Mitchell E. Batoff

The Unit Box Approach:

a novel facet of elementary school science and mathematics teacher preparation*

The Unit Box[1] is an innovative development in elementary school teacher preparation. Its construction is the principal assignment in a science methods course evolved by the author over a six year period at Jersey City State College.[2]

Each student in the course (college seniors in most cases) assembles a materials-centered, inquiry-oriented, multimedia unit package. Its core is a commercially available unit of study that has been tested in many classrooms. Units of a modular nature are used and they may be teaching units, resource units, or quasi-resource units. Students put together their Unit Boxes outside of class, during a five or six week period prior to beginning the student teaching experience and use the Unit Box during student teaching. In some situations, where the methods course is taught in the schools, students prepare their Unit Boxes over a fifteen week period concurrent with the apprentice teaching experience. In either case, the Unit Box provides an opportunity for apprentice teachers to *do* with children the kinds of teaching-learning they experienced in their methods course; with materials at hand an ideal can become a reality not a pious wish.

overview

The Unit Box Approach is novel in that students are not required to write a unit. Prior to the Spring Semester of 1969, the author had students write units — a practice which is widespread in methods courses around the country — and for which elementary education students generally are ill-pre-

*An earlier version of this paper and the project described herein was honored by the National Science Teachers Association and American Gas Association through a S T A R (Science Teaching Achievement Recognition) Award for 1973.

pared.[3] Furthermore, writing science or mathematics units is not part of the real world of teaching. Working with materials is. The thrust of this approach is the implementation of a unit around which the Unit Box is built. Students are asked to start with a good modular Teacher's Guide and to bring together all the hardware (in multiples), all the supportive software, and all the other media needed to teach the unit effectively. Great emphasis is placed on getting and making appropriate concrete manipulative materials in classroom quantities of thirty-two or sixteen. But the focus of the approach is on learning rather than teaching per se and the Unit Box helps to provide a rich, stimulating learning environment.

Each Unit Box is not only a multimedia, but also a multisensory, and multilevel package of instructional materials and strategies intended for in-depth use over a period of four to eight weeks or longer. Each one is custom made by the apprentice teacher who uses and owns it. Its purpose is actively to involve children and teachers in meaningful investigations associated with a significant topic chosen from the geophysical or biological sciences or mathematics. Each Unit Box is also directed toward the development of one or more rational thinking powers. These intellectual process skills include observation and discrimination, classification, measurement, sampling, extrapolation, communication, number use, inference, and others. Some topics and Teacher's Guides also facilitate the development of manipulative motor skills.

contents

A Unit Box consists of the following integrated components:

1. One or more related Teacher's Guides used as a starting point.[4]
2. Manipulative materials for each pupil.
3. A set of record sheets or work sheets for pupils.
4. A tape cassette, associated work sheets, and manipulative materials.[5]
5. A set of overhead transparencies.
6. Trade or library books for pupils and teacher.
7. A set of vocabulary cards.[6]
8. A construction project to provide enrichment.[7]
9. Thoughtfully considered evaluation devices.[8]
10. A large sturdy box, smaller containers, and a file — all labeled and organized.

The Unit Boxes may contain a wide variety of other instructional materials — large pictures, charts, science learning games,[9] a set of task cards, information on field or museum trips appropriate to the unit, and a teacher-made filmstrip or slide set. Certain items, to be sure, are included in the Unit Box (singly, or in small numbers) for demonstration purposes, but these demonstration items are not the mainstay of the unit. The manipulative-investigative materials are the *sine qua non* of the Unit Box.

rationale for the materials emphasis

Why provide materials in quantity? Why provide materials at all? The actualities of scientific investigation — whether by children or adult scientists — entail direct experiences with the multitudinous phenomena of the real world, opportunities to manipulate variables and invent organized explanations of observed phenomena. In short, scientific investigation involves experiences in search of meaning. For this, materials are needed. Enlightened teaching that gives excitement and pertinency to the learning environment entails the fostering of direct meaningful experiences with phenomena. For this, materials are needed. General exhortations, good intentions, grand proposals, impressive lists of objectives and activities are all meaningless sterilities unless and until they become operational in the classroom.

