Science Curriculum in Practice: Student Teachers' Use of Hands-On Activities in High-Stakes Testing Schools

Charles J. Eick

This article describes the influence of recently adopted high-stakes testing on the curriculum and instruction of 12 secondary science student teachers (or interns). The study, which used a postpositivist, qualitative method with researcher as participant as the university supervisor, focused on interns' abilities to implement hands-on, reform-minded practices in the context of their school placements. Findings indicate that high-stakes testing could adversely influence interns' use of hands-on activities in courses assessed on tests and in schools where students did not receive high scores.

Nationwide reform efforts in education during the past two decades have concentrated on improving public education by holding schools accountable for student learning through comparison testing (Jones et al., 1999). Commercial tests have been predominantly paper-and-pencil tests of basic skills and content knowledge (or traditional tests). They are considered "high stakes" because results are used to determine such actions as teacher merit pay, school takeovers, student promotion, graduation, and scholarship (Charlesworth, Fleege, & Weitman, 1994; Falk & Larson, 1996). Where this testing exists, curriculum and instruction are test driven (Charlesworth et al., 1994; Shepard & Dougherty, 1991). Teachers emphasize the curricular objectives that they know will be covered on the test at the expense of other studies (Barksdale-Ladd & Thomas, 2000; Charlesworth et al., 1994). This emphasis on "teaching to the test" casts doubt on the validity of these tests to measure student learning (Madaus, 1988; Smith & Fey, 2000).

The influence of high-stakes testing on concurrent national reform efforts in curriculum and instruction could be detrimental. Reforms in curriculum and instruction emphasize a best-practice approach to education. Best-practice strategies include authentic learning and assessment experiences where students interact and manipulate materials to construct knowledge (Daniels & Bizar, 1998). A best-practice approach for science instruction is mirrored in

Charles J. Eick is assistant professor of science education, Department of Curriculum and Teaching, Auburn University, Auburn, AL. Correspondence concerning this article may be sent to **eickcha@auburn.edu.**

the National Science Education Standards (National Research Council (NRC), 1996). The standards (NRC, 1996) emphasize a more process-oriented approach to learning science in which students are prompted toward higher-order thinking through investigative inquiry, which is often supported by hands-on, minds-on teaching methods that foster deeper understanding of science concepts and scientific processes (Mintzes, Wandersee, & Novak, 1997; NRC, 1996). Because most traditional high-stakes tests emphasize discrete facts and skills that are committed to memory, teachers are unlikely to pursue best-practice reform efforts in curriculum and instruction when high-stakes testing exists in traditional forms (Mitchell, 1997). Science teachers under such testing pressures will find it difficult to implement best-practice-based instruction even if they are inclined to do so (Yerrick, Parke, & Nugent, 1997; Veronesi & Van Voorst, 2000).

In this article, I focus on the influence of traditional high-stakes testing on the curriculum and instruction of 12 secondary level science student teachers (or interns). The intent of this qualitative study was to understand the salient personal and contextual factors influencing these interns' ability to implement hands-on science activities (Adams & Krockover, 1997; Eick, 2000). Personal factors included past educational history, beliefs about education, and values. Contextual factors were classroom-based influences on attempted practice. One of the contextual factors that emerged in this study's data was high-stakes testing. The questions addressed in this article include how do the schools in these cases meet the demands of high-stakes testing in their science curriculum and instruction? and what influence does this approach have on interns' planning and use of hands-on activities? Knowing how these schools implement state testing mandates will add to the current understanding of the effect of these tests on science curricula and instruction. Also, understanding how high-stakes tests directly affect intern practice could be used for future intern placements because schools that stifle best practice approaches would not be appropriate sites for interns to begin implementing hands-on activities. This information is valuable in preparing program graduates to cope in the situations they may face when employed.

Context

Intern Selection and Placement

Four interns were studied for each 10-week period (three consecutive quarters) during 1998 and 1999. Four interns were selected each quarter from a cadre of 6 to 12 student teachers. The selected students were independently rank-ordered by the two science education professors (not the researcher) and chosen on the basis of their potential (stemming from past performance in methods courses) for using hands-on activities. The researcher

selected the 4 students each quarter who were ranked highest by both professors. Ten of the 12 interns were female and all were White.

