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ABSTRACT

A significant alternative to the traditional text-based approach to elementary science has been represented by the Science Curriculum Improvement Study (SCIS). Although the literature documents the process of the investigative approach, greater utilization of available programs and support from teachers are not evidenced. This investigation was devised to determine teacher perceptions and their relationships to this concern. These questions were addressed: (1) "To what extent are teacher variables, such as grade level, years of experience, and frequency of scheduling science time, related to teacher evaluation of the SCIS-II program?" (2) "How do teachers perceive the barriers and support systems that exist in their district's elementary science program?" (3) "What student outcomes do teachers see as significant results of the SCIS-II program? Are these perceptions related to teachers' degree of positive attitude about the program? Are they consistent with the body of research? and (4) "What specific concepts, materials, activities, etc., do teachers find to be problems in the present program, and what changes do they feel might alleviate the problems?" It was concluded that teachers in grades 3-6 perceived more barriers to effective instruction and experienced greater problems with management, materials, and equipment during activities than their colleagues in the lower grades. (RT)

Teacher's Perceptions of Barriers in Utilizing SCIS-II

(Alternate Title: SCIS-II and the Elementary Teacher: A Program Analysis)

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SCIS-II and the Elementary Teacher: A Program Analysis

Introduction

Since its inception in the late 1960's, the Science Curriculum Improvement Study (SCIS) program has represented a significant alternative to the traditional text-based approach to elementary science. Together with ESS and SAPA, two other NSF-funded curricula of the period, SCIS emphasized the development of science process skills and broad concepts, rather than the accumulation of terms and isolated facts. The success of the investigative approach is well documented in the literature. Shymansky, Kyle, and Alport (1982, 1983) used a meta-analysis to paint an overall picture of the differences between investigative and traditional curricula in such areas as student achievement, science process skills, student attitudes, and related skills. While SCIS, ESS and SAPA each had their stronger areas, they all consistently outperformed the traditional programs. Bredderman (1982, 1983) obtained similar results in his meta-analysis, which combined results from all three "alphabet" curricula. Furthermore, Bredderman found that disadvantaged students benefited even more from activity-centered programs than did their non-disadvantaged counterparts. Atwood and Oldham (1985) found that teachers perceive the SCIS program to be more amenable to mainstreaming handicapped students than other elementary curriculum areas, such as language arts, mathematics, or social studies. Student attitudes toward science are also improved under the SCIIS program, a revision of the original SCIS (Kyle, Bonnstetter, and Gadsden, 1988), sometimes despite less positive attitudes on the part of the teachers. Indeed, Kyle, et al, found that SCIIS teachers' attitudes were essentially the same as for the non-SCIIS comparison group. Consistent with this finding, Noraas (1988) found that only 43% of teachers would continue using the SCIIS program if given a choice, while 34% would definitely not choose to continue the program.

With the abundance of evidence supporting the outcomes of an investigative approach to elementary science, why do we not see greater utilization of the available programs, and greater support from the teachers? Even among districts that adopt one of the programs, do teachers perceive the kinds of successes that the research indicates should result? Are there significant barriers that prevent teachers from doing their best job of teaching investigative science, or that discourage them from making a full effort? Are such barriers different from those usually identified by science supervisors, teacher educators, and curriculum developers? The present study was initiated to investigate questions such as these.

Purpose

The present investigation utilized a two part opinionaire, addressing the following questions:

1. To what extent are teacher variables, such as grade level, years of experience, and frequency of scheduling science time, related to teacher evaluation of the SCIS-II program?
2. How do teachers perceive the barriers and support systems that exist in their district's elementary science program?
3. What student outcomes do teachers see as significant results of the SCIS-II program? Are these perceptions related to teachers' degree of positive attitude about the program? Are they consistent with the body of research?
4. What specific concepts, materials, activities, etc., do teachers find to be problems in the present program, and what changes do they feel might alleviate the problems?

Methodology

The selected district is a metropolitan public school district in Kentucky. Within the district are elementary schools that may be considered urban, suburban, and rural, in terms of student population. The schools themselves range in size from having 10 classroom teachers, grades K-6, up to 39 teachers in those same grade levels. The original SCIS program was piloted in the district beginning in 1974, and was adopted as the elementary science curriculum in 1977. The SCIS-II revision was adopted in 1983. The annual budget for the program is administered by a Science

Coordinator at the Central Office. Staff development is performed chiefly through an annual three day workshop before the opening of school. While attendance at the workshop is not mandatory, building principals are encouraged to identify teachers who would benefit from participating. The focus of the workshop is to familiarize teachers with the philosophy and operation of the SCIS-II program through a large degree of hands-on experience with the materials and activities they will be using. Furthermore, each school building has at least one "building representative" for science, who takes care of ordering and distributing materials, serves as a resource person, and acts as a liason between the teachers and the Central Office. Thus, a number of support mechanisms exist in this district that may not be present in other locations.

The opinionaire was constructed in two parts. The first part was a forty eight item multiple choice instrument. The first seven items collected information about the respondent. The remaining items used a Lickert-type five point scale to collect responses to questions in the following areas: nature and operation of the SCIS-II program, barriers to teaching science effectively, effectiveness of support systems, and perceptions of student outcomes. Responses to the forty eight items were recorded on an answer form for machine scoring.