In too many instances the science unit is a carefully typewritten paper prepared to satisfy a course requirement and then carefully laid aside. At best, a demonstration or two might be performed from the unit by a conscientious teacher — but talk and chalk are the predominant modes of instruction. Needed materials are lacking. The well-intentioned but hurried and harried student teacher, under ordinary circumstances, has neither the time nor know-how, desire nor confidence to gather the necessary hardware to involve each child in meaningful experiences; this is so, unless the gathering of needed materials is built into the teacher preparation program. Accordingly, in the Unit Box Approach it is built in as an integral part of the course. Hence, one aim of the Unit Box Approach is to foster maximum involvement of each pupil in his/her search for first-hand evidence and meaning. The goal is to provide concrete materials in a "wet laboratory" situation so that learning can go well beyond empty verbalisms of talk and chalk that lack an experiential base. This is not a utopian impossibility but a mandatory condition for teaching children. It is a compelling reason for the materials emphasis in the Unit Box Approach.

sources of the materials

Where and how do students obtain all these materials? They use various means and diverse sources. Scavenging plays a prominent role in the Unit Box experience. Some devices the students build, others they improvise from recycled objects, and a great many items they have to buy. But a concerted effort has been made, over a six year period, to search out sources of inexpensive equipment. Both students and the author have contributed numerous resources to a growing repertory of free and low-cost hardware. The list continues to expand and increase in usefulness. Each semester it becomes easier and more economically feasible for students to obtain classroom quantities of such items as magnifying lenses, Celsius thermometers, fifty cent cameras, compasses, magnets, tuning forks, electrical wire, metric teaching aids, live butterflies, and the like.[10] This assignment represents a cooperative rather than competitive venture between the college teacher and his students.

pedagogic values

What are some other values of this approach? The great stress on making and collecting items involves students — from the start of their teaching career — in using materials and living organisms in inquiry teaching. Students are immediately confronted with the problems of obtaining and the rewards of using concrete manipulative materials in teaching children. Furthermore, as several science educators have suggested, one of the most valuable outcomes may prove to be the experience of producing the kit.[11] The student scrounges, improvises, builds, assembles, shops, orders from catalogs, "debugs," and creates tangible objects; reads and builds a library of books and pamphlets; programs and uses audio tape cassettes; makes overhead projectuals; previews films and filmstrips, produces films, loops, slides, task cards, vocabulary cards, and learning games; laminates, designs, organizes manipulative materials and print media of all sorts, visits places, tests hardware, explores phenomena, and does mini-investigations. In short, the student undergoes a very broad and practical learning experience.

The Unit Box Approach puts teeth in the theory of how children (and adults) learn. Or, to switch the metaphor, this approach sets an ignition spark to some philosophical and psychological fuel espoused by educators since the 3rd century B.C.[12]

beginning

How and where does the student begin? Part of the first session in the methods course is used to expose the class to a wide, varied, and enticing smörgåsbord of modular Teacher's Guides. At this first meeting students have a chance to give a cursory glance to more than one hundred units. In addition, the author distributes to each student printed items that provide capsule descriptions of several hundred Teacher's Guides. After consultation with his/her cooperating teacher, the student selects a unit around which to build his/her Unit Box. This choice is influenced by his background and inclinations, the science curriculum and/or texts used in the school to which he is assigned, and suggestions his instructor makes on the strength of past experience with the units. Students are urged to choose a topic in which they can become deeply involved and around which they can build an enthusiastic classroom experience. A central purpose of the Unit Box Approach is to have each apprentice teacher acquire a depth of knowledge in a particular area through firsthand experience, and to develop expertise in exploring and teaching the unit. It is desirable that each student teacher pursue a different topic, since both students and professor learn more if a wide variety of units is handled by the class.