The university is located in a rural region of the southeastern United States. The teacher education program is traditional and typical of large universities (McIntyre, Byrd, & Foxx, 1997). All student teaching sites were located within a 60-mile radius of campus and included eight rural and two urban schools. Four interns were assigned middle level school placements, and 8 interns were placed in high schools. The supervising science education professor placed interns with cooperating teachers in their subject areas, taking into consideration how the intern and teacher would work with each other. Thus, final student teacher placement was a subjective process based on the known personalities of the cooperating teacher and student teacher. Nine of the cooperating teachers had worked successfully with interns from the program in the past. The cooperating teachers varied in their stated degree of use of hands-on practices.

Nature of the High-Stakes Testing in Local Schools

All schools in this study had mandatory state or county testing. All 9 local (or state) schools administered the Stanford Achievement Test (SAT-9) annually to all secondary grade levels except grade 12. Two schools in this study were in a neighboring state and did not administer the SAT-9. One of those schools was a middle level school and was locally mandated to administer the Iowa Test of Basic Skills (ITBS) for accountability purposes.

All 7 high schools in this study also administered a high school graduation exam at the end of students' sophomore year. These tests could be considered high stakes. Schools that did not improve their SAT-9 scores above a minimum level could be taken over by the state. High school students could not graduate with an academic diploma until they passed all sections of the graduation exam. Local high schools were in the process of raising the grade level equivalent of content on the graduation exam from grades 8–10. A science component covering physical science (30%) and biology (70%) would soon exist and was currently being normed. This component already existed in the neighboring state's high schools.

Method and Analysis

A qualitative, postpositivist methodology with researcher-as-participant was used in this study (Maxwell, 1996). The researcher participated as the interns' university supervisor. Data sources for each intern came from field notes on three announced videotaped observations of teaching, three guided responses to these videotaped teachings (including electronic mail follow-up questions), daily lesson plans, an in-depth interview, exit interview, and exit portfolio. The Teachers Pedagogical Philosophy Interview (TPPI) protocol

for first-year teachers was used for the in-depth interview (Richardson & Simmons, 1994). The TPPI was used because it could help to clarify the interns' pedagogical philosophy or reasoning behind their practice and the values, beliefs, and contexts informing that philosophy. Responses to the TPPI were coded thematically for the research questions of this article. Data also came from each cooperating teacher in the form of a semistructured interview on the cooperating teacher's practice (including philosophy, approach, and other school influences) and field notes on ongoing conferences on intern practice. A limitation of this study was the inability to directly observe cooperating teacher practice. Additional data came from each school's principal through a semistructured interview on his or her personal philosophy of science education and the emphases placed on science teaching practice in the school. Cooperating teacher and principal interviews helped corroborate intern data sources. Participants read the transcripts of their interviews and had the opportunity to make changes for accuracy.

The data from each case were analyzed at the end of each quarter. The data from participant interviews and interns' written reflections (including email communications) were coded thematically using a grounded approach (Strauss & Corbin, 1990). Thematic coding identified the nature of the issues related to high-stakes testing across data sources. Recurrent or consistent themes were identified in each case. Field notes on the interns' weekly lesson plans, observations of their practice, and conversations with cooperating teachers were compiled to describe the interns' teaching practice during the quarter. Summaries of intern practice, including the type and degree of use of hands-on activities, were written from the analysis of these data. Table 1 shows the type and frequency of hands-on activities used by each student teacher on a weekly basis.

At the end of each quarter, crosscase analysis was conducted to search for common themes among cases (Maxwell, 1996). Common themes that helped in understanding the influence of high-stakes testing on intern practice are highlighted as findings in this article. Triangulating the data from the interns, cooperating teachers, and principals helped to support the validity of the findings for each case. Quotations from participant interviews and interns' reflections are used to illustrate research findings. Individual cases illustrating typical data on a finding or assertion are described. Discrepant data within each case are mentioned to further strengthen assertions from the study.

