Science Teacher Supply and Estimated Demand in Kansas–2006

John Richard Schrock
Department of Biological Sciences
Emporia State University.
[presented at April 8, 2006 Kansas Academy of Sciences, WSU]

The crisis in science education in Kansas in 2006 has nothing to do with evolution-creationism or with sex education. The quality of science teaching in Kansas classrooms primarily depends on the number of well-trained science teachers. Recent difficulties many school superintendents have finding qualified science teachers has made the questions "how great is the shortfall?" and "why is there a shortfall?" the center of current policy proposals and disputes.

Upon request, KSDE staff provided data on the number of new Kansas science endorsements in the various disciplines for the six academic years from 1999-2000 to 2004-2005.

Figure 1 shows that, over six years, new Kansas biology endorsements dropped from 235 to 83, about one-third of 1999-2000 levels. Provisional endorsements are awarded to current teachers from another field who have completed half of the biology content requirements and are making progress toward fulfilling the remainder. In biology, provisional endorsements are not a significant proportion of teachers.

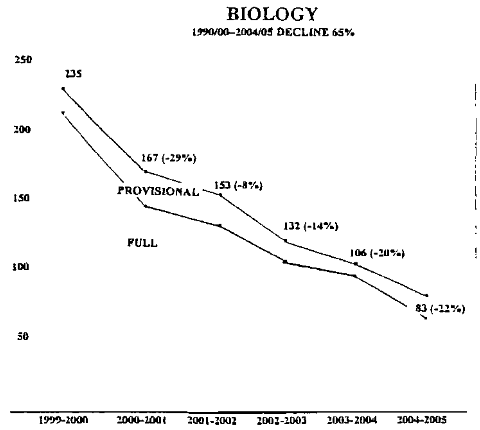

Figure 1. New endorsements in secondary biology partitioned into full and provisional licenses.

Biology endorsements awarded to teachers entering from out-of-state were higher during the initial shortage caused by the new KBOR Qualified Admissions (QA) requirement but have since dwindled (Figure 2).

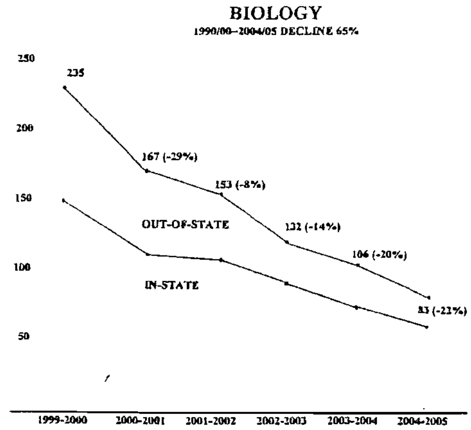

Figure 2. Comparison of biology endorsements separated into in-state and out-of-state.

New endorsements in secondary chemistry have declined by half. Because of the QA requirement that one natural science course be either chemistry or physics, many schools pressed other teachers to add provisional licenses; this source is essentially exhausted.

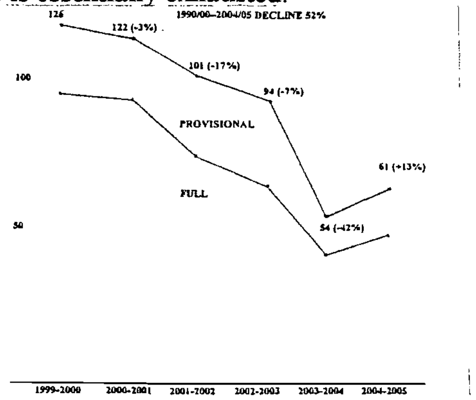

Figure 3. New endorsements in secondary chemistry have declined by half; provisional endorsements were initially significant.

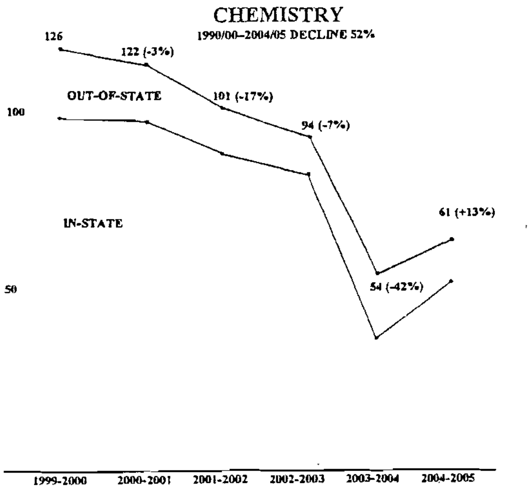

Figure 4. New endorsements in secondary chemistry partitioned by in-state and out-of-state.