the teacher's guides used as a starting point

What are the sources of the Teacher's Guides used for Unit Boxes? To date the writer has used mainly four sources of teaching and resource units: those developed and classroom tested by the Elementary Science Study (ESS); the modular Experiences in Science Units (EIS) authored and tested by Tannenbaum and Stillman; the units developed and field tested by the Science Curriculum Improvement Study (SCIS); and the pre-primary unit *Sense and Tell* authored and tested by Marshall, Podendorf, Swartz and Shoresman. In addition, a number of successful Unit Boxes have been assembled using Minnesota Mathematics and Science Teaching Project (MINNEMAST) units; *Guppies, Bubbles and Vibrating Objects;* and *Kitchen Photography*. These seven sources offer the student teacher 161 choices of units in science and mathematics. Furthermore, they offer seven different contrasting and complementary styles insofar as the format of a *Teacher's Guide* is concerned. The latter vary in sequencing suggested, in statement of objectives, and in the amount of background information given. Since research has not shown that any one program or type of Teacher's Guide is generally superior to all others for every purpose for all teachers and students under all circumstances, the apprentice teacher should be offered a number of options and given an opportunity to choose those he finds personally appealing. This honors his or her individuality in selecting one or several complementary guides as a starting point.

In addition to the seven primary sources designated above, there are a multitude of unit modules — particularly resource units and quasi-resource units — available from numerous other sources worldwide. However, some of these are less accessible and/or have not undergone as much classroom testing as those units previously mentioned. Currently under review as additional starting points for Unit Boxes are the following: *Science 5/13* from England; *BEBCO Guides* developed in Maryland; *Examining Your Environment* (EYE) developed in Ontario; University of Illinois Project in Elementary School Mathematics and Science (UICSM); *Individualized Science* (IS) modules; *Science Inquiry Project Series* (quasi-resource units); ASEP modules developed in Australia; SCOPES units under development at the University of Northern Iowa; units developed for the African Primary Science Program; ESCS units from Newfoundland;[13] pollution control units developed in a Union, New Jersey, project; APS from Montréal; OBIS units being developed at the Lawrence Hall of Science, University of California; BSCS elementary school science modules from Colorado; COPES units from New York University; ESC units developed in California; MAPS units by Berger and Associates; *Unified Science and Mathematics for Elementary Schools* (USMES) units from Newton, Massachusetts; National Wildlife Federation *Environmental Discovery Units;* National Audubon Society *Teacher's Guides;* and a host of units on metric measurement.

Some of these guides were used in the inservice Unit Box Project conducted in the summers of 1972 and 1973 at Owen Sound, Ontario and Ottawa respectively. This was done as part of an Ontario Ministry of Education Certificate Course in elementary school science. It should perhaps be noted that *Science — A Process Approach* (S*APA), the printed exercises developed by the Commission on Science Education of the American Association for the Advancement of Science (AAAS), do not seem to lend themselves to the Unit Box Approach. Nevertheless, this matter is still being explored. The revised version, S*APA-II (1974), may be useful since it is more modular than the first version. One possibility, which the writer would like to try, is to have a student put together a Unit Box built around a sequence of S*APA exercises on metric measurement or utilize the entire series of eighteen exercises on measurement.

Where and how do the students obtain the teachers' guides? Guides for each modular unit are obtained through the college bookstore, from the publishers, and in some cases from the professor. Since the Unit Box was introduced in 1969, the ordering of units through the college bookstore has taken considerable time. A half-yearly inventory of supply is taken and units are reordered each semester. Teachers' guides are ordered in numbers varying from four to forty depending on the title. The Curriculum Materials Center has a full collection of ESS, EIS, SCIS, EYE, BEBCO, UICSM, Science 5/13 and MINNEMAST Teacher's Guides and similar sets are on reserve in the college library at Jersey City State College. Thus, in addition to seeing the guides briefly at the first class session, students can examine them in the Curriculum Materials Center or borrow them from the library before making their choice. Students are also free to examine units from the author's personal collection. It is important to get the selection of teacher's guides into students' hands as quickly as possible both for viewing and purchase.

finale/commencement

At the conclusion of the methods course on campus or the program in the schools, each student brings in his completed Unit Box and everyone has an opportunity to see all the boxes. Twenty minute conferences allow the professor to discuss with each student the contents and use of the Unit Box. Each box is then photographed so that it may be shown to future classes. Large open-house displays may be set up in the gymnasium or cafeteria to give the boxes more exposure and such displays at Jersey City State College and in Ontario attracted hundreds of viewers. They also engendered a valuable cross-fertilization of ideas among the students involved, their teacher, and outside visitors.

