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ABSTRACT

This paper summarizes a pair of studies titled "The Impact of Longer Term Intervention on Reforming the Approaches to Instruction in Chemistry by Urban Teachers of Physical and Life Sciences at the Secondary School Level" (William J. Priestley, Holly D. Priestley, and Joseph S. Schuckler) and "Profile of Instructional Practices Related to Experiences in Laboratory Oriented Instruction in Secondary and Beginning College Level Chemistry Instruction" (Alexandria Wilosky, Frank Sutman, and Mei Wang) that examined instructional practices or teaching behaviors during the laboratory component of chemistry instruction at both the secondary and college levels. These examinations of teaching practice indicate that at both levels and across chemistry courses, there is an emphasis on the teacher addressing procedural concerns with virtually no time spent in using behaviors designed to develop higher order thinking skills. The studies employed the Modified Revised Science Teacher Behavior Inventory (MR-STBI) to identify verbal and non-verbal teaching behaviors. The behaviors identified that relate to inquiry-oriented instruction include use of lower and higher level divergent questions, group-centered cooperative group activities, activities designed to assist students in reevaluating scientific conceptions and misconceptions, and teacher generated discussion related to laboratory observations. Contains 35 references. (DDR)

SCIENCE LABORATORY INSTRUCTION: SUMMARY OF FINDINGS AND IMPLICATIONS FROM FOUR COMPANION STUDIES

The Impact of Longer Term Intervention on Reforming the Approaches to Instruction in Chemistry by Urban Teachers of Physical and Life Sciences at the Secondary School Level

(William J. Priestley, Holly D. Priestley and Joseph S. Schmuckler)

Profile of Instructional Practices Related to Experiences in Laboratory Oriented Instruction in Secondary and Beginning College Level Chemistry Instruction

(Alexandra Hilosky, Frank Sutman and Mei Wang)

(Presented at the National Association for Research in Science Teaching Meeting, March 23, 1997, Chicago IL)

Introduction (Earlier Studies)

Earlier meta-analyses of research results (1970-1994) indicated that science laboratory experiences at both high school and college levels perceived to be inquiry oriented, resulted in significantly positive cognitive and non-cognitive learning outcomes. Yet, in many of these studies "inquiry based" was vaguely defined and, in most instances, the researchers also served as instructors, creating possible bias.

A second pair of studies examined instructional practices (teaching behaviors) during the laboratory component of chemistry instruction at both the high school and college levels. These examinations indicated that at both schools and college level, as well as across levels of chemistry courses, (high school: advanced placement,, "ChemCom" and college preparatory chemistry, and college level: chemistry for majors and chemistry for non-majors) regular laboratory and post laboratory experiences emphasized teaching behaviors that emphasized the instructor addressing procedural concerns with virtually no real laboratory time spent in using behaviors designed to develop higher order thinking skills.

Except in two instances in a university in Germany, observed laboratory instruction could not be classified as inquiry oriented. Even the written procedures to be followed by students were seldom read by the students, resulting in the undue time spent by the instructor, during the laboratory experiences, answering students' procedural questions. Third practice resulted in little need for students to learn to read and comprehend the written directions. Likewise, post laboratory experiences seldom drew upon the results of data and other observations obtained from the actual laboratory experiences.

The 25 hours per week of laboratory experiences in the German university were inquiry oriented (as defined in the next section) chemistry, but the content was limited to traditional qualitative analyses of chemical species. The German students worked in teams; even in searching the literature for the procedures to be followed. Observing this behavior or practice led to the understanding that searching for and following directions, as part of laboratory instruction (the so-called "cookbook" approach), can be a part of inquiry experiences. This is a process used by scientists.