A second part of the opinionaire was prepared for each of the twelve SCIS-II units (grades 1-6) and the SCIS "Beginnings" unit used in kindergarten. Each of these unit opinionaires consisted of the same two free-response questions about each section of the unit: 1) What most often does not work well?; and 2) What change or improvement is most needed in this section? Each unit opinionaire was completed collectively by the teachers at the particular grade level at each school. The length and substance of the responses were up to the teachers, and are taken to represent a consensus of that school's teachers using the unit in a classroom setting.

Through the cooperation of the elementary school principals, both parts of the opinionaire were administered to teachers on a day when students were not present. Each teacher responded to the individual opinionaire and returned the forms to the principal. Subsequently, teachers met in grade level groups to discuss and respond to the questions on the unit opinionaires for the SCIS-II units they were teaching. The teachers were asked to return the unit opinionaire forms by the end of that day, but circumstances forced some groups of teachers to return theirs a few days later.

Forms for the individual opinionaire were returned by 663 teachers, out of a total of 685, for a return rate of 96.8%. To facilitate analysis, responses from related items were summed to produce four new variables, representing evaluation of the overall program (9 summed items), barriers to effective instruction (12 summed items), support systems (7 summed items), and student outcomes (10 summed items). Analysis was performed on the individual opinionaire data using Minitab statistical spreadsheet software.

The number of unit opinionaires returned for each of the thirteen units ranged from 24 (77%) to 30 (97%). All responses on each unit opinionaire were initially listed by unit, section, and question. Those responses listed by 10% or more of the groups responding were then transferred to a priority list by unit, section, and question. Finally, a summary sheet for each unit was prepared which included these priority responses.

Results: Individual Opinionaire

The first task was to test the validity of the summed variables as representative of the individual items on the survey. A correlation matrix was constructed for each summed variable and its component items. Correlations ranged from .46 to .83, indicating that the new variables were more strongly related to some items than others. In particular, the overall evaluation of the SCIS-II program (called "sum rating") was strongly correlated to three individual items: the teacher's indication on a 1-5 scale of how strongly he/she likes or dislikes the SCIS-II program; the teacher's perception of the degree of student interest in the activities; and the teacher's evaluation of the appropriateness of the concepts and activities for that grade level. Such items as management ease and availability of materials were less strongly related to the summed rating. This result is encouraging in its suggestion that satisfaction with the program is more strongly related to instructional concerns than logistical ones. Figure 1 contains summary statistics for the four summed variables.

(INSERT FIGURE 1 HERE)

Next, exploratory data analysis techniques were used to identify potentially noteworthy relationships. In particular, box-and-whisker plots were constructed to examine the four summed variables according to responses to the seven descriptor items from the survey. Examples are illustrated in Figure 2 and Figure 3.

(INSERT FIGURES 2 AND 3 HERE)

In the Figure 2, the boxplots for the various experience levels overlap appreciably. This would indicate that years of teaching experience has little relationship to the program evaluation given by the teachers. Such a result is surprising, since it was expected that positive outlook toward the SCIS-II program would be strongest for relatively new teachers, who have received more preservice exposure to such programs. Subsequent analysis of variance confirmed the lack of a significant relationship between these variables (F=1.36, df=657).

In the case of Figure 3, there appears to be an increase in teacher rating of the program as the perceived appropriateness of the topics and activities increases. An analysis of variance confirms this as a significant relationship (F=187.25, df=659).

By performing similar examinations of the survey items and the four summed variables, the following additional outcomes were noted:

1. Teachers in this school district are divided in their overall evaluation of the SCIS-II program. The item, "My general evaluation of the adopted science program is:" yielded a slightly negative mean response of 2.8 (1=lowest, 5=highest, s.d.=1.3). However, the item, "My students' evaluation of the adopted science program is:" yielded a more positive mean response of 3.5 (s.d.=1.0). These evaluations were not significantly related to years of teaching experience, years of grade level experience, size of the school, or the

number of days a week that science is scheduled. There were, however, some significant differences in the mean evaluations of the thirty-two participating schools. This would indicate that some aspect(s) of the school environment are involved with the teachers' attitudes toward the science program. Further investigation is needed to identify those aspects more clearly.

Furthermore, the variable, Sum Rating, which was the sum of nine separate survey items, had a highly significant relationship to the single item where teachers expressed their general evaluation of the SCIS-II program (F=352.34, df=660). Indeed, as the plot in Figure 4 illustrates, the mean values of the summed variable for each of the five response levels of the single item form a virtually linear pattern. This would indicate that the teachers' overall opinion of the SCIS-II program colored their responses to the nine component items of the summed variable in a very regular manner. That is, teachers critical of the program were consistently critical when considering particular aspects of the program; teachers who rated the program highly tended to rate the individual aspects equally highly. Such an outcome might indicate general differences between teachers who accept the philosophy of an investigative model of science teaching and those who do not. On the other hand, such an outcome may simply be the result of teachers failing to give careful consideration to the component items, instead allowing their overall feelings to determine their responses. The present data do not allow a determination of which interpretation (if either) is the proper one.

(INSERT FIGURE 4 HERE)

2. Primary grade (K-2) teachers had more positive rating of the program than did intermediate grade teachers (3-6). Ratings did not differ significantly within the intermediate grades. Figure 5 illustrates this pattern.

