skills.

In one sense the child study team is conducting an experiment. It is hypothesizing from the team's collective experience with normal and handicapped learners that the instructional activities which will be undertaken (independent variables) will lead to the accomplishment of the goals (dependent variables). Adherence to the scientific method is necessary, however.

It is very easy to state, "The goal for the child is to read at a fourth-grade level." But what does this statement mean operationally? The team determined that the child reads at a 1.5 grade level. What must be done to correct the deficit? Traditionally, intervention took the form of placing the child at the appropriate level of a basal reader and trying to keep him progressing through the series. The scientist would look at the intervention differently: What is the nature of the stimuli in fourth-grade reading material (e.g., average number of syllables in words, length of sentences, percentages of regular and irregular words, type of grammar used in sentences)? Special education practitioners call this "task analysis." The observations gathered earlier should shed some light on how the student responds to these various dimensions? The global fourth-grade reading level has been reduced to its elements — an application of classifying skills.

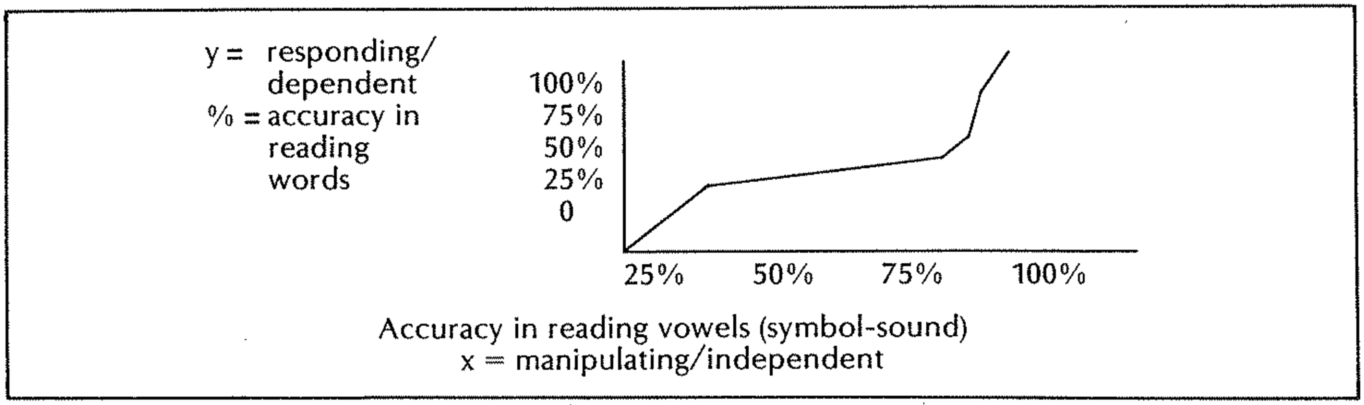
Earlier, the child was said to have difficulty with medial vowels. We can state an operational objective which, if accomplished, will eliminate the child's difficulty with medial vowels: "Upon teacher presentation of one-syllable words on flash cards with any long or short vowel the child will be able to read orally the words at a rate of 30 words per minute with 97% accuracy." Thus, we know explicitly what the outcome of the selected activities should be. Stated in another way, the outcome is hypothesized to bring the child closer to the desired fourth-grade level.

Our hypothesizing now goes one step further. In deciding upon activities to accomplish the objective (the dependent variable), essentially one hypothesizes that the selected activities (the independent variables) will lead to (produce) the objective's outcome. Each activity that is selected should be considered carefully; it is in fact a major component of the experiment.

Scientists use variables. They must "list a series of variables that have a probable effect on the outcome of an investigation and set up an experiment and identity which variables are manipulated (independent) variables, which are controlled variables, and which are responding (dependent) variables."

The scientist, therefore, works very much like the child study team. The outcomes the team desires for a child are the dependent variables; the activities or materials selected and described in the IEP are the independent variables. There also are controlling variables. They are specified in the given of the objective. For example, "one-syllable words on flash cards" is the control in the objective stated. If the child's on-task behavior in completing assignments was desired, an initial control might specify the confines of a study carrel (i.e., given a study carrel, student will complete . . .).

As in an experiment, an outcome or result is expected. It may be positive or negative. Special education teachers often convey their results in graphs and charts.



This use of charting parallels the scientist's work in two ways: (a) scientists communicate much of their findings in graphs and (b) they must defend their results. It must be remembered that from the outset the work is being done only on the basis of inferences and hypotheses. However much experience the special education teacher and the child study team may have had working with handicapped children who manifest the same type of problems, carrying out the IEP is still an individual experiment. It does not assure the desired outcome. The IEP demands the specification not only of the objectives, but also, the criteria that are necessary to indicate learning. Thus the special education teacher can talk of results only by operationally describing the outcomes, that is, the child has improved from 50% accuracy to 97% accuracy as a result of the experiment. This is the only proof that the child reads better.