Subsequent to the conferences at the conclusion of the methods course, students go out into the schools and begin student teaching. Hopefully and ideally, the apprentice teachers will be given an opportunity to use their Unit Boxes and see some of their efforts come to fruition during the practice teaching experience — as well as in their own classrooms after graduation. An assessment of what they actually do in science in the classroom is made through classroom visits and is part of a ten-year follow-up study of the Unit Box Approach. One report of findings will be published in 1974-75. To date, the study has included well over six hundred classroom visits to student teachers and graduates and nearly seven hundred interviews with graduates who assembled Unit Boxes in the course.

numbers and topics

As of June 1974, 784 Unit Boxes had been completed in thirty-eight classes which the author has taught over an eleven semester period at Jersey City State College. The boxes were prepared by early childhood, general elementary, and special education majors for grade levels pre-kindergarten through grade eight; by day students and evening students; by preservice and inservice students; by undergraduates and graduates. Experienced teachers enrolled in Ontario Ministry of Education Certificate Courses in elementary school science produced another 104 Unit Boxes at Owen Sound in the summer of 1972 and 39 more at Ottawa in the summer of 1973. Most of the 927 Unit Boxes centered on topics in the physical and biological sciences (e.g., Batteries and Bulbs, Mystery Powders, Clay Boats, Life Cycles, Material Objects, Organisms, Chemical Change, Rocks and Charts, Growing Seeds, Bones, Hot and Cold, Continuity of Life). Many, however, were interdisciplinary or mathematics oriented units (e.g., Peas and Particles, Relative Position and Motion, Balancing, Mapping, Attribute Games and Problems, Time, Metric Measurement).[14] A fair number have been readiness or pre-science units (e.g., Sense and Tell, Using Our Senses, Early Experiences).

summary

The Unit Box Approach minimizes certain traditional writing and copying activities frequently encountered in Education courses. Instead of finishing the course with the usual paper (unit) the student ends up with a complete custom-made multimedia kit plus a background of many experiences associated with its construction and use.

In summary, the Unit Box is mainly, but not merely, a collection of *things, assembled, used, and owned by the apprentice teacher;* it is a teaching-learning mediating system that interlocks materials and other media with the development of concepts, intellectual process skills, pupils' self-image, language facility, and desired attitudes toward school, science, and above all, toward learning. These are its aims. The thrust of the Unit Box Approach is development and acquisition of materials and strategies to *implement* a tested Unit in the classroom; to implement recognized and worthy objectives. Successful implementation of the Unit certainly depends on the teacher's skill in handling the contents and class effectively. Organization and disciplined freedom are key elements in the magical mix of successful utilization. But being prepared with all the materials at hand and experience in their acquisition and use — is surely an important beginning. This is the Unit Box Approach.

acknowledgments

The author is grateful to Mr. Douglas M. Jolley of the Ontario Ministry of Education and Mr. John G. Cornfield, Assistant Head of Science, Ridgemount High School in Ottawa, whose foresight and diligent efforts made two projects in Ontario possible and successful.