(INSERT FIGURE 5 HERE)

3. Kindergarten and first grade teachers reported significantly fewer barriers to effective teaching in the SCIS-II program, compared to the other grade levels. For the total sample, lack of adequate preparation time, difficulty in evaluating students, and lack of supplementary materials were rated the most serious barriers.
4. The size of the school was not significantly related to the degree of perceived barriers. This is reasonable, in light of the fact that 84% of the teachers reported that they taught science to a self-contained class, rather than using a team or departmental approach.
5. Teachers who rated the program more highly perceived significantly fewer barriers to effective teaching in the program (F=76.19, df=660).
6. The most beneficial support mechanisms for the SCIS-II program were perceived to be cooperation among fellow teachers and the three day summer workshop. Perception of the overall level of support for teaching the SCIS-II program was positively related to the teachers' evaluation of the program itself (F=17.47, df=660).
7. The teachers in the sample reported that the following student outcomes were all achieved well in the SCIS-II program: opportunity to experience science directly, development of social skills and positive attitudes toward science, and ability to experience success in school. However, the development of science process skills, acquisition of appropriate science content, and reinforcement of "basic skills" were seen as being achieved to a lesser degree, particularly by teachers in grades 4-6. The meta-analyses of both Bredderman (1982, 1983) and Shymansky, Kyle, and Alport (1982, 1983) clearly demonstrate the greater achievement of SCIS students compared to "traditional" students on measures of content acquisition, process skills, and related skills (language, mathematics, etc.). In light of such research, the perception in this study that such outcomes are not well achieved is of some concern to the authors. Again, further investigation is needed to address this concern.

8. Primary grade teachers (K-2) were significantly more positive than intermediate grade teachers (3-6) in their overall assessment of student outcomes.
9. Teachers with over 20 years experience were significantly less positive in their overall assessment of student outcomes. Teachers with 0-2 years of experience were significantly more positive than the remaining group. Recall that years of teaching experience were not significantly related to the overall evaluation of the SCIS-II program; however, the experience factor does enter into the assessment of particular student outcomes. It would seem that teachers who began their careers before the dissemination of the "investigative" science curricula are more likely to compare present outcomes to memories of outcomes under traditional programs. Brand-new teachers, on the other hand, would have received more extensive pre-service preparation for the kinds of outcomes emphasized in the investigative programs, and so would adjust their expectations accordingly.

Results: Unit Opinionaires for Each Grade Level

Beginnings. For the Beginnings unit from the original SCIS program, seven different problems were listed by at least 10% of the 24 school groups responding. The totem pole pictures stimulated the most complaints (14) by far. Four groups suggested the pictures are too complicated, while the remaining ten groups just said the totem pole pictures do not work well. Other problems are given below (together with the number of groups listing them):

1) The Colors section can only be done successfully working with a small part of the class at any one time. (3)
2) The activities using the glasses and color windows generally do not work well and/or cause disruption. (3)
3) The touch screen is awkward to use and not sturdy enough. (4)
4) The odor boxes fall apart easily, are hard to clean, and not enough boxes are supplied. (3)

5) The magazine picture activity is poor, since the relative sizes of objects shown in magazine pictures can be misleading. (4)

6) The lesson consisting of positioning dots and drawing figures is not effective. (5)

The change or improvement identified as being most needed for the Beginnings unit was to provide more, and more stimulating, activities and materials. In fact, 10% or more of the groups made this recommendation for eight of the nine sections. A prominent view seemed to be that simply completing the unit activities would not adequately teach much of the content that is introduced. Also, teachers want to have to scrounge fewer materials. Another view seemed to be that today's kindergarten children are more sophisticated, having had more pre-K educational experiences than children a decade ago, and so need a more challenging and stimulating unit.

Material Objects. Problems identified by 29 teacher groups for the SCIS-II Material Objects unit were as follows:

1) Some shells and wooden rectangles do not differ enough within each of these two groups of objects for effective classifying by the children. (3)

2) The unit includes too much repetition, especially in classifying, which reduces interest and makes the unit seem to "drag out". (11)

3) The grab bag activity is too complicated for some children. (4)

4) The liquid activities are too messy and clean up is too difficult to be worth the trouble. (11)

5) Too much teacher preparation time is required. (3)

The most frequently suggested change or improvement for the Material Objects unit was to either greatly improve or eliminate the liquids activities. The other major suggestion was to privide more interesting and challenging activities, including more investigative activities and more supplementary activities.

Organisms. Many complaints about the Organisms unit were directed to the performance and viability of the living organisms, as can be seen from the responses of the 27 groups returning the opinionaire:

1) The seeds do not germinate. (8)
2) The daphnia die before they can be used. (11)
3) The guppies die prematurely. (8)
4) Some pairs of guppies do not reproduce. (6)
5) Problems were experienced with living materials arriving in short supply, in poor condition, too immature, and/or too late to use. (13)
6) Vandalism wipes out the habitat board activities. (5)

Thirteen of the responding groups agreed that the major improvement needed is to solve the problems encountered with the living organisms. The need for supplementary activities to do while waiting for the living systems to change was also expressed.