If the outcome meets the criteria, the teacher can say that the hypothesis (this type of intervention with this type of need) has been supported. The teacher thereby contributes to the theories that an experienced teacher consciously or unconsciously uses. If the outcome has not met the criteria, then the hypothesis has not been supported and a new hypothesis with different variables must be formed. The teacher continues the research until the all-important goal — meeting the child's educational needs — has been achieved.

One further parallel may be drawn between the work of scientists and the demands made on professionals in the development of an IEP. The IEP must specify for each objective the time frame in which it will be achieved. Scientists are called upon to "make predictions by extrapolating or interpolating from a self-made graph which describes a set of variables of a self-designed investigation." The child study team like the scientist makes predictions from the data that are available from diagnostic teaching, the child's past rates of achievement, and rates of learning of similar types of children.

The IEP calls for a number of conditions. In complying with the requirements to meet the needs of handicapped children, the special education teacher and the other team members are using the model that scientists use.

FLAWS IN THE IEP PROCESS

The development and execution of the IEP are of paramount importance in protecting the rights of handicapped children. It is not a legally binding contract under which a child or his parents can bring suit if the conditions are not met, but it is a significant document. Its rigor was established to make sure that no child be subjected again to the old practice of "out of sight, out of mind."

The use of the scientific method brings definition to the IEP and its preliminary and resultant activities. Consider the following six questions which a scientist might ask to greatly improve the IEP process:

1. Are enough observations being gathered?
2. Have sufficient observations been gathered to support making inferences?
3. Do any observations fail to contribute to inferences?
4. Are the inferences of causation instructionally useful for forming hypotheses?
5. Do the experiments begin to approximate accepted practice in scientific research (controlling variables, charting results, operationally defining outcomes, etc.)?

All is not well in IEP use, according to Schenck and Levy (1979). In a study of 300 IEPs for mildly handicapped students (LD, ED, and EMR) in 37 Connecticut School Districts, the researchers found "a lack of a relationship between the psychological assessments and the long-term goals/short term instructional objectives [which] highlights the [absence] of 'specificially designed instruction'. The inability to trace goals and objectives back to diagnostic data raises serious doubts concerning the efficacy of current educational plans" (p. 24). In scientists' terms, experiments are being designed for the instruction of handicapped students without using the observations and inferences which are often gathered at great expenditures of time and money by team members.

Schenk and Levy suggested that the relative lack of training by both psychologists and teachers in the process of relating diagnostic information to 'specifically designed instruction' is a contributing factor to this mismatch.

Perhaps psychologists devote too much time to the garnering of etiological types of inferences that have proven to be of little value in special education remediation (Bateman, 1976). The wisdom of S. Alan Cohen (1969) aired a decade ago in an article on the dread disease Dyspedagogia may be exceedingly important in designing experiments for handicapped children. Cohen demonstrated that independent variables such as direct instruction and time engaged on task allowed for large gains in achievement without identifying causative factors (e.g., minimal brain dysfunction, poor auditory sequential memory, dyslexia, hyperactivity).

Is there a contradiction between using the scientific method and ignoring the causation of handicaps? After all, we depend on science to find causes. But causation of handicaps is a medical problem, not educational, and we do not need to know the cause of a handicap to treat the educational problems a child exhibits. In the medical profession itself treatments for diseases often are discovered and prescribed before etiologies are known.

By the use of the scientific method (remember experiments should be replicable), contributions are made to the body of knowledge on the education of handicapped children. When enough experiments are conducted under similar conditions and have the same outcomes, we can use the findings safely with "at risk" children to prevent problems. In fact, the research question becomes, what intervention can keep children with the same reading problem from having the same type of difficulty?

Another potential explanation for the mismatch between diagnostic findings and "specially designed instruction" comes from the propensity of specialists to use standard measures (e.g., PIAT, Key Math, and ITPS) rather than to gather observations with curriculum-based assessment devices (CBAs) (see Lilly & Blankenship, 1979). CBAs eliminate the "leap" from diagnostic findings. to instruction. Also, appropriate CBAs enhance a mainstreamed child's chances to benefit from the classroom curriculum (if it is appropriate).

The type of instructional materials used by the special education teacher is critical. If the specialist develops a sense of comfort with a particular type of remedial material (e.g., DISTAR, Sullivan Programmed Readers, or Peabody Language Kit), the child may become a prime candidate for the favored material irrespective of the diagnostic findings. In such a case, the selection of the experiment's independent variables has been faulty.

