Autoinstructional Materials In Science Methods Courses

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College "how to teach" courses maximize integration of educational theory and practice when students are actively engaged in the development, preparation, and testing of instructional materials. Towards this end we have found the development of autoinstructional science kits by students in science methods courses to be a viable self-instructional technique, useful in fostering an awareness and understanding of science-teaching methods and their application.

Contents and Use of the Kit

An autoinstructional science kit consists of instructions, science materials, and subject content designed to teach a particular science concept or principle. Specifically, there is a package of materials (costing approximately $1) in a shoebox or other container of similar size, along with detailed instructions for using these materials in a science demonstration or experiment. A list of instructional objectives, a glossary of scientific terms, and a pre- and post-test for assessing learning achievement are included. The learner manipulates the materials according to the instructions and is guided to the attainment of the objectives via the activities, content, and glossary. Attainment of objectives is measured by the learner's post-test score.

The idea of an autoinstructional kit is simple. However, the development of kits that are interesting, effective, and truly autoinstructional requires much skill and effort. Consequently, considerable time is expended in explaining to students the nature of an autoinstructional kit and the problems involved in its development (fig. 2). The student selects a science concept such as force, work, energy, tropism, solubility, pH, or taxonomy (classification) that can be presented in whole or in part in approximately one hour to a student of "average" ability in a designated grade. The inquiry method is used whenever possible. Inexpensive materials are begged, borrowed, or purchased for one or more simple science demonstrations or experiments related to the concept.

Kits have been developed that teach the user to measure the relative strength of three small magnets; measure the solubility of selected substances in water and other solvents at different temperatures; test and distinguish between acids and bases by using litmus and pH paper; classify plants on the basis of physical features; determine the relation-

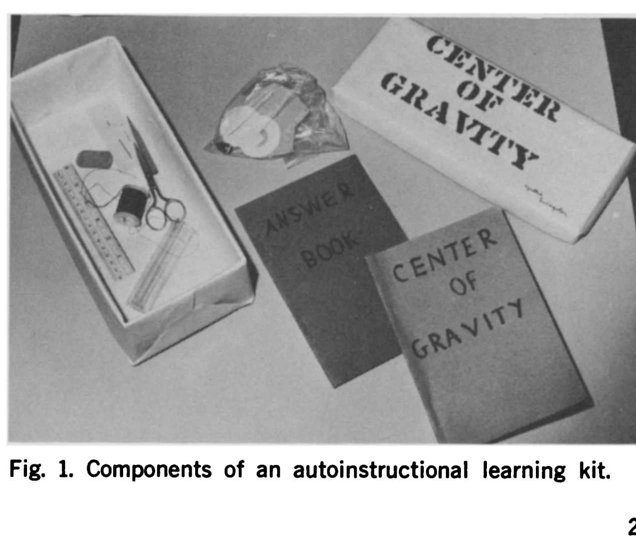

Fig. 1. Components of an autoinstructional learning kit.

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Fig. 2. Instructions for developing an autoinstructional science kit.

1. Choose a topic appropriate to a time limit of about 50 to 60 minutes.
2. Use inexpensive materials suitable for inclusion in a small carton. Shoebox is maximum size.
3. Avoid harmful and corrosive materials.
4. Organize the learning program as follows:
   a. To learn (objectives)
   b. To use (materials)
   c. To do (procedure)
   d. Key words (science vocabulary terms)
   e. Self-check (post-test)
   f. Further reading
5. In writing directions use simple declarative sentences of 15 words or fewer. Keep new vocabulary terms to a minimum. Strive to reach the thought-forms of the learner.
6. Define each new science word in a single sentence.
7. Keep the procedure simple and detailed. Safety precautions should be written in capitals or underlined, or both. Include a diagram where it will prove helpful.
8. In programming instructions strive for interest, motivation, and success.
9. The post-test should consist of 5 to 10 multiple-choice questions.
10. Cite an appropriate "further reading" reference.
11. Try out the kit with one or more pupils and revise it on the basis of feedback from this trial.
12. Make a carbon copy of the program to be retained by your instructor.
13. Criteria for success:
    a. The learner becomes interested enough to complete the program.
    b. The learner can carry out the procedure correctly without asking any questions.
    c. The learner is successful on the post-test.
    d. The learner achieves satisfaction. He is likely to come back for more.

ship between potential and kinetic energy by using a pendulum; determine the relationship between concentration gradient and osmotic pressure; measure large distances by means of a range-finder; and determine the reaction of mealworms to various stimuli. The shoebox size of the container serves as a practical restriction on the amount and complexity

Fig. 3. Using a kit in the study of dominant and recessive traits.

of materials to be included in the kit. Due consideration is given to safety: poisonous or corrosive materials are not permitted.

Motivating the kit-user by insuring that he is successful in manipulating materials and subject content is best accomplished through the proper selection and sequencing of kit activities. These activities must be arranged as small "learning steps" that require frequent response by the learner as he works through the program. The components of the kit must be organized to avoid error, confusion, and frustration. A poorly organized autoinstructional kit causes rapid dissipation of motivation on the part of the student. A kit-user can automatically be "turned off" halfway through a program if he finds the material dull, confusing, or too complicated. It requires no little effort on the part of the kit-developer to guarantee that this will not occur.