footnotes

1. The term "Unit Box" was coined by the author in January of 1969.
2. This article deals with only one facet of the methods course, namely, the major project and terminal assignment. It is beyond the scope of this paper to describe the course. However, the following brief statements might be helpful to the reader by placing the Unit Box Assignment in perspective. It is a hands-on, non-lecture, media-oriented workshop type course. At *every* session students have an opportunity to work with ESS, SCIS, and AAAS-S*APA materials and activities. Films produced by ESS and SCIS along with slides and 8 mm motion pictures taken by the author are interspersed with the laboratory activities. These show real live children in classrooms engaging in activities similar to those the prospective teacher is involved in throughout the course. The atmosphere is non-threatening with high priority placed on interest, building of confidence, success, and joyful learning.
3. This statement is expanded at considerable length and documented with numerous references in a longer report available from the author. The paper presented here is a much condensed version of the full report in which many reasons are given for *not* having elementary education students write science units.
4. For example, the Elementary Science Study (ESS) *Teacher's Guide on Growing Seeds* and the *Experiences in Science* (EIS) Teacher's Guide, *Plants in Spring;* or the ESS units, *Life of Beans and Peas* and *Butterflies,* along with the Science Curriculum Improvement Study (SCIS) unit on *Life Cycles;* or the ESS unit, *Mystery Powders* combined with the Baltimore County, Maryland (BEBCO) unit on *Chemical and Physical Changes* and the EIS unit, Chemical Change; or the MINNEMAST unit Number 4, *Using Our*

Senses, combined with the Scott, Foresman modular pre-primary unit, *Sense and Tell*, plus the BEBCO unit on the Senses, and parts of the SCIS unit, Material Objects — and so forth.

5. This quasi-audio-tutorial component of the Unit Box is intended to *further* individualize learning (e.g., to accommodate a particular Piaget developmental stage of the pupil or to provide for a particular preference in learning style) — and might be considerably expanded. The writer may at some future date explore the idea of having an entire Unit Box built around a sequence of A-T modules. For more information on this topic consult the work of Novak at Cornell (1972) and a book by Novak to be published in 1974-75. See also the use of tape cassettes in *Individualized Science* (IS) under development at the Learning Research and Development Center of the University of Pittsburgh.
6. See L. S. Vygotsky (1962) and chapters 3 and 6 of Lansdown, Blackwood and Brandwein (1971).
7. For example, the construction and use of a shaving mirror telescope as one component of a Unit Box on Light or Optics or Astronomy. The construction project is usually not mentioned in the Teacher's Guide — but is a relevant and useful adjunct. A comprehensive list of Unit Box construction projects is available from the author.
8. For example, the evaluation supplements developed for each unit by the Science Curriculum Improvement Study (SCIS) or the evaluation materials recently developed for Elementary Science Study (ESS) units. See also the evaluation devices being produced for the Elementary Science Curriculum Study (ESCS) in Newfoundland.
9. See, for example, the use of science learning games in *Individualized Science* (IS); see articles by Weber (1971), Doran (1973) and the board game, *Metricat1On*. See, also, the puzzle-game component of the Science Curriculum Improvement Study (SCIS) unit, *Relativity*.
10. All of this does *not* preclude pupils bringing in science materials from home, nor does it preclude pupils constructing devices in class and at home. Both should certainly be encouraged. But the writer believes that these activities and contributions on the part of elementary school students should follow (and complement) the Unit Box Experience of the student teacher and classroom teacher. Tomorrow's science lesson should *not* depend upon whether or not the pupils bring in the necessary materials. Pupils may, however, be encouraged to stockpile and bring in certain items to be used several months from now. In regard to these points see the SCOPES units being developed at the University of Northern Iowa.
11. This is in contrast to situations in which a commercially prepared kit is handed to a teacher. The writer does *not* imply that all science kits should be teacher-produced or that unit kits are the only way to teach science or that commercial unit kits are useless. Nevertheless, there seems to be some definite definable value for teachers who put it all together themselves, i.e., the materials *not* the Teacher's Güide. This complex topic is treated at greater length in the Final Report of this project.
12. In addition to Piaget, Vygotsky, Bruner, Dewey, and others, see Huxley (1869), Spencer (1860), and Page (1847). See, also, chapter 8 of Hsün-tzu (3rd Century B.C.). Many ideas in vogue today can

