Technology as a Vehicle for Education Reform

David E. Tanner and David Andrews

***Abstract*—Technology as a Vehicle for Education Reform. School reform in the United States has been a central theme for 30 years and for the last decade has included national government involvement in what was traditionally a states' responsibility. Central to the movement has been an effort to improve science and mathematics performance by secondary school students who are consistently wanting in international comparisons. National Science Foundation efforts such as the Robert Noyce program encourage compensating for a shortage of science and math teachers with electronic materials available from on-line sources. Initial data indicate that teachers use the resources and feel better prepared to teach as a result.**

***Index Terms*—Secondary science teaching, on-line teaching resources.**

I. Introduction

There is a substantial shortage in the United States of secondary school teachers who are prepared to teach mathematics, the sciences, and other technology-related disciplines. One estimate put the short-fall at 240,000 mathematics and science teachers [1]. The gap reflects enrollment increases, and career shifts among teachers. Approximately one-third leaves teaching within their first three years [2]. The problem is particularly acute in the inner-city and in rural areas where students are poor.

The teaching shortages are also evident in California particularly in secondary school sciences and mathematics. Colleges and universities in the state are preparing only about 70% of the science and math teachers that are needed. Recent data indicate that at the middle school level, 10% of these teachers lack a teaching credential in the field and 30% are first or second year teachers. Nine percent of science teachers and 12% of mathematics teachers are currently teaching out of the disciplines they were credentialed to teach. Inadequately prepared science and mathematics teachers tends to be more common in poorer schools [3].

In California's central valley in the first decade of the 21st century, approximately 80% of the students belonged to ethnic minority groups and more than 25% were English Learners. Frequently these two categories overlap. Using as a criterion for poverty the percentage of students who qualify for subsidized meals at school, recent figures indicate that 80% of these students qualify. Probably not unrelated to these conditions, the 4-year drop-out rate in the largest school district in the central valley of California, and the fourth largest school district in the state is 15.8% [3].

Manuscript received May 13, 2012; revised June 21, 2012.

David E. Tanner and David Andrews are with California State University, Fresno (e-mail: davidt@csufresno.edu).

II. The Noyce Program

The research on classroom effectiveness demonstrates a persistent relationship between student performance and teaching quality [4], [5]. Teachers' knowledge of their disciplines, particularly in science and mathematics, is an important factor in determining student achievement [6].

The Robert Noyce Scholarship program is one response to the need for greater numbers of teachers in the sciences and mathematics, and to the necessity of improving the quality of mathematics and science teaching for secondary school students. Administered by the National Science Foundation (NSF), the program provides financial and academic support to talented science, technology, engineering, and mathematics (STEM) students who will pursue secondary school teaching careers.

The Noyce program is structured so that STEM majors receive consistent and substantive academic, as well as economic support. In return for scholarships, stipends, seminars, research projects, and academic counseling services all designed to help students complete degrees in STEM-related areas and earn teaching credentials, graduates agree to complete four years of teaching in a school district identified as "high- need." The criteria for high-need are fixed to the percentage of students qualifying for reduced-price meals, the percentage who are English learners, or the percentage who are members of ethnic minority groups.

Even with an augmentation for science, technology, engineering, and mathematics teacher preparation, however, there are still substantial obstacles to effective science and mathematics teaching for the newly-credentialed teachers One deficit is the availability of teaching resources, deficits which can be acute in high-needs schools. It isn't uncommon for new teachers to find that they lack the support system they enjoyed during their undergraduate studies. The laboratory materials that are usually the science teacher's stock-in-trade are likely to be least available in the schools where student poverty is highest. A central component of the Noyce program has been to introduce preparing teachers to the materials that are available in on-line depositories and to encourage the integration of these resources into regular classroom teaching.

III. The National Science Digital Library

The National Science Digital Library (NSDL) is funded by the National Science Foundation. It makes available to anyone who accesses the on-line site, k-12 teaching

materials in any of the STEM disciplines. The materials include lesson plans, laboratory simulations, demonstrations, assessment materials, and perhaps most importantly, the opportunity to interact on-line with other educators who teach in similar circumstances. Consistent with the changing demographics among students in the country as a whole and in California schools particularly, it also includes multilingual materials.

IV. MERLOT

The Multi-media Educational Resource for Learning and On-line Teaching (MERLOT) provides another resource for those teaching STEM subjects. In partnership with the 23-campus California State University system, MERLOT is a an on-line library of more than 34 thousand teaching materials related to STEM subjects that can be accessed without charge by anyone who creates an account. Many of the materials have been developed specific to the conditions that prevail in California's secondary math and science classrooms. They include materials based on California's required teaching standards.

V. CURRENT CIRCUMSTANCES

Besides an ethical and moral responsibility for their students' improvement, educators now have a vested interest. One of the artifacts of the current round of educational reform in the United States is that educators are held more directly responsible for students' academic progress [7]. As classroom teachers begin to rely on on-line materials to supplement more conventional classroom activities the MERLOT and NSDL materials provide resources that new teachers have lacked historically. The on-line resources offer the opportunity to network with others who are teaching in the STEM areas and in high-needs schools and they provide a wide range of teaching materials for the classroom.

The Noyce program initiative represents a substantial departure from traditional teaching in semi-autonomous and self-contained classrooms. The National Science Data Lab and MERLOT pool resources and ideas from thousands of teachers facing every variation in teaching circumstance. But the track record for a reform such as this isn't promising. Absent the integration of disabled students into the regular classroom, there has been little change in elementary and secondary education in the United States since the days of racial integration in the mid-20th century [8]. Are there reasons to believe that instructional changes in the individual classroom have a greater chance of success?