Findings

Testing has little influence on curriculum and instruction sequenced after the sophomore year of high school. In this study, high-stakes testing had little observable effect on sequenced curriculum and instruction above grade

Table 1. Examples of Hands-On Activities and Weekly Frequency of Use

Name	Typical hands-on example(s)	Frequency of use
Carey	Data-generating laboratory	One per week
Tracy	Data-generating laboratory, demonstration, student activity, and project	Four per week
Charlene	Applied laboratory and student activity	Four per week
Tabitha	Exploratory and confirmatory laboratory and student activity	Two per week
Nancy	Exploratory laboratory, student activity, and project	Three per week
Jake	Data-generating laboratory, demonstration, and student activity	One or two per week
Sherry	Demonstration, data-generating laboratory, student activity, and project	Two per week
Roberta	Student activity	Two per week
Erin	Confirmatory and exploratory laboratory and student activity	Two per week
Kendra	Data-generating laboratory, demonstration, and student activity	Three per week
Mitch	Exploratory and data-generating laboratory, engineering projects, and demonstration	Four per week
Shelly	Data-generating laboratory and student activity	Two per week

Note. Pseudonyms are used in place of student teachers' real names.

10 because state high school exit exams only test science curricula through tenth grade. The last year that the SAT-9 would be given was in grade 11, but the state was phasing out the eleventh grade test. Cooperating teachers of these upper-grade courses stated that testing had little influence on their teaching because of the lack of junior and senior curricula on these tests. Thus, courses such as chemistry, anatomy, and physics were exempt from accountability from high-stakes testing. Mitch's cooperating teacher taught physics and chemistry and was aware of the SAT-9 for her grade 11 chemistry students, but she was only concerned from a skill perspective. She stated that she taught graphing and interpretation skills in her course without regard for the test. She also shared that the upcoming implementation of the more difficult high school graduation exam was influencing biology teachers at her school, who had to teach more about plants, but was not influencing her teaching. She stated:

> As far as what it's [high school graduation exam] changing [for] me, the kids don't have to have had, you know, physics or chem-

> istry so, if I'm lucky in that instance or not, I mean, you know—as far as it changing me—no.

Erin's teacher was department chair of her school and taught chemistry. She said that she was not under any pressure to cover specified curricula for state testing, but that the new graduation exam would dictate curricula for teachers in grades 9 and 10:

> This [graduation exam] is starting to drive our curriculum...it's almost like a real fearful thing for us as teachers if our students aren't passing this graduation exam. And it especially hits back into ninth and tenth grade levels.

Interview and reflection data on local teaching influences and constraints for the 4 interns who taught courses in grades 11 or 12 did not mention any teaching restrictions as a result of state testing requirements.

Teaching test objectives on top of existing curriculum creates time constraints that may limit hands-on practices. Two cases in this study (Sherry and Tabitha) were observed teaching test objectives in addition to the existing curriculum. Sherry and Tabitha, at the direction of their cooperating teacher, prepared their students for testing by taking time each day to review discrete facts and skills that would likely be on the test. These objectives had to be documented in their daily teaching. This testing focus took place in addition to teaching the state-adopted curriculum. Interview data from cooperating teachers and principals suggested that the principal influenced teachers to prepare for testing in this manner. Principals in these two schools stated that they checked teachers' lesson plans to ensure that a portion of each day's lesson was spent on test objectives. Tabitha's principal clearly stated the importance of the SAT-9 test and that it affected the instruction of his science teachers:

> Now that [SAT-9] does [affect teaching] because irregardless of what they think that they need to teach in science, they have got to teach those skills because, not our school but all schools are going to be judged by their SAT scores and you have got to be sure that you teach those skills that the children are going to be tested on.... I mean, they can't do what they need to do probably in science, but I expect them—I require them to follow that SAT-9 objective and to teach those skills irregardless of what they think about what they need in science—I do require it.

Teaching test objectives separately from an already full curriculum created added time constraints on these 2 interns' ability to teach their curriculum. Intern descriptive summary data showed that both interns used hands-on practices in their classrooms about two times per week (see Table 1).