The parallel between the IEP process and the scientific method may not be acceptable to those who consider scientific research manipulative. But the scientific method is a set of procedures and a way of thinking. Perhaps it would have more appeal for these teachers if the processes could be described in less impersonal terms. Special education teachers always have had a warm regard for handicapped children.Yet, until special education research shows significant results in solving the children's problems, this warm regard will be more sentimental than useful. The Connecticut data shows that we have a long way to go to insure that the lives of children are being affected by appropriate "experiments."

Regular and Special Education Comparisons

With skepticism abounding on the quality of services provided by "trained" specialists, can we be optimistic about the role of "nontrained" regular classroom teachers in working with the handicapped child? Teachers have been characterized as clinical information processors, decision makers, diagnosticians, and problem solvers who are to specify objectives, select learning activities, organize learning activities, and specify evaluation procedures. Thus, for almost 30 years the regular education teacher-training literature has suggested the use of a rational means-end planning model (Popham, 1970, Taba, 1962, and Tyler, 1950). Taba characterized curriculum planning as "a task that requires orderly and careful thinking, and this model is proposed as a rational and scientific method for accomplishing such a task" (p.3, cited in Clark & Yinger.)

The similarities among this rational means-end planning model, the IEP, and the scientific method are obvious. Perhaps concern with the "untrained" regular classroom teacher is unfounded? The ray of hope for the mainstreamed child seems, however, to be dashed by Clark and Yinger's (1978) study of teacher thinking.

> On the topic of teacher planning, the available literature suggests that teachers do not seem to follow the "rational" model that is often prescribed in teacher training and curriculum planning. In particular, the teachers studied neither began nor guided their planning in relation to clearly specified objectives or goals. Rather, teacher planning seems to begin with the content to be taught and considerations about the setting in which the teaching will take place. The focus then shifts to student involvement — a process objective. The activitiy rather than the objective seems to be the unit of planning (p.38).

From a scientific viewpoint, the teachers studied by Clark and Yinger are making the fundamental error of confusing dependent and independent variables if the outcome expected is academic achievement.

Can we expect teachers to think and operate like scientists? If elementary school children can be taught to use process skills to solve science problems — the premise of the Unified Science sequence at CST — why cannot adults who should know how to learn become adept in the use of the scientific method also? It would be ironic indeed if we accepted teachers in the public schools who did not possess or know how to use the very skills they are expected to teach their charges! The recognized purpose of schools, according to different surveys, is not only to teach basic skills but, also, and perhaps more important, to facilitate the use of thinking skills.

The reason that the rational means-end model has not been widely adopted may be the pace of the modern classroom. According to Durkin (1979), teachers have time to be only "mentioners" of content. In fact, when prospective teachers first enter classrooms to practice their skills, they often are told by supervising teachers to forget the theories of the ivory tower and to focus instead on the methods which have served for generations.

The extensive use of all-encompassing curriculum objectives, pretests, posttests, and so on places the teacher in nothing more than a dispenser role. When the curriculum fails to meet the needs of a pupil, current practice supports labeling the child "handicapped" and referring him to Title I or special education. The teacher is often explicitly discouraged from wondering why the curriculum has failed and designing an experiment to find out. And special education teachers who evaluate the pupil may use only the standard tests they learned.

Perhaps teacher training fails in one critical area: it is not enough for a good researcher to meticulously employ the scientific method; he/she also must know the discipline. Teachers are instructed in methods that it seems, no one expects them to use, and they are assumed to know Reading, Math, Spelling, and Language Arts not only at the level of literacy but also at the level of being able to task-analyze the objectives set for children. But do they? Too many Curriculum and Methods Courses place more emphasis on methods than the content of the curriculum; yet the methods are seldom used and teachers have only a narrow understanding of the subject matter they are supposed to teach.

Other than a positive feeling about working with handicapped children, any teacher needs to be able to use process skills to insure that the children receive the remediation they need. Thus rather than calling upon continual proliferation of special education resource services for mildly handicapped pupils, regular teachers should be given the supports (e.g., continuing inservice training to maintain proficiency standards, classroom aides, and various curriculums and supplements) which will equip and free them to work with mildly handicapped children. Unfortunately, present practices of funding school districts discourage such an enlightened policy. It is simple to predict outcomes when the placement of children in special education is rewarded rather than the quality of education in regular classrooms.

This position does not advocate the "dumping" of children in need of special services, however. When IEP objectives are teaching additional facts, phonetics, and language arts, cannot this "special" education be provided as a normal procedure by regular classsroom teachers? Of course, IEP goals must be met, but in this era of educational responsibility one must wonder whether the quality of education that is universally desired does not depend on the performance of regular classroom teachers rather than additional services.