VI. HOMEOSTATIC THEORIES REGARDING CHANGE

Perhaps not, even when there is compelling evidence of the need for change in education, the tradition is often not to embrace it in any meaningful or long-lasting way. Over time, educators often reinterpret reforms to make them consistent with existing practices.

Resistance to change is a phenomenon not unique to educators. A series of mid-twentieth century theories attempted to explain the reticence. Heider [9] suggested that evidence of the need for changed is countered by the inclination to restore the previous balance to one's life. Festinger's [10] theory of cognitive dissonance explained how this occurs: When information conflicts a deeply-held belief, the tendency is to find a way to reduce the dissonance or conflict, by discounting the source, altering the information so that it no longer conflicts, or by simply repressing it [11]-[13]. Teachers who believe they already do an effective job in the classroom will find a way to resolve a challenge to that belief without altering it.

Although all of these theories offer descriptions of what happens in the face of change, none of them explain why people tend to resist altering the status quo. Pearse [14] explained that the call to change present practice is implicitly an indictment. For the individual asked to change, observation and recommendation become criticism. If this is true for classroom teachers who are encouraged to change their instructional practices, it doesn't augur well for educational improvement. Homeostatic theories predict that there will inevitably be resistance, that classroom teachers will find a way to rationalize either the demand for change, or their existing teaching practices so that there is no need to change.

VII. THE DATA

Federally-funded educational initiatives such as the Noyce program require yearly evaluations of the fidelity with which the program is implemented, and the progress of those involved. One of the information sources for one Noyce program at a university in central California is a survey instrument electronically administered to Noyce scholars in Likert-type format. It asks the degree to which scholars agree with a series of statements about program objectives, including the use of on-line materials to supplement their classroom instruction, and the development of electronic learning communities that place them in communication with other educators who teach in similar circumstances. Their responses provide a test of the degree to which the homeostatic change theories predict teachers' responses to the request that they do things differently.

The first statement below is directed at one of the central emphases of the program, which is to employ on-line technology to create a series of virtual learning communities which bring together those teaching in a variety of different high-needs schools. The 15 Noyce participants responded as follows:

I feel connected to others who are teaching in high-needs schools.

- Strongly agree 11
- Agree 1
- Neither Agree nor Disagree 3
- Disagree 0
- Strongly Disagree 0

The results to this first item suggest that teaching practice has changed, at least for this group. They are in association, if only electronic, with others I like circumstances. This is a

substantial departure from traditional teaching practice.

I intend to use on-line [MERLOT and NSDL] resources to enhance my teaching

- Strongly agree 10
- Agree 5
- Neither Agree nor Disagree 0
- Disagree 0
- Strongly Disagree 0

While a statement of intent carries no assurance of fundamental change, all respondents at least predict that they will make use of the on-line teaching materials.

The 15 respondents above were a mixture of students working their way through their degree programs and the credentialing process, as well as those who had completed their formal schooling and begun to complete their commitment to teach for four years in a high-needs school. The responses below are all from those who were teaching full-time in high-needs schools by the time the instrument was administered.

Because of Noyce, I communicate often with other teachers

- Strongly agree 5
- Agree 3
- Neither Agree nor Disagree 4
- Disagree 0
- Strongly Disagree 0

In spite of feeling connected to others at other sites (the first item above), there is some ambivalence about actually communicating with them "often." There is, however, no disagreement with the proposition.

I feel very committed to high-needs schools.

- Strongly agree 8
- Agree 4
- Neither Agree nor Disagree 0
- Disagree 0
- Strongly Disagree 0

Among those teaching in high-needs schools as these data were collected, there is no ambivalence about their commitment to these neediest of secondary schools. Probably there have always been educators committed to the least supported students, but it is unanimous among members of this group.

I find on-line resources to be very helpful to my teaching.

- Strongly agree 6
- Agree 6
- Neither Agree nor Disagree 0
- Disagree 0
- Strongly Disagree 0

These responses are perhaps the most indicative of fundamental change. In a substantial break with traditional practice, these educators all at least agree that the on-line resources have been helpful. They are consulting a resource characteristic of only the most contemporary instructional practices.

VIII. Discussion

From the standpoint of teacher evaluation and advancement in the United States, improving student achievement data has become "the coin of the realm." That emphasis represents something of a paradigm shift in the area of teacher evaluation, but there are reasons to be cautious about expecting a corresponding shift in the way teachers teach. Underscoring the impact that social learning [15] has in the classroom, a good deal of the evidence suggests that teachers tend to teach the way they were taught [16]. To make fundamental changes in teaching practice even more unlikely, much of the theory about change suggests that changes to basic teaching practices are unlikely if the teacher identifies strongly with present practice, that is, if teachers feel some emotional commitment to what they have been doing in the classroom.

There are likely many reasons for the resistance, but at least one is that the suggestion to change is implicitly a criticism of what the teacher has been doing. The homeostatic theories predict that for the classroom teacher with a substantial commitment to existing instructional practice the tendency is to discount any recommendation to change, reinterpret the recommendation so that it no longer represents a challenge to current practice, or simply ignore it. The theories suggest that the most likely outcome is for educators to re-trench rather than reform.

The willingness to create support systems by way of virtual learning communities is a substantial break with traditional practice, as is the tendency to use on-line resources to supplement instructional practice. For those who despair of fundamental change in education, particularly in secondary school science and mathematics classrooms where the need is greatest, these very limited results suggest reason for optimism, as well as for further study. The Noyce scholars are involved in practices which offer the potential to help classroom practice evolve. Resistance to educational change needn't mean the exclusion of educational change. A needed next step will be to determine the impact these changes have had on student achievement.

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