Fewer chemistry teachers were drawn from out-of-state, in part due to neighboring states having broadfield rather than chemistry endorsements (Figure 4).

A historical shortage of physics teachers was exposed by the new QA requirements, and nearly a third of endorsements were initially provisional. The 63 percent decline in physics teacher production in part reflects a "mining out" of potential Kansas teachers who can add physics endorsements (Figure 5).

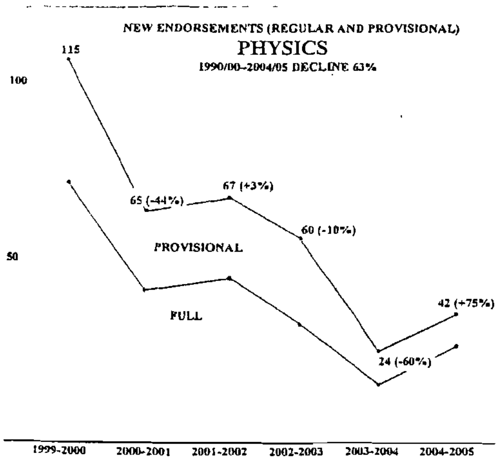

Figure 5. New endorsements in secondary physics have declined by half; provisional endorsements were initially significant.

The proportion of physics teachers coming from out-of-state has always been insignificant, again due to neighboring states having broadfield licenses and lacking specific physics endorsements (Figure 6).

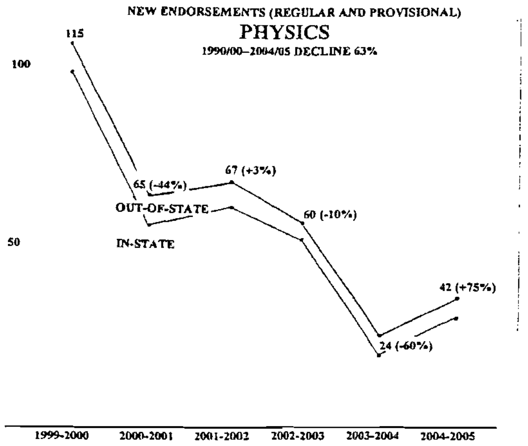

Figure 6. New endorsements in secondary physics partitioned by in-state and out-of-state.

While earth science endorsements have also dropped by half, the total numbers of earth science teachers is small. The proportion from out-of-state or teaching on provisional licenses has been consistent (Figures 7–8). While QA recognizes earth science, in contrast to biology which is on the state science assessment, and physics-or-chemistry (one of which is required), earth science is not required.

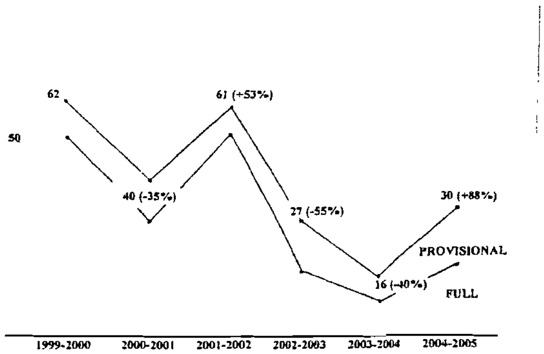

Figure 7. New endorsements in earth science have declined by half; provisional licenses remain consistently a small proportion.

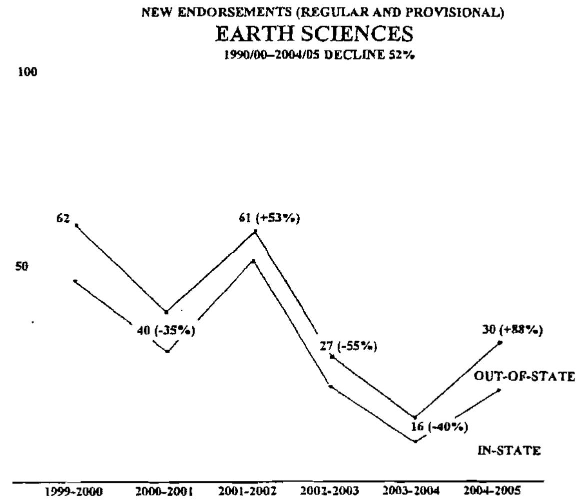

Figure 8. New endorsements in earth science; out-of-state licenses remain a small proportion.