Interaction and Systems. All 30 groups responding complained about problems with the pulley systems in the Interaction and Systems unit. Problems mentioned included: difficult set-up; pulleys easily slip off the spindles; slippage of the rubber bands; management and discipline problems resulting from malfunction of the systems. Other problems included:

1) The review activites in the first section are too simple and are not challenging. (4)
2) The review activities require too much time to obtain materials not in the kit. (4)
3) The ozalid paper/light interaction activity does not work well. (8)
4) A variety of complaints were voiced about the batteries, bulbs and motors, including: the batteries "die" too easily and the motor wires break off easily. (15)
5) The copper chloride activities are too dangerous. (3)

Needed improvements listed focused on the pulley system problems. The sentiment clearly was to "fix it or forget it". Teachers want the materials to do the review activities to be included in the kit, and they want ozalid paper that works. They also want more durable materials for the electricity activities and more supplementary materials, especially for section 3 (systems) and section 6 (interaction at a distance).

Life Cycles. Most of the 30 responding groups focused on the viability and performance of the living organisms in the Life Cycles unit:

1) The seeds do not germinate and/or problems were experienced with the plastic bag germinator. (9)
2) Problems related to plant growth beyond germination include: the plants get tall and spindly; the plants do not grow on schedule; and the light sources are not sturdy. (6)
3) Problems with animal organisms include: they frequently do not arrive on time or arrive dead; they die before all stages of the life cycle are observed; mealworms sometimes arrive already in the beetle stage; and the fruit flies are too inactive and hard to transfer. (30)
4) The biotic potential concept is too absract and difficult. (3)

The responses included so few comments on the last two sections of the four section unit, and those few comments tended to be so superficial and show so little insight, that the question of whether many teachers are teaching the last two sections was raised. Improving the viability and performance of the living organisms was the major change recommended. Strengthening the last two sections, including providing enrichment activities, was also suggested.

Subsystems and Variables. For the Subsystems and Variables unit the concerns on the 28 opinionaires were scattered across all five sections of the unit, as the list below indicates:

1) The review section is too repetitious of the second grade work with batteries. (6)
2) It is hard to keep all of the batteries and bulbs working at the same time. (11)
3) Problems occur with other materials, such as the BTB not reacting as expected. (3)
4) The system and sub-system concepts are often difficult for students. (3)
5) The concepts and results in the section on solutions are often vague. For example, differences between cloudy and clear liquids are sometimes too subtle. (4)

6) Preparation and clean up time for the messy and smelly liquids activities may take longer than actually doing the activities. (4)

7) The thermometers are inaccurate and easily broken. (3)

8) Obtaining ice and hot water for adequate temperature contrasts is one of the preparation problems of the temperature section. (6)

9) The rubber bands for the whirlybirds are not uniform, break easily, and cause management problems. (7)

10) The post and wing nut for the whirlybird will not tighten, and wear out quickly. (3)

11) The number of turns of the whirlybird is hard to count. (4)

12) Playing, rather than working, with the whirlybirds is a problem, and it tends to raise the noise to unacceptable levels. (3)

The 28 groups returning forms showed little agreement on needed improvements and changes. Eight groups want the review section strengthened in content, background information for the teacher, and practice for students in keeping track of a system. Four groups want more durable and uniform materials, particularly rubber bands, for the whirlybirds; they also want help on management problems.

Populations. Most of the problems identified in teaching the Populations unit are problems with the viability and performance of the living organisms utilized in the unit. Specific concerns from the 29 responses are as follows:

1) The brine shrimp seldom hatch. (7)

2) Plants do not grow at the expected rate, which throws off the timing of other living material shipments. (14)

3) Crickets, chameleons, and/or daphnia die prematurely. (29)

4) Large numbers of daphnia sometimes makes counting the daphnia population difficult. (4)

5) The seeds do not germinate. (5)

6) Plants die prematurely, leaving no food for the crickets -- and the chameleons have not arrived. (5)

7) Crickets are too large for the chameleons to eat, or some other reason keeps them from being eaten. (4)

8) The 8 liter containers are too small to use for aquaria; they are not sturdy enough for repeated use; the tops do not fit well. (4)

Although no specific problem was identified by at least 10% of the teacher groups for section 4 of this unit ("The Community"), the comments made about the section suggest that some teachers have a low regard for it, and perhaps spend little or no time on it. Suggested changes include: supplying healthier organisms; providing "back-up" activities for when organisms do not live or perform as expected; more durable aquaria, with lids that fit well; more detailed teacher instructions for keeping it all going.

Measurement, Motion and Change. Twenty four groups returned the opinionaires for this unit. While the comments suggest some ambivalence about this unit, relatively few groups agreed on specific barriers to successfully teaching it:

1) The plastic straws do not work as well as paper ones for the sound activity. (4)

2) The review activities are difficult -- some children seem to lack the background needed for them. (3)

3) Some of the puzzles are confusing. (3)

4) Treasure hunt and observers reports are too difficult, except for above average students. (4)

5) Compasses do not work well; the needles become unattached. (4)

6) Difficulties arise in working with the overlays. (4)

7) Rubber bands on the pegboards break and cause discipline problems. (5)

8) The relative motion concept is difficult for students to grasp. (5)

9) The weather section is weak, and needs much supplementing. (3)

Comments suggest that some teachers view this unit as useful, noting that it complements mathematics and social studies content at this grade level. Apparently, other teachers see the unit as being hard to manage and requiring too much preparation time. Suggested changes include providing more interesting individual activities in all sections. Providing more background for the teacher and practice for the students is needed on the relative position and relative motion concepts. The weak weather section needs a great deal more activities, media, etc., in order to be worthwhile.