be found in some form somewhere in the historical literature on education. A noteworthy and engaging example is the emphasis today — as reflected in the Unit Box Approach — on inquiry, discovery, and individual activity by pupils who interact with real things and phenomena. These ideas are *not* new; they were all espoused by J. W. A. Young, over sixty years ago, for the teaching of mathematics and by Henry Edward Armstrong, a prominent nineteenth century English chemist and teacher. Both men were probably perceived as deviant by other members of their local social system. Armstrong and his heuristic method, in his day, made little impression in the United States, and hardly a wave in his native England. This is understandable in historical perspective, since acceptance of new ideas and widespread change in education tend to be glacial. But change does occur and its effects are perceptible over a period of time.

13. During the Spring Semester of 1974 the writer explored the use of ESCS Teaching Guides. Students used ESCS process/principle oriented units (as a nucleus for their Unit Boxes) in combination with the relevant ESS, SCIS, EIS or MINNEMAST Units. ESCS is a second generation hybrid, and like biological hybrids may be even stronger than its pure strain origins. This Canadian curriculum represents a synthesis of some of the most significant elements in AAAS--S*APA and ESS plus elements of SCIS and MINNEMAST.
14. In regard to mathematics oriented units, the Unit Box Approach may also be useful in connection with teacher preparation for laboratory-centered mathematics teaching. Regarding this type of teaching see Kidd (1970), Berger (1973), Davidson and Walter (1972); also, the very early work of Young (1907).

references cited and other relevant literature

1. Bureau de Recherche et de Consultation en Education, *Approaching Problems Scientifically* (APS), Montréal: Librairie Beauchemin Limitée.
2. Henry E. Armstrong, *Teaching Scientific Method and Other Papers on Education,* London: Macmillan Co., 1913, pp. 236 and 255.
3. *Australian Science Education Project* (ASEP), 11 Glenbervie Road, Toorak, Victoria 3142.
4. Mitchell E. Batoff, *Kitchen Photography on a Shoestring,* Jersey City, New Jersey: By the Author, 1972.
5. G. W. Beeson, "Making Curriculum Decisions," *The Australian Science Teachers' Journal,* LIX: 45-52, September, 1973.
6. Emil J. Berger, ed., *Instructional Aids in Mathematics,* Thirty-fourth Yearbook, Reston, Virginia: National Council of Teachers of Mathematics, 1973.
7. Board of Education of Baltimore County (BEBCO), Thirty Modular Units, Greenwood, 6901 North Charles Street, Towson, Maryland 21204. (Katherine M. Klier, Curriculum Consultant).
8. Matthew Bruce, "A Study of Undergraduate Programs for Science Teachers," unpublished report, Washington, D.C., USOE Project 7-C-001, "Science Education for Elementary Teachers," unpublished report, Washington, D.C., USOE Project 7-C-016.

9. The Commission on Science Education of the American Association for the Advancement of Science (AAAS), *Science-A Process Approach* (S*APA), and S*APA-II, 1974, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005.

10. Robert K. Crocker, Project Director, *Elementary Science Curriculum Study* (ESCS), Memorial University of Newfoundland, St. John's, Newfoundland.

11. Patricia S. Davidson and Marion I. Walter, "A Laboratory Approach," *The Slow Learner in Mathematics*, Thirty-fifth Yearbook, Reston, Virginia: National Council of Teachers of Mathematics, 1972.

12. Rodney L. Doran and William Watson, "Games for the Science Classroom," *The Science Teacher*, XL: 31-35, April, 1973.

13. Henry S. Dyer, "The Art of Unwrapping Curriculum Packages or How to Be An Educational String Saver," *The Bulletin of the National Association of Secondary-School Principals*, LII: 155-57, May, 1968.

14. *Elementary Science Study* (ESS), Education Development Center, Inc., 55 Chapel Street, Newton, Massachusetts 02160. (French translations and adaptations, of ESS Teacher's Guides are available from McGraw-Hill, Editeurs, 750 Boulevard Laurentien, Montréal.)