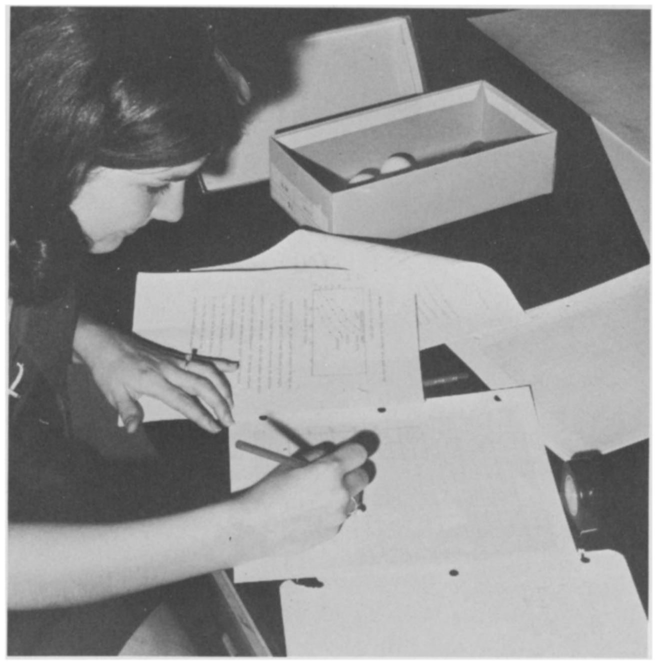

Fig. 4. An autoinstructional exercise in coordination chemistry.

What the Kit-Maker Learns

The writing of materials for use by junior and senior high school pupils is a new and challenging task for most students in college methods courses. Their initial efforts are likely to be wordy, unclear, and possibly pedantic. To help overcome this problem, guidelines for written materials are specific: limit sentences to 15 words or fewer; avoid polysyllabic non-science words; restrict the use of science words and terms; include a glossary of science words; arrange all series of questions and directions in order from simplest to complex; and include diagrams to increase clarity.

The student submits his completed autoinstructional kit to at least one junior or senior high school

Fig. 5. Students in a science methods class try out each other's autoinstructional kits.

pupil for trial use. "Bugs" in the program are identified from results of the pre-test and post-test and from subsequent discussions between the developer and the user. Failing to make objectives and directions clear, omitting critical material, providing too much content for the intended time-span, and making the post-test too difficult are faults commonly uncovered.

Kits are revised on the basis of feedback from the pupil trial and brought to a meeting of the methods class, where they are exchanged among class members for a second trial. Each kit is reviewed and evaluated by a class member and the instructor in terms of criteria previously established for kit development. In this way each student is exposed to the work of his classmates and benefits from the general discussion that follows.

Admittedly it takes an exceptionally able teacher to package his teaching into a shoebox that can be used by his pupils without additional assistance. Most of the kits developed by beginners fall short of the ideal set by the kit-development criteria. One might logically ask: "What, then, do the kit-developers learn?" In general they become sensitive to the need for controlling vocabulary, stating objectives succinctly, clarifying explanations, and relating material to the pupil's abilities, interests, and motives. In addition, they often find that their understanding of basic science concepts increases markedly as they work through the process of developing successful autoinstructional kits to teach these concepts.

One important reason for using the autoinstructional-kit learning procedure in our methods classes is that it introduces a mode of teaching that is consistent with the principles of educational psychology and with the current emphasis on individualizing instruction in the classroom. Inviting methods-class students to participate in the development of autoinstructional programs encourages active rather than passive participation in the learning process while at the same time increasing the students' awareness of the necessity for individualizing classroom instruction. Methods-course students often use their autoinstructional kits in student teaching along with other individualized materials. Thus it is our conviction that the development of autoinstructional kits and other, comparable material in college methods classes causes future teachers to be exceptionally predisposed to the use of individualized materials in their science-teaching.

REFERENCES

ABBOT, J. 1970. Auto-tutorial systems: students prepare some dandies. *Science Teacher* 37: 19-22.

PATTERSON, M. D. 1970. Individualizing science instruction within Project Plan. *Science Teacher* 37: 33-35.

MCBURNEY, W. F. 1969. Individualized instruction: a case for the independent student investigation in science. *School Science and Mathematics* 69: 827-830.

Copper Reagent . . . .

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ysates); that is, the nonglucose components of the disaccharide in the case of lactose and sucrose. Fortunately, unchanged disaccharide does not interfere with the monosaccharide reactions. Here it should be mentioned that the monosaccharide test, if carried out with the disaccharide solutions (5 ml sugar solution plus 5 ml of reagent), gives reactions that are quite different from the hydrolyzed disaccharides (table 2).

Discussion

Cuprammonium compounds are well known but do not appear to have been previously used as sugar-analysis reagents. The reagent described here is superior to Benedict's reagent in that if carefully used it gives a wide variety of color and precipitation reactions with various common sugars and permits individual sugars to be identified.

There are, of course, many organic reagents that enable different types of sugars to be identified; but some of these may not always be easily or cheaply available and are usually best prepared fresh before use. On the other hand, the cuprammonium reagent is quickly and conveniently prepared from inexpensive and easily available laboratory chemicals and is stable for months.

The color reactions of sugars with the cuprammonium reagent is an empiric finding, and the chemistry involved may be complex. A possible approach to elucidation of the mechanisms involved is suggested by the fact that the cuprammonium ion forms complexes with polyhydroxy compounds including sugars (R. E. Reeves, 1951: "Cuprammonium–Glycoside Complexes," *Advances in Carbohydrate Chemistry* 6: 107-134). It may be that this is involved in the reactions of sugars with cuprammonium reagent to give the observed variety of appearances.