Environments. Enthusiasm was generally lacking from the 27 teacher groups responding about the Environments unit. The identified problems and teacher comments suggest that the last two sections may get only a short play (if any) in the classroom:

1) Organisms die prematurely. (11)
2) Organisms do not arrive on time. (5)
3) Discipline and management problems are present. (3)
4) Some animals burrow, leading to difficulties observing and noting population changes. (4)
5) The weather does not cooperate for using Section 2, "Outdoor Activities". (3)
6) Outdoor activities do not fit in the available time blocks allocated to science. (3)
7) Outdoor activities are too long-term, and get boring before completion. (3)
8) Animals are difficult to keep alive for the duration of the study; the brine shrimp are particularly difficult -- they often do not hatch, and die prematurely if they do hatch. (15)
9) Expected results are frequently not obtained. (3)
10) Section 4, "Plants Response to Environmental Factors", is redundant, having already been observed in Section 1. (4)
11) The light source in the kit is inadequate; good window light is needed to make the activities work. (4)

12) Section 5, "Total Environment", is redundant. (3)

The recommended changes were topped by a request to provide more viable and interesting organisms, rather than ones familiar from previous units. Some groups asked for more activities to reinforce the concepts, text material or supplemental materials to use, and a back-up set of plans to use when organisms die unexpectedly. The last two sections were seen as being in particular need of enhancing.

Energy Sources. Sixteen of the 25 groups responding identified problems with the roto-plane systems as the major source of concern in this unit (e.g., propellers slipping, parts easily broken, etc.). The stopper poppers were also identified as being troublesome. Among the 13 complaints about the stopper popper activities, the lack of appropriate classroom space, misconduct by students, cracked syringes, and safety concerns were prominent. Other kinds of concerns were as follows:

1) The review section revealed little student knowledge of previous work with SCIS-II. (4)
2) Thermometers are hard to read, and the tube slips in the holder, throwing off the calibration. (6)
3) The spheres are noisy and give poor results, unless they are rolled on an ideal surface. (5)

The lack of substantive comments on the last two sections suggests some teachers may be quitting the unit after section 4. Redesign and upgrade of the roto-plane quality was the major suggested change. Specific suggestions included: using shorter sticks; improve the PRP subsystems and platform/post connection; provide uniform rubber bands. Teachers also want more background and practice activities for the review section, as well as more durable thermometers.

Communities. As with the other life science units, the viability of the organisms was the major concern of the 25 teacher groups responding. A list of the problems follows:

1) Seeds do not germinate. (8)

2) The dark chamber is not dark enough for green plants to lose their color and die in the time recommended. (3)

3) Animal organisms do not arrive on time. (6)

4) Crickets and/or frogs arrive dead. (4)

5) Crickets die before frogs arrive, leaving no food for the frogs. (6)

6) Organisms are difficult to keep alive. (4)

7) Organisms have died before reaching Section 4, and so reproduction is not observed. (3)

The Paucity of knowledgeable comments on the last two sections of the four section unit raises questions about the extent to which the last two sections are being taught. The improvements most needed, according to the responding teacher groups, are more viable organisms, back-up organisms, and back-up activities for use when the systems are not changing. Addressing the redundancy problem was recommended. The last two sections are judged to be in need of major revitalization.

Modeling Systems. As the list below reveals, the 25 responding groups did not agree on the barriers to successfully teaching the Modeling Systems unit:

1) Fresh batteries and bulbs are needed. (7)

2) The magnesium ribbon/bleach activity is difficult to make work correctly. (4)

3) The coil/rivet system is difficult to keep together. (3)

4) The electromagnet activity does not work well. (5)

5) Corrosion on the brass clips and/or bulb give misleading results. (3)

6) Investigating magnetic fields is generally abstract and difficult. (3)

7) The compasses become dysfunctional easily. (5)

8) Section 4, "Air Ocean", is academically weak, and not worth the time and effort. (3)

In addition to recommendations aimed at solving the problems listed above, some teacher groups suggested the need for assistance in understanding the major concepts of this unit, as well as applications of the concepts. The content of the unit is apparently considered to be difficult by many teachers.

Ecosystems. The 26 groups expressing views on the Ecosystems unit identified the following problems:

1) Organisms die prematurely, especially the daphnia. (17)
2) The aquarium/terrarium system is not durable, particularly the lids. (9)
3) The crickets jump into the water and drown. (3)
4) Section 1, "Classroom Ecosystems", is not sufficiently academic or challenging for sixth graders. (3)
5) Organisms die before they can be used in Section 2, Section 3, or Section 5. (9)
6) Section 2, "Water Cycle", lacks the substance to fill the scheduled time. (4)
7) The BTB stains clothes and carpet. (3)

Comments suggest that teachers are dropping out in increasing numbers after the second section of this five section unit. Suggested improvements included requests for more durable and separate aquaria and terraria. Teachers want healthier organisms on shorter notice, as well as supplementary activities to do when living systems fail, or when changes are slow to occur. More stimulating activities, more content, and more emphasis on scientific processes were also requested for this unit.