15. Len Ennever, Project Director, *Science 5/13*, University of Bristol School of Education, 19 Berkeley Square, Bristol, England BS8 1HF; General Learning Corporation, 115 Nugget Avenue, Agincourt, Ontario; Purnell Educational, 850 Seventh Avenue, New York, New York 10019; Macdonald Educational, 49-50 Poland Street, London, England W1A 2LG.

16. Paul DeHart Hurd, "Elementary School Science for the 1970s in Perspective," in *Developments in Elementary School Science, A Report of Seven Regional Conferences for School Administrators*, Washington, D.C.: American Association for the Advancement of Science, 1970, pp. 1-11.

17. T. H. Huxley, *Scientific Education*: *Notes of an After-Dinner Speech*, 1869.

18. Willard J. Jacobson, "U.S.A.: Post-Sputnik Science Curricula," *Strategies for Curriculum Change*: *Cases from Thirteen Nations*, R. Murray Thomas, Lester B. Sands, and Dale L. Brubaker, eds., Scranton, Pennsylvania: International Textbook Co., 1968, pp. 116-35.

19. Kenneth P. Kidd, Shirley S. Myers, and David M. Cilley, *The Laboratory Approach to Mathematics*, Chicago, Illinois: Science Research Associates, Inc., 1970.

20. Leopold E. Klopfer, Project Director, *Individualized Science* (IS), Learning Research and Development Center, University of Pittsburgh, 160 North Craig Street, Pittsburgh, Pennsylvania 15213.

21. Louis I. Kusland and A. Harris Stone, *Teaching Children Science*: *An Inquiry Approach*, Second Edition, Belmont, California: Wadsworth Publishing Co., 1972.

22. Brenda Lansdown, Paul E. Blackwood and Paul F. Brandwein, *Teaching Elementary Science Through Investigation and Colloquium*, New York: Harcourt Brace Jovanovich, Inc., 1971.

23. J. Stanley Marshall, Illa Podendorf, Clifford Swartz, and Peter B.

Shoresman, *Sense and Tell Teacher's Guidebook: Unit One of Pre-Primary Science System,* Glenview, Illinois: Scott, Foresman and Co., 1968; Scarborough, Ontario: Gage Educational Publishing Ltd.

24. John McGavack, Jr. and Donald P. La Salle, *Guppies, Bubbles and Vibrating Objects: A Creative Approach to the Teaching of Science to Very Young Children,* New York: The John Day Co., 1969.
25. *Metricat1On,* Metrix Corporation, Box 19101, Orlando, Florida 32814. A Monopoly-type board game which has been found to be effective for introducing the language of the metric system in an informal, fun way.
26. *Minnesota Mathematics and Science Teaching Project* (MINNEMAST), Minnesota School Mathematics and Science Center, University of Minnesota, 720 Washington Ave., S.E., Minneapolis, Minnesota 55414.
27. Marshall A. Nay, "Avoid Obsolescence: Build a Curriculum Resource Information Bank," *The Crucible* (Science Teachers Association of Ontario), IV: 4-11, February, 1973.
28. David E. Newton and Fletcher G. Watson, *The Research on Science Education Survey* (ROSES), *The Status of Teacher Education Programs in the Sciences,* 1965-1967, Harvard Graduate School of Education, Cambridge, 1968, pp. vii, 63-4, 72, 85, 115-16.
29. Joseph D. Novak, "A Case Study of Curriculum Change — Science Since PSSC," *School Science and Mathematics,* LXIX: 374-84, May, 1969.
30. "The Use of Audio-Tutorial Methods in Elementary School Instruction," *The Audio-Tutorial Approach to Learning Through Independent Study and Integrated Experiences,* Third Edition, S. N. Postlethwait, J. D. Novak, and H. T. Murray, Jr., eds., Minneapolis: Burgess Publishing Co., 1972.
31. "Audio-Tutorial Techniques for Individualized Science Instruction in the Elementary School," *Individualized Science,* Henry J. Triezenberg, ed., Washington, D.C.: National Science Teachers' Association, 1972.
32. *Outdoor Biology Instructional Strategies* (OBIS), Lawrence Hall of Science, University of California, Berkeley, California 94720.
33. David P. Page, *Theory and Practice of Teaching,* 1847.
34. Mary Budd Rowe, *Teaching Science As Continuous Inquiry,* New York: McGraw-Hill Book Co., 1973.
35. Schools Council Research Studies, *Evaluation in Curriculum Development: Twelve Case Studies,* Basingstoke: Macmillan Education Limited, 1973, pp. 1-35.
36. *Science Curriculum Improvement Study* (SCIS), Lawrence Hall of Science, University of California, Berkeley, California 94720. (The French translation and adaptation of the SCIS program was completed in the Spring of 1973. Further information on the International French edition is available from the Institute of Psychological Research, Inc., 34 ouest, rue Fleury, Montréal.)
37. Herbert Spencer, *Education: Intellectual, Moral and Physical,* 1860.
38. A. Harris Stone and others, *Science Inquiry Project Series,* Englewood Cliffs, New Jersey: Prentice-Hall, 1966-1974.