Inquiry Based Instruction, The MR-STBI:

The above studies considered inquiry-oriented instruction as instruction that emphasizes certain teaching behaviors included in the Modified Revised Science Teacher Behavior Inventory or MR-STBI. The MR-STBI is a modification of the original STBI developed and used by Vickery in 1968. Modifications have been made by: Clark (1974), Hilosky (1994) and Priestley and Priestley (1996). The verbal and non-verbal teaching behaviors included in the modified revised instrument, that relate to inquiry oriented instruction include: the use of lower and higher level divergent questions, group centered cooperative group activities, activities designed to assist students to reevaluate scientific (mis)conceptions, laboratory results that are integrated with theories from other disciplines, teacher generated discussion related to laboratory observations, use of collected data as a primary source of post-laboratory student/teacher interactions, teachers' use of process terminology (such as classify, analyze, predict, create), teachers encourage students to engage in meaningful discussion with each other, teachers encourage students to engage in meaningful discussion with each other, teachers encourage clarification of students' initial responses, student centered, students explain science concepts (asks teacher for support in interpreting data, drawing conclusions and developing concept[s]), teachers accept students ideas related to investigative procedures and teacher supervise laboratory activities moving from group to group.

<u>Inquiry Based Instruction, Revised Levels of Inquiry:</u>

Schwab (1962) described four "levels of discovery" or levels of <u>openness</u> in instruction. The degree of openness is based upon the extent to which teachers provide (1) the problems, (2) the ways and means of addressing the problems, and (3) the answers to the problems. The less teachers supply these, or the more students are involved in supplying these components the greater the degree of inquiry,. Herron (1971) elaborated on this scheme of open oriented instruction and Hofstein and Lunetta (1982) proposed that the scheme might require further research.

In 1995, McComas viewed the Schwab classification scheme as providing "some information regarding the relative roles of the teachers, the laboratory manual, and the students." In 1995 Sutman revised the classification scheme to include five levels of openness or inquiry and four areas of student and teacher involvement. This revised classification scheme is indicated below.

Levels of Inquiry Oriented Instruction

Level of Inquiry	Proposed Problem or Issue to be Explored	Addresses or Plans Procedure to be Used	Explores or Carries Out Procedure	Supplies Answers or Conclusions
0	By Teacher	By Teacher	By Teacher	By Teacher
1	By Teacher	By Teacher	By Teacher	By Students
2	By Teacher	By Teacher	By Students	By Students
3	By Teacher	By Students	By Students	By Students
4	By Students	By Students	By Students	By Students

Revised from Schwab by Sutman (1995)

The research related to preparing teachers to orient their laboratory based instruction toward inquiry (see next section) anticipates that science instruction overall will, at the very least, meet the criteria for level two of the revised scale.

Report on Four Studies

In 1996 the team of researchers from Temple University's Center For Science Laboratory Studies reported in detail on the meta-analyses referred to above and on the analysis of laboratory based instruction, in chemistry, at the beginning college level. The report also addressed the procedure followed and the data obtained from the two studies of the impact of longer term modeled intervention on orienting teachers more toward laboratory driven inquiry oriented science instruction. This year's report emphasizes the implications of these two studies and the recommendations. The report also includes a detailed report of practices in high school laboratory instruction in chemistry and a comparison of the results of this study with the college level study reported in 1996. Also to be reported, in 1997, are the results of further analyses of the data from the two studies that determined results of longer-term intervention as well as conclusions and implications from these studies.

The Impact of Longer Term Intervention on Reforming Science Teachers' Approaches to Science Instruction

The two studies conducted by W. Priestley (1996) and H. Priestley (1996) explored the impact of modeled longer-term inservice experiences on reforming pre- and post-laboratory instruction. Twenty-four urban inservice middle and high school science teachers who were enrolled in an inservice science methodology course that offered experience in using the findings from laboratory investigations as the driving force for further science instruction. This instructional approach was modeled by the course instructors, followed by the teachers, working in cooperative groups, designing and teaching sequences of lessons directed at following the model and moving away from the more traditional approach. This inservice instruction occurred over a 13 week period and was followed by observations and videotaping the instruction being carried out in the inservice teachers' school classrooms. Behaviors or strategies emphasized in their classroom instruction was analyzed using the Modified Reformed Science Teacher Behavior Inventory (MR-STBI) and the profiles of behaviors developed were compared to that of the traditional and the modeled reformed instruction. In addition, ethnographic interviews were utilized to discern possible reasons why individual teachers could or could not adapt to this reformed approach to instruction.