Do the declines in state-issued endorsements reflect an overall universal decline, or just the failure of a few teacher-training schools? Figure 9 provides a 32-year record of biology student teacher production at one Kansas university; ungraphed data from several other Kansas schools show the same pattern over a shorter recent time line. The most dramatic turndown has been in the last six to eight years when both QPA and NCLB regulations have mandated more assessments. Figure 9 does not reflect even higher science teacher production during the "Sputnik years" when Kansas trained substantial numbers of science teachers under NSF-funded academic year and summer institutes that concentrated on fortifying teachers content knowledge. These AYI and SI teachers are now retiring, contributing greatly to the abrupt shortage.

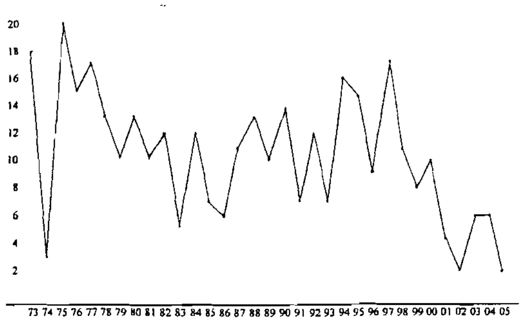

Figure 9. Biology student teacher production from 1973 to 2005 at one major teacher training university.

CONTEXT

The data showing a substantial drop in science teacher endorsements can only be understood in the context of the factors affecting teacher training, licensing, and secondary curriculum requirements.

The surge in science teacher production from the Sputnik-era does reveal why there has been a massive retire-off of teachers as they reach retirement age. The 1991 study of Kansas biology teachers by Schrock showed the biology teaching force was heavily loaded with aging veteran teachers. Other factors are also critical in determining teacher demand.

Commissioners

Kansas education commissioners have enforced teaching-in-field requirements differently. Under Droegemueller, only two sciences were required for a Kansas high school diploma and they could include "food science" (home economics) and "tech prep" (shop). The majority of high school graduates did not enter college and the curriculum focused on the non-college-bound students. While certification of teachers was supposed to be matched with courses taught, there were many ways for local administrators to represent an out-of-field teacher as in-field.

Under Commissioner Tompkins, the system moved toward licensure, removed the penalties for having out-of-field teachers, instituted a waiver system, and allowed long-term substitutes to teach a class all year. Most high school graduates now entered college and the focus shifted to preparing all students for college; thus bringing an end to food science and tech prep as science credits.

Current suggestions include removing education requirements for alternative-route teachers and using test-out without coursework in content fields as a possible solution to any teacher shortage.

Qualified Admissions

The most effective reform to establish some level of rigor in coursework and teacher training has been the KBOR Qualified Admissions (QA) requirements that went into effect for 1997 high school freshmen graduating as seniors to enter regents' colleges in 2001. The QA Natural Science standards required three courses from among biology, chemistry, physics or earth/space sciences or derived courses or CORD approved technical courses. One of the courses had to include either chemistry or physics. This was a bold move when 15 percent of school surveyed had indicated they could not staff the chemistry-or-physics requirement. The most important part of QA was the elimination of general science and physical science as courses that would count toward admission to regents's schools. The intent of the QA task Force and the KBOR was to ensure rigorous coursework taught by a teacher with substantial depth in training in each science discipline. The history and rationale for the development of the Kansas Qualified Admissions Natural Science Standards is documented in *Kansas Biology Teacher* 6(1): 6–9.

Many Kansas superintendents and principals were unhappy to lose a pool of teachers who were certified to teach these general areas. Those teachers could renew their certificate as a license under the same name and continue to teach general and physical sciences in high school, but these courses would not apply toward regents college admissions. Several meetings were held by KSDE to persuade or coerce changes in the QA criteria but the requirements have so far held. A KBOR open hearing was scheduled in April 2006 and did not modify the distinct fields, although several high school course equivalencies have been defined including AP coursework.

The QA requirements caused an immediate shortage of all science teachers. Previously, schools did not declare a shortage of physics or chemistry because they did not offer physics or chemistry. Because either chemistry or physics had to be offered, any biology teacher who could teach those areas was pressed into service, thus causing a biology shortage that has never gone away.

Surveys of freshmen college students have shown the number who have taken chemistry has risen from roughly under 20 percent before 2001 to over 70 percent since. However, the general opinion of college science teachers across community colleges and universities, in annual statewide core competency meetings, is that the increase in student knowledge in chemistry has not been great. Increasing course requirements alone is not perceived by college facutly as effective if teachers of those high school courses are not well trained in that field.