Discussion and Implications

In looking for generalizations from the individual opinionaire data, the lack of significant relationships between some of the organizational/demographic variables and teacher perceptions of the barriers and outcomes of the SCIS-II program was somewhat surprising. For example, *none* of the following were significantly related to the overall perception of barriers to teaching the program: size of the school, years of teaching experience, self-contained vs. departmental organization, or number of days/week science is scheduled. However, perceptions of barriers were significantly related to teachers' overall perception of the SCIS-II program and to the teachers' grade level (primary or intermediate). Teachers in grades 3-6 perceived more barriers to effective instruction in general, compared to their colleagues in the lower grades. In particular, student management during activities and unexpected results were seen to be significantly greater problems among teachers in grades 3-6 than among teachers in grades K-2. Teachers in grades 3 and 6 also perceived greater problems in managing materials and equipment during activities.

There was reasonable consistency between the perceptions of barriers in the individual opinionaire and the comments written on the unit opinionaires, particularly as regards the need for preparation time and supplemental activities. Curiously, student management, equipment management, and unexpected results were not rated on the individual forms as being particularly severe problems in the lower grades, although they were mentioned frequently as problems in responses to the unit opinionaires. Perhaps these problems do not become apparent to teachers until they begin thinking about specific sections of a unit or about specific activities.

Reviewing the major barriers to the full and successful implementation of the SCIS-II program as reported on the unit opinionaires, problems with the living organisms collectively represent the principal stumbling block. The following "what can go wrong" scenario for the Populations unit is typical of the difficulties cited by teachers for the life science units at all grade levels: Seeds are planted, but few germinate. The crickets arrive with little to eat, so they immediately begin dying. Meanwhile, the few spindly plants that have grown are pressing against the terrarium lid, which fits poorly, and may even be cracked near the fastening points. Once the lid pops up, the remaining crickets start to disappear from the terrarium. Then, of course, the chameleons arrive, again in a hungry state. The crickets that are still in the terrarium are comparable in size to the small chameleons, making the expected predator/prey interaction difficult to observe. Teacher background materials give little direction on alternate food sources, so soon the chameleons begin to die as well. The students in this third grade class have had numerous opportunities to observe and discuss death and decomposition. Unfortunately, however, these concepts are not the primary objective of the terrarium activities in this unit. Assuming the teacher has "hung in there" until now, which may be doubtful, he/she probably has rather negative feelings about SCIS and may be reluctant to try the unit again the following year.

On the other hand, some teachers are able to do what must be done to make the unit work. This can sometimes be laborious and time consuming. Are these teachers more capable than the others? Is it just "luck" that their seeds germinate and their predators consume their prey? Perhaps these teachers are more committed to the program -- teachers who rated the program higher were also more likely to perceive fewer barriers and more support systems. Such questions merit investigation in subsequent research.

Based on the accumulated problems and suggestions from the group opinionaires, a number of improvements are indicated to strengthen the useability of the SCIS-II program:

1) Perhaps heartier organisms can be substituted for some of the more vulnerable ones, such as the daphnia. Furthermore, such substitutions should be well thought-out in advance. Replacement of the land snails by earthworms in the revision of SCIS to SCIS-II has produced problems of smell, messy containers, and difficult observation. The hermit crab, used in the SCIIS revision, seems to lack these disadvantages.
2) More explicit care and feeding instructions for animal organisms, including alternate food sources, would be helpful for teachers.
3) Beans are cheap and germinate quickly, but children who are in the SCIS-II program for seven years would probably be stimulated by more variety in the plant life. This could be done without sacrificing the concepts to be developed.
4) Living systems materials -- containers, light sources, etc. -- need to be more durable and functional.

Noraas (1988) reported that some of the problems with using the living materials in SCIIS were eliminated when a resource biologist was hired to assist the teachers. The district she studied had only 71 elementary teachers, compared to almost 700 in the present study, making such a solution less practical here. However, the use of more specialists in teaching elementary science would reduce the pool of teachers needing assistance, perhaps to a level where Noraas' findings would be transferable.

5) The need for supplemental and extension activities is apparent, not only for when things don't work as planned, but also for when the students grasp the concepts quickly and exhaust the activities suggested. Moreover, teachers in grade 5 or 6 in a middle school organization are likely to teach 45 minutes of science every day. Their need for additional ideas, consistent with the learning cycle approach, is even more evident. While the developers of the original SCIS and the two modest revisions (SCIS-II and SCIIS) have surely not denied the desirability of adding supplemental activities, it is unrealistic to expect elementary teachers to consistently have the time to select possible activities, to scrounge the needed materials, and to test the ideas thoroughly before using them with students. Perhaps print and video resources can be developed for supplemental use during the application phase of the learning cycle.
6) Other equipment problems need to be corrected through redesign of materials or replacement by new activities. In particular, the pulleys in the Interaction and Systems unit could be replaced by the more reliable gear systems in the SCIIS version. Similarly, the whirleybird and rotoplane systems have design problems that need to be eliminated to reduce teacher and student frustration with their use.