In her reflective writings, Tabitha, who taught 90-minute periods each day, felt that she could not do more activities than those she was currently doing with her students. Her school's emphasis on the SAT-9, and the added time that it took to teach toward it, limited her use of more inquiry-based activities in her classroom. She observed:

> SAT-9, that's big around here...and you've got to say "On this date, I covered this objective."... So you've got to have them covered and you think I want these kids to have activities and I want them to do hands-on activities, but those activities require a lot of time in the classroom.

Tabitha's cooperating teacher said in her interview that science teachers need to teach discrete skills and detailed science content. With this view of curriculum and instruction and the added administrative pressure on testing, she may not have given Tabitha the support needed to use more hands-on practices in the classroom.

Sherry reflected that a daily portion of her teaching was geared to her school's upcoming ITBS. Teachers in each subject area made their students keep an ITBS section of their notebook for daily review of test objectives. This review was observed to take approximately 5 to 10 minutes of class time at the beginning of the period. In her interview, Sherry's cooperating teacher stated that this test created time constraints on teaching the course curriculum during most of the school year because the test's objectives had to be taught by the end of March when the test was administered. She voiced concern about the time that reviewing for the test took away from inquiry-based teaching. She was especially upset about reteaching ITBS skills and science facts out of context to ensure that all her students would do well on the test. Sherry's teacher noted:

> Well, there are some objectives for the ITBS that I wouldn't ordinarily cover this year and I'm trying to cover these little factoid objectives so the kids will either have it for review or they will have it for the first time.

Sherry's cooperating teacher supported the use of hands-on practices, even though time constraints limited using them more often.

Integrating curricula with testing objectives creates space for hands-on practices. Three schools in this study (Jake and Charlene's high school, Nancy's high school, and Kendra's middle level school) supported the integration of state curricular and testing objectives, and emphasized a process approach to meeting them. Charlene, who taught biology, believed that the state curriculum and testing objectives had to be addressed in her teaching. She felt that these mandates directed the content that she taught. Her school had

developed a finely tuned curriculum that integrated test objectives with the existing state curriculum. She had to strictly follow the content outlined in this tailored curriculum. Charlene noted:

> With biology, I feel that I must follow a certain set of rules and cover topics on the SAT. Also, the school has developed a program which relates the SAT objectives with the state objectives. Therefore, I am told what I must teach.

However, her descriptive summary data show a high use of hands-on practices in her teaching (see Table 1). Even with the state curriculum and test objectives, Charlene was able to plan a hands-on activity for her students almost every 90-minute period that she taught. The teaching format that Charlene used followed her principal's prescription for the 90-minute (block) period. When asked what he expected to see when he walked into a science teacher's classroom, Charlene's and Jake's principal shared this:

> Well, here at [our high school] we have a block schedule. What I would expect to see is possibly a 15- to 20-minute lecture at the first of the class—an introductory thing or whatever the concept is that day. Small group work experimentation—basically break the block into four periods—a start, a work, a work, and a wrap up. Kind of pull it all back together. Pretty much that's what we've got going.

Charlene's principal also articulated his philosophy for a more process-oriented and hands-on approach to science teaching at his school. He wanted his teachers to share the same philosophy:

> My philosophy is a more applied approach in science and we have gone to that in several of our areas; not as much as we'd like to. To have kids do as much hands-on, experimental, off-campus, interactive social science—science study—would be my philosophy and we're getting there.

Charlene was able to frequently use hands-on practices during her internship. Many of these practices helped students apply their learning in new situations. In her exit interview, she said that her cooperating teacher encouraged and supported her to teach as she did. In his interview, her teacher shared a similar philosophy and approach to teaching science as his principal.

The principals and cooperating teachers at Kendra's and Nancy's schools also emphasized a hands-on and process-oriented approach to teaching science. Kendra's principal specifically stated that he wanted to see science taught through inquiry. Both Kendra and Nancy's descriptive summary data showed that they used a high level of hands-on practices in their classrooms.

Both interns' schools had taken supportive stances toward hands-on learning and made decisions to meet test objectives by integrating test criteria with existing curricula. This two-fold approach appeared to create a classroom environment that supported the interns' use of hands-on activities.