39. Harold E. Tannenbaum, Beulah Tannenbaum, Nathan Stillman, and Myra Stillman, *Experiences in Science* (EIS), New York: Webster/McGraw-Hill, Inc., 1967.

40. *Unified Science and Mathematics for Elementary Schools* (USMES), Education Development Center, Inc., 55 Chapel Street, Newton, Massachusetts 02160; see *EDC News*, Issues 1-4; *School Science and Mathematics*, October 1974 and *Mosaic* (published by the National Science Foundation), Volume 5, Number 1, Winter, 1974.

41. Donald A. Vannan, "The American Elementary Science Methods Teacher Today," *Science Education*, LIV: 183-84, April, 1970.

42. L. S. Vygotsky, *Thought and Language*, Cambridge: Massachusetts Institute of Technology Press, 1962.

43. Fletcher G. Watson, "New Approaches to Science in Elementary Schools," *Science and Mathematics: Countdown for Elementary Schools*, Frontiers of Science Foundation of Oklahoma, Inc., A Symposium held at Oklahoma City, Oklahoma, 5 December 1959, pp. 32-38.

44. ————, "The Teaching of Physics . . ." *Science Activities*, X: 35-37+, November, 1973. Useful navigational aid for rational selection of any curricular material.

45. Victor L. Weber, Jr., Albert P. Nous, and Robert N. Costa, "Science Learning Games in an Individualized Setting," *Science Activities*, VIII: 13-19, March, 1971.

46. Daniel F. Wentworth, J. Kenneth Couchman, John MacBean and Adam Stecher, *Examining Your Environment* (EYE), Toronto: Holt, Rinehart, and Winston of Canada.

47. Dean K. Whitla and Dan C. Pinck, *Essentially Elementary Science: A Report on the Status of Elementary Science in Massachusetts Schools*, Submitted to the Massachusetts Advisory Council on Education, Office of Instructional Research and Evaluation in the Faculty of Arts and Sciences and The Harvard Graduate School of Education, Cambridge: Harvard University, March 1973. A significant study which is relevant to the starting points, rationale and spirit behind hundreds of Unit Boxes assembled at Jersey City State College and in Ontario, 1969-1974, cf. references 48 and 49 also.

48. Dean K. Whitla and Dan C. Pinck, *Something of Value: A Summary of Findings and Recommendations for Improving Elementary Science in Massachusetts*, Submitted to the Massachusetts Advisory Council on Education, Office of Instructional Research and Evaluation, Harvard University, March 1973.

49. Dean K. Whitla and Dan C. Pinck, *Lively Elementary Science Programs: A Handbook of Suggestions for Introducing and Maintaining Innovative Science Activities*, Submitted to the Massachusetts Advisory Council on Education, Office of Instructional Research and Evaluation, Harvard University, January 1974.

50. J. W. A. Young, *The Teaching of Mathematics in the Elementary and Secondary Schools*, New York: Longmans, Green, 1907.