It became readily apparent when reading through the unit opinionaires that the number of comments and concerns tended to decrease sharply for later sections in certain units. Based on the relative lack of insight even in the relatively few complaints on these later sections, together with the investigators' experience in working with elementary teachers, it is inferred that the number of teachers actually teaching the program also decreases sharply for the later sections of those certain units. Assuming that a dominant factor in this decrease is the level of teacher frustration arising from the barriers cited, some general recommendations can be made regarding priorities for improvements. While some problems exist in all units, the frequency and nature of responses on the Material Objects, Interaction and Systems, and Subsystems and Variables unit opinionaires suggest that these units are generally being attempted by teachers all the way through, indicating a somewhat lesser need for modifications. On the other hand, the Ecosystems, Communities, Energy Sources, and Life Cycles units seem the most likely to have teachers stop using them midway through the unit, indicating the need for significant modification.

It is unfortunate that the SCIS program has not undergone a series of incremental improvements over the years, rather than just the two simultaneous revision projects that occurred in the early 1980's. Addressing the accumulated needs discussed above will require a significant effort -- a much more daunting task than a series of smaller changes over a longer time. Even with its problems, though, the SCIS program remains (together with ESS and SAPA) an amazing success story. No other subject area has a set of programs so demonstrably superior to traditional programs. That is, superior in terms of student outcomes, not in their share of the elementary science market. Textbook publishers have borrowed many of the ideas from these investigative curricula, but have not adopted the instructional philosophy that is the key to their success. To be competitive, these inquiry-based programs must become more "user friendly" without sacrificing the philosophy and approaches that have made them successful.

There will always be problems with doing investigative science, especially with living materials and simple apparatus. Some teachers will always be able to cite reasons why they cannot teach this program, even while their colleagues are overcoming the same barriers and doing an outstanding job. It is the contention of the authors that the large numbers of teachers who fall between these two extremes would be willing to give investigative science a try if some of the obvious barriers could be reduced. This study represents an initial effort in this direction, for just one of the investigative programs that exist. Much remains to be done. It is our hope that those groups developing the latest round of NSF-funded elementary science curricula will give attention to what has gone before, and make a concerted effort to expand the spirit of those programs, while reducing the difficulties they possess.

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```
                     Sum       Sum       Sum       Sum
                   Ratings   Barriers  Support  Outcomes

# ITEMS SUMMED        9        12         7        10
N                   663       663       663       663
# MISS               13        13        13        13
MEAN              26.63     33.63     24.50     32.78
MEDIAN            26.00     34.00     25.00     33.00
MAX                  45        59        35        50
MIN                   9        12         7        10
STDEV              6.45      8.69      5.67      9.40
SE MEAN            0.26      0.34      0.25      0.40
```

FIGURE 1: Summary statistics for four summed variables

```
Teaching Experience           ------------
     0-3 years  --------------I    +     I---------
                              ------------
                            -------------
     3-5 years  ------------I      +    I---------
                            -------------
                               ---------
    6-10 years      -----------I  +    I---------
                               ---------
                             -----------
   10-20 years  -------------I     +   I----------
                             -----------
                            -----------
 over 20 years  ------------I    +    I------------  *