Results/Conclusions:

The Priestleys' studies concluded that instructors of life and physical sciences need to learn how to revise their instructional approaches to emphasize facilitation of learning by their students; not through verbally unfolding procedures but instead through longer term interventions preparing teachers to be facilitators of moving at least to the first and second levels of Sutman's Revised Inquiry Scale. The facilitator role, in itself, must go beyond data collection. In addition, laboratory instructors must learn to follow the data collection activity with ample opportunities for interpretation and explanations based on scientific theory.

The analyses of these two studies indicate that, the teachers adopted the modeled approach and made significant changes in their course organization. These results indicate that the longer term modeled approach to reforming instruction appears to be effective, at least immediately during the treatment and immediately following it.

While the exploration reported herein did not reveal significance in the teaching behaviors between the two groups of teachers, the physical science teachers (PSTs) and the teachers of life science (LSTs) did show significant differences in the amount of time used in conducting post-laboratory sessions. It was discovered that all of the LSTs that significantly fit the model, did conduct laboratory activities in which numeric data was collected, the greater time spent by the PSTs in post-laboratory instruction may indicate that the laboratory experiences used by the PSTs called for the collection and thus analysis of more numeric data than was true for the LSTs. If this is indeed the case, it may call for changes in the nature of the data collected.

Recommendations/Implications

Teachers of life and physical sciences at the high school level experienced modeled lower-level inquiry-oriented instruction emphasizing shorter pre-laboratory sessions in which limited lecturing and no definition of terms was included, as well as longer post-laboratory activities that emphasized the use of student data and observations to drive further instruction. The experience resulted in significant changes in their course organization and teaching strategies used in the pre- and post-sessions. This resulted in the following recommendations: (1) pre- and in-service science teachers must experience the reformed approaches to instruction that they are expected to practice; (2) they need ample opportunity to experience appropriate pedagogical practices within the context of science content in which they have the greatest strength. This experience is especially critical for life science teachers because they conduct post-laboratory sessions that are less than half the length of those conducted by the physical science teachers and (3) inservice courses should be designed to involve school administrators in the modeled instruction so that they can better understand why and how to be more proactive in supporting laboratory instruction. This proactive support needs to include school schedules that places laboratory experiences in priority over assemblies and other non-academic activities.

A summary of the recommendations from the studies are:

1. Professional development experiences for inservice science teachers needs to extend over longer periods of time to allow for
   a) modeling, practice, critiquing, mentoring and developing a continuing sense of support.
   b) school administrators need to be proactively supportive of laboratory experiences in science instruction (note 4, below).

c) teachers not only must have opportunity to expand their knowledge of reformed teaching strategies and course organization; they also need opportunity to be involved in modeling reformed approaches and school administrators to support the reform. This experience will be most effective if experienced within the context of science content.

2. In order to increase the importance of the laboratory component of instruction, at least 50% of the final grade should be based on the learning that takes place as a direct result of laboratory based experiences.
3. Development of a more extensive web of support outside of the actual science department.
4. Formal content/pedagogical inservice courses should team science teachers and administrators.
5. Separate sections of the inservice course should be offered, built along content lines. The separation or content focus would afford the opportunity for teachers to address pedagogical issues within the context of the content areas in which they have the greatest strength and hopefully in which their major teaching assignments occur.
6. The use of a laboratory activity content analysis scheme, such as the example proposed by Schwab (1962) should be a component of each of these course experiences. This type of analysis scheme should serve to complement the present course efforts in assisting students (teachers) to reflect on the extent to which they use inquiry-oriented experiences in their approach to instruction thus leading to an increased level of inquiry.
7. Sessions of the course, designed to address assessment of student learning strategies, need to be expanded to include experiences with strategies for assessing learning that develop directly from the reformed approach to utilizing laboratory experiences and that involve the enrolled teachers in developing, under supervision, direct laboratory-based assessment practices. The implementation of effective assessment procedures related to laboratory experiences can strengthen overall instructional reform.

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