Schools with high test scores have greater freedom in the implementation of curriculum and use of hands-on practices. Roberta taught at a school in a university community. Tracy taught at a magnet school where students had to apply for admittance and then maintain a C average to remain at the school. Neither intern nor their cooperating teachers cited any concerns over the influence of testing on their teaching. When asked about feeling any pressure from the SAT-9 testing, Roberta's teacher responded:

> No, that's one thing I've worried about working at [this school] because—and I think that a lot of it—I mean there are good teachers all over America—but—and there are good teachers here—but the good kids we have. The majority of them come from well-educated backgrounds—over 50% come from people who work at the university and have Ph.D.s and Masters and everything else. So, they're more pushed toward academics; and that's one reason why [this school] has higher SAT scores. And so I have been lucky and not had to feel that pressure where my mother-in-law, you know, they had to a month before the test, you know, start practicing and drilling them for it and all of those other things. And we've never had to do that.

Roberta's principal wanted teachers to consult state objectives and testing manuals to ensure that all objectives were met. He was elated with his school's high test scores and determined to keep them "knocking the top off." However, he encouraged teachers to deviate from the prescribed curriculum to make learning exciting, motivational, and more hands-on:

> I like for a teacher to take bold steps. I do not want a person to walk in a classroom and feel so confined—'I cannot deviate from my textbook, I cannot deviate from the state course of study'—because if you stayed strictly by your textbook, I think you have a boring class. You just be mindful of that. So, you have the freedom.

Roberta and Tracy both had more freedom to plan and implement best practice approaches in their schools. They did not have to worry about the effect of state testing on their teaching because their students already scored well. However, Roberta relied heavily on the structure of her cooperating teacher's plans. She felt that she could not deviate from his approach. Tracy, however, had free rein to plan and teach a hands-on component in almost every lesson (See Table 1).

Discussion

In this study, interns use of hands-on practices varied based on personal and contextual influences on their planning and instruction (Eick, 2000). Personal influences, such as prior knowledge and beliefs about teaching and learning, likely affected who they were and what they wanted to do as student teachers (Adams & Krockover, 1997; Eick, in press; Knowles & Holt-Reynolds, 1991). For those interns who wanted to use hands-on practices frequently, contextual influences shaped their ability to do so (Adams & Krockover, 1997). High-stakes testing was a salient contextual influence for those interns trying to implement hands-on practices and who taught below grade 11 in schools that did not emphasize a best practice approach and had a student population with historically lower-than-desired test scores. All schools in this study were under high-stakes testing mandates. However, the way these mandates emerged in the curriculum and instruction in each intern's classroom varied. Cooperating teachers played a large role than did testing mandates in mediating the curriculum that interns had to teach. This curriculum followed local school system prescriptions for meeting the demands of high-stakes testing and state courses of study. These prescriptions may have been formulated, or at least encouraged, by local school principals.

In this study, two schools added daily review times for high-stakes tests that took away from the time needed to teach the state-mandated curriculum. This additional time constraint especially affected high school teachers under the pacing constraints of the 4 x 4 block schedule.[1] The constraint on instructional time by this add-on approach may have limited the time available for a more process-oriented approach to teaching, as well as teaching lessons in context (Barksdale-Ladd & Thomas, 2000; Charlesworth et al., 1994; Sheldon & Biddle, 1998). Evidence from past studies suggest that limiting instruction to teaching discrete facts and skills at the expense of greater inquiry in context can place at-risk students at greater risk of failure (Charlesworth et al., 1994; Hilliard, 2000). Some of the student populations in this study that might have benefitted most from a best-practice approach to science education were getting less of it. The inclination of principals and teachers to abandon more time-consuming process-oriented approaches to science education seems logical in meeting added curricular mandates, and the inclination of teachers who have limited time to teach required content is to cover the content in as efficient a manner as possible. But this