"Redesign"

The "Redesign of Teacher Licensure" reform that was first broached publically in 1994 proposed to condense nearly 200 teaching fields into just 13 areas, including one-size-fits-all science teachers. Public school science teachers, many scientists, and most university science teacher training professionals successfully fought the proposal. It was mainly conservative Board members who attended the hearings and listened to teacher testimony who then defended depth-of-training and deadlocked the KSBE on Redesign for five years. When Redesign was finally approved, the sciences and some other disciplines were not reduced to shallow broadfield licenses.

New HS Graduation Requirements

In its December 2002 meeting, the KBOR approved new Kansas high school graduation requirements that boosted the science requirements and provided this definition.

> "Requiring three credits of science to include physical science, biology, and earth and space science concepts. This is to include at least one unit of laboratory course."

The term "physical science" was used to recognize the chemistry or physics course already required by QA. The term "concepts" was used to prevent the requirement from being interpreted as requiring three specific courses (i.e. physical science, biology, and earth and space science). "At least" was inserted to prevent schools from interpreting this as limiting labwork to just one course.

Since some earth science concepts are covered by both biology teachers (ecology) and physics teachers (planetary science), earth and space science has become the forgotten stepchild in secondary science education. Because Kansas lacks the earth science teachers to teach more than a fourth of Kansas secondary students, it was recognized this could not be a required course. Additional details are provided in the *Kansas Biology Teacher* 11(1): 4.

The impact of the new graduation

requirements, effective for high school freshman entering in 2005 and graduating as seniors in 2009, varies among school districts. Some Kansas high schools already locally required three sciences to graduate and the new requirements did not affect them. The superintendents complaining loudest in the December 2002 KBOR hearings were from the larger school districts. Class size in larger districts is near capacity and an added science requirement means more classes, teachers, and laboratory classrooms. In small rural Kansas schools, class size is often less than ten students and the science teacher already was teaching several fields. The added requirement is easily absorbed by increasing class size.

Kansas School Size

Kansas is a unique state with many school districts serving small and mid-sized rural populations and a few districts serving a large number of suburban and urban students. Figure 10 graphs the number of school districts and the number of students based on number ofhigh school graduates.

Approximately one-third of biology teachers teach in schools that are too small to offer biology all day; these teachers must pursue second-field licenses in several areas. In these small schools, the science teacher will usually have four to six preps a day, will have small classes, will have less lab equipment, and will be less likely to pursue graduate coursework in science (Schrock, *Kansas Biology Teacher* 2: 21-34).

Teachers in the large schools rarely have more than two preps a day, will usually have full classrooms, will have equipped labs, and most will pursue graduate degrees. Discussion with current student teachers indicate that the larger and wealthier schools are hiring much of the small supply of new science teachers as well as attracting some veteran teachers away from smaller schools. The smaller rural schools are increasingly finding there are far fewer new science teachers left to hire.

Figure 10 is based on KSBE data when there were 303 USDs. School consolidations in the last year and currently underway will shift the left columns slightly to the right.

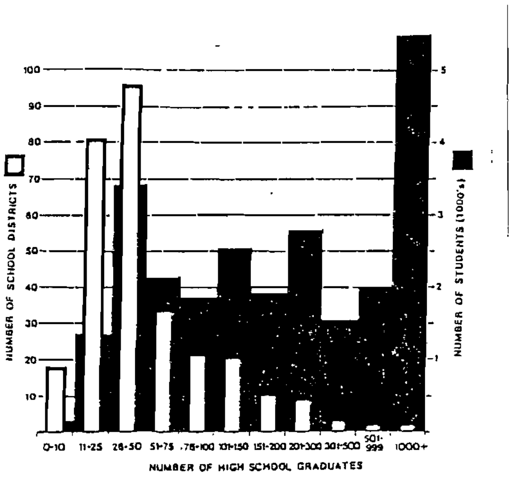

Figure 10. The number of school districts (open narrow bars) and students (black broad bars) graduating few to many students. (After Schrock, *Kansas Biology Teacher* 2: 21-34)

Retirement Rate

Each year in January, the KSDE tabulates and makes available on its website the lists of Kansas teachers as reported by school districts in the fall.