               --+---------+---------+---------+------
                 10        20        30        40
                Summed Evaluation of SCIS-II Program
```

FIGURE 2: Boxplot of variable "Sum Rating" by Teaching Experience

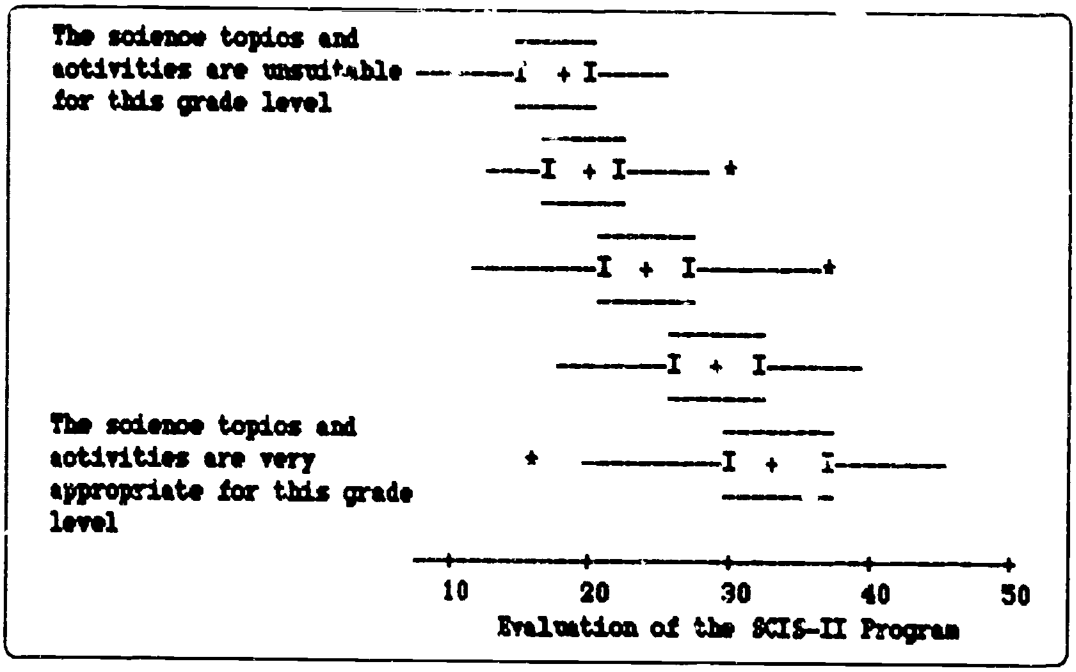
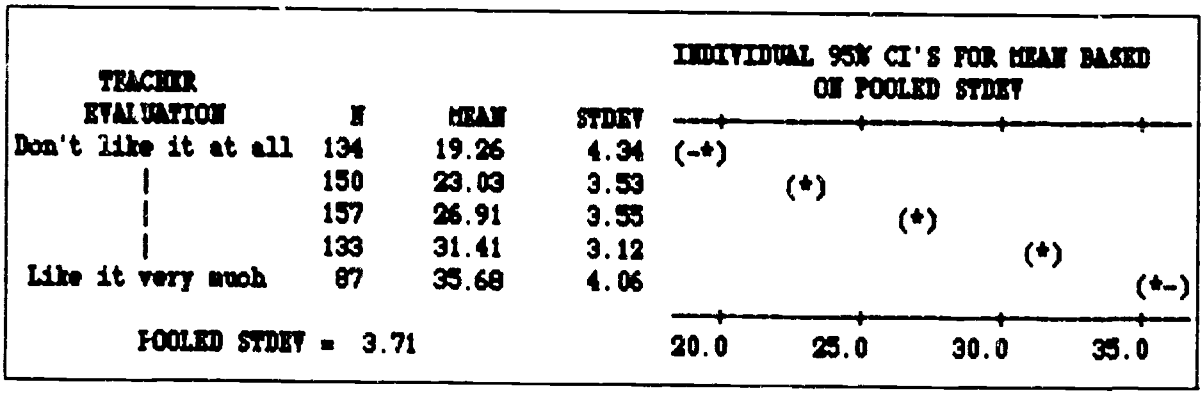
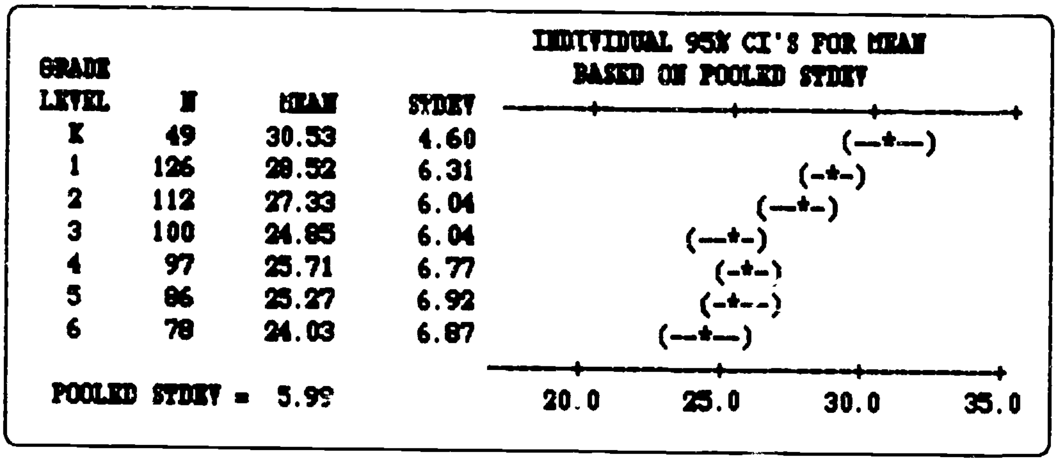


FIGURE 3: Boxplot of Sum Rating by Teacher Perception of Appropriateness



```
                                               INDIVIDUAL 95% CI'S FOR MEAN BASED
     TEACHER                                              ON POOLED STDEV
    EVALUATION          N        MEAN      STDEV   ---+---------+---------+---------+---
Don't like it at all   134      19.26      4.34   (-*)
         |             150      23.03      3.53           (*)
         |             157      26.91      3.55                   (*)
         |             133      31.41      3.12                            (*)
  Like it very much     87      35.68      4.06                                    (*-)
                                                   ---+---------+---------+---------+---
     POOLED STDEV =   3.71                           20.0      25.0      30.0      35.0
```

FIGURE 4: Plot of Mean Values of Sum Rating versus Response to Overall Evaluation Item



```
                                           INDIVIDUAL 95% CI'S FOR MEAN
GRADE                                      BASED ON POOLED STDEV
LEVEL     N       MEAN      STDEV   ----+---------+---------+---------+
  K      49      30.53       4.60                           (--+--)
  1     126      28.52       6.31                        (-+-)
  2     112      27.33       6.04                      (--+-)
  3     100      24.85       6.04                  (--+-)
  4      97      25.71       6.77                    (-+-)
  5      86      25.27       6.92                   (-+--)
  6      78      24.03       6.87                 (--+--)
                                    ----+---------+---------+---------+
POOLED STDEV =   5.99                  20.0      25.0      30.0      35.0
```

FIGURE 5: Plot of Mean Values of Sum Rating versus Grade Level of Teacher