[1] In a 4 x 4 block schedule, an entire course is taught in one semester instead of one year. The class meets every day for 90-minute periods. Although the 90-minute periods are longer than the traditional 50-minute periods, the total time that the class meets on a block schedule is still less than on the year-long, 50-minute period schedule. Schools on block schedules also have established elaborate pacing charts in order to cover the same information as was covered in the year-long course.

seemingly efficient method often excludes the time necessary for lengthier hands-on practices. In Tabitha's and Sherry's cases, administrative prescriptions also mandated that a daily review of process-oriented skills and science facts be incorporated into their lesson plans and already existing course of study. However, Tabitha's and Sherry's cooperating teachers had two very different philosophies and approaches to teaching science. Tabitha's cooperating teacher viewed her role as "hav[ing] the kids learn facts and figures," whereas Sherry's teacher resented "going over little isolated factoids that are out of the main context of other units that [she was] teaching." Cooperating teachers' beliefs can powerfully influence what student teachers do in their classrooms (Nespor, 1987; Su, 1992). Tabitha's cooperating teacher viewed laboratory exercises as a break for the students from the normal routine of learning. Perhaps, Tabitha's cooperating teacher's beliefs also influenced her to use fewer hands-on activities in daily 90-minute periods.

At least three schools in this study emphasized teaching an integrated curriculum that incorporated testing objectives into their courses of study. Charlene, Nancy, and Kendra were all able to plan for and use hands-on activities. Pacing constraints and a prescribed curriculum still existed for these interns, but hands-on practices still took place frequently and were supported by cooperating teachers. Teachers in these schools were well aware of the curriculum that they had to teach and the pacing constraints under which they operated; however, they continued to make time for teaching through a best-practice approach as much as possible. The principals in these three schools also encouraged and supported a hands-on and process-oriented approach to science education. Each of these principals had obtained their doctorate in administration from the participating university. Perhaps, their education influenced their beliefs in maintaining a best-practice approach to education in their schools. An administration with a strong best-practice philosophy may illuminate those anomalous situations in previous survey studies where traditional high-stakes testing appeared to support reform-minded practices (Jones et al., 1999; Veronesi & Van Voorst, 2000).

Conclusion

Several cases in this study corroborate past research on the negative effect of traditional high-stakes testing on a best-practice approach to education. However, other cases in this study also highlight how schools are successfully coping with mandated testing. Several schools in this study developed curricula that met multiple mandates while continuing to support best educational practices. These schools took a holistic view of their science curriculum in which teachers and administrators planned a program that did not duplicate educational objectives prescribed by testing and state courses of study. This planning allowed time for hands-on activities to be incorporated

in daily lessons. In each of these cases, administrative leadership emphasized a process-oriented and hands-on approach to science education that balanced best-practice approaches to teaching with traditional high-stakes testing mandated by their states.

This study also supports a more holistic view of field sites for student teachers. In making intern placements, leaders in teacher education programs should consider more than the teaching ability and philosophy of cooperating teachers. The instructional environment of a school can have a greater influence on intern practice and ability to use hands-on activities and other process-oriented approaches. Interns need some level of freedom to plan and implement best-practice approaches in a supportive and supervised program. The skill or desire of a cooperating teacher to use hands-on practices may not be as important as the freedom that a student teacher has to do so. Schoolwide curricula and pacing plans directly affect this freedom. Schools that develop plans for curricula and instruction that support a process-oriented and hands-on approach to teaching science should be favored for intern placements because they would likely support and extend the reform-minded goals of the teacher education program. In this way, the continuity and credibility of a standards-based teacher education program can be maintained.

To create and sustain best-practice environments, colleges of education must make concerted efforts to build closer educational ties to reform-minded instructional leaders in area schools. Education faculty members and area school leaders should collaborate to provide practical assistance to other local schools to meet state curricular and testing mandates through a best-practice approach to instruction. University leaders can reach out to local schools that are struggling with their implementation of high-stakes testing and help those schools and their principals develop better instructional options. Concurrently, all instructional leaders (K–16) should continue to work together to lobby their state boards of education and local legislatures to support multiple and more authentic measures of accountability that will enhance the curricular reforms already in place (Falk & Larson, 1996; Mitchell, 1997).

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