This "label" file has continuously evolved and is still dependent on the quality of information provided by the school districts. For instance, in 2004, a large number of districts including Wichita and Salina reported all of their secondary biology, chemistry, physics and earth science teachers under the one label of "science" despite the fact that there is no longer any secondary science license. Such tactics can be used to hide out-of-field teachers, as has been discovered in the process of determining the number of "highly qualified" teachers.

The January 2006 iteration of labels is much more closely aligned with actual teaching licenses. Because of the continuously changing categories reported, it is difficult to be precise in comparing one year with the previous. However, by aligning lists and counting the teacher names that disappear when compared with the previous year's list, it is possible to roughly approximate the number of teachers who are either retiring, leaving teaching, or moving to another state. When this number of vacancies is then compared to the number of student teachers produced, it reveals the extent of the shortfall. (Note: There is substantial room for error in this estimate: name changes due to marriage, a teacher moving to a distant district, etc.)

Last year, this crude process revealed that statewide, Kansas produced enough student teachers to fill slightly over three of every ten vacancies. This January, the comparison shows slightly less than three student teachers for every ten new vacancies. From visiting schools along the borders, and from the out-of-state data in Figures 2, 4, 6 and 8, I estimate we are probably filling a fourth vacancy by hiring teachers from border states, especially Missouri and Oklahoma where salaries have historically been lower. The remaining 6-out-of-10 vacancies must be filled by out-of-field teachers, full-time substitutes, alternative teachers, or warm bodies. This deficit in science teacher replacement is accelerating. Because it is not possible to predict the extent remaining veteran teachers will take early retirement, any estimate must be subjective. However, I estimate that nearly half of our secondary biology teachers will be unqualified (out-of-field by current definitions) in five years!

Current Endorsements

The number of current endorsements held in the KSDE database in 2006 is provided in Table 1 below.

The 1991 survey of Kansas biology teachers (Schrock, *Kansas Biology Teacher* 2: 21-34) also provided an estimate of the number of teaching positions needed to staff one science class discipline across Kansas schools. Approximately 800 licensed teachers are needed to teach each mandated course for Kansas high school students, teaching a full day at the middle and large size schools and partially at the rural schools.

Table 1. Science Endorsements in KSDE Database (2006)

	KSDE Current	2004-2005 Awarded
Biology	2,579	83
Chemistry	1,493	61
Physics	808	42
Earth Space	520	30

The KSDE database shows a surplus of currently valid endorsements in all science teaching fields. Why is there an actual classroom shortage?

First, many science teachers hold multiple endorsements. A biology teacher who is teaching all chemistry classes cannot be counted as available toward a biology vacancy. Second, the valid endorsements include teachers who are sitebound and have not yet found a position, have retired, moved from the state, or quit teaching. Many of the science teachers trained during the "Sputnik era" and who have just retired will still be in the count, but will rapidly disappear when they do not renew their license.

Why?

There are no overall reliable surveys of Kansas science teachers' reasons for taking early retirement, or of students' reasons for not pursuing science teaching degrees. However, extensive contact with both groups provides substantial anecdotal evidence of two major factors: recent curricular-and-assessment-reforms and salaries.

Cooperating teachers of my student teachers, colleagues at meetings, and teachers taking early retirement greatly resent the erosion of their professional decision-making and the substitution of standardized lessons and teach-to-the-test requirements. While the KSBE has been clear that science standards are to be used as guidelines and not dictate curriculum, more and more superintendents and principals are telling teachers to not only teach only what is in the standards, but to teach in the order of the standards. This has contributed to some veterans taking early retirement and others seeking employment in international schools or jobs outside of teaching.

The numbers of young college students aspiring to go into biology teaching is not a lot lower than a decade ago. However, for every four students initially entering my BSE-biology program, roughly one is not college material and flunks out within the first two years, one finishes the program, and two switch from teaching to research careers after encountering the introductory education course that accurately presents them with the QPA/NCLB framework. "I want to teach the excitement of biology, not teach to some test" approximates comments I hear over and over again. This disgust for scripted lessons and standardization is common among teachers in all fields from kindergarten up. But science teachers are unique in having other career options and a subject discipline that does not respond well to the straight-jacket of standardized curricula. Math teachers have a lock-step curriculum that allows for little variation in content coverage. Science thrives on an exciting and diverse range of teaching strategies utilizing labs and fieldwork.

A second major factor is salary. Good teachers do not enter teaching for the money. But when the salary fails to keep up with inflation and a teachers find they cannot support their families, they must seek other work. One example is a teacher who holds endorsements in all the secondary science fields and has five years of quality service in a Kansas classroom. He is currently driving an 18-wheel truck. The salaries are about equivalent but health insurance for his family costs only $200 a month as a truck driver, over $800 a month as a teacher. He is bored as a truck driver and would prefer teaching, but cannot afford to return to the classroom.

A national survey of teachers' salaries adjusted for inflation over the last decade found Kansas ranked 49th–next to last among the 50 states. Kansas teachers' salaries have lost 11 percent. We have historically been stealing science teachers from Missouri and Oklahoma, but the gap is closing fast.

Two decades ago, I had over 50 students in the four-year BSE-biology pipeline with 5-15 student teachers per year. Today, I have 15 advisees and one or two student teachers per semester, and this pattern holds for other state and private colleges.

SOLUTIONS?

What can be done to either solve the science teacher shortage or ameliorate the situation? There are good, ineffective, and bad solutions being proposed.

1. **A return to teacher professionalism** would involve the rejection of NCLB money by the state (about $150 million/year), a near-complete scuttling of the oppressive assessment system, and a return to a culture of professionalism, but this is politically impossible in the current climate.
2. **School consolidation** is occurring slowly. This decreases the number of science teachers needed by combining small districts. This solution cannot solve more than about ten percent of the shortage; it would move the first two bars on the left in Figure 10 into the middle-size school category. It would not address the shortages in any other schools where class size is normal. This is a small and ineffective solution.
3. **Increasing class size** for qualified science teachers in middle and large schools would increase the impact of the current remaining science teachers. In the 1960s, a science teacher often had 160 students in a day. Today, most secondary teachers only teach 80-90 students. "Small class sizes" has been a mantra and is perhaps valuable in early grades for reading, etc. but desperate times call for utilization of the troops you have. Asian schools often have class minimums of 60 students. Our students are not Asian students. Nor can our classrooms hold 60 students, but I see some quality teachers who could do it, and their rooms are not full. This is a limited solution likely to meet with resistance.
4. **Recruitment** into science teaching fields must be improved. A good college student who loves science classes and can't wait to tell his/her roommate should be encouraged to enter teaching. They can continue to "ride" the developments of the sciences the rest of their lives and convey that excitement to a new generation. If they enter research, they will be stuck on some remote metabolic pathway and miss the full picture. This excitement and drive must be great enough to ride out the endless parade of education reforms.
5. **Relaxing alternative or restricted licensure requirements** and even eliminating the education requirements to allow folks with non-teaching bachelors degrees into the classroom as full-fledged teachers. The current Transition-to-Teaching grant has put over two dozen alternate-route teachers into

high-risk Kansas classrooms and some are doing well before they have finished their online education coursework. However, Kansas is a rural state with most severe shortages in rural areas far from our small number of unemployed degreed citizens. There is no evidence that there are substantial numbers of citizens with degrees in science who could make a dent in the massive shortfall that is occurring. I taught as a "permit" teacher in Kentucky before I finished my teaching credentials at college. Kentucky continued to have the shortage that rural Kansas superintendents are now facing: hiring an unqualified "warm body" to hold the fort until they can get someone qualified. It may be necessary to do this, but it is not honest to claim that the vacancy is now filled and the problem solved.

6. **Broadfield science licensure** would "solve" the problem on paper tomorrow. Colorado, Missouri, Nebraska and Oklahoma all train science teachers in shallow broadfield science, about one-third the depth of content in biology, physics, chemistry, and earth science as Kansas requires. If this mistake is made, Kansas students would have to suffer with undertrained teachers for the rest of the teacher's 40-year career. Educationists who believe you can teach what you do not yourself understand promote this, as do many school administrators who are eager to use current teachers across science disciplines. This is the worst "solution" and also one that continually looms on the horizon–there are many "Redesign" advocates still active in Kansas.
7. **"Water down" QA requirements** by allowing versions of general science back in. Some school administrators are eager to use shallow-trained teachers for a shallow-science course. The rest of the world is increasing the science literacy of their populations and their scientist production. This would take us the wrong direction; we cannot buy our next generation of scientists from foreign countries and attract foreign students when their countries are about to surpass ours in standard of living.
8. **Delivering courses by distance learning** is discussed as a solution for the one-third of students in rural schools. Distance learning has a long and proven track record of low completion rates and poor effectiveness. A failed experiment that began in the 1960s, it remains a correspondence course where barely ten percent of students effectively learn. It is even more inadequate in science, where hands-on experiences and lab skills are critical.
9. **Increasing scientist cooperation** with school districts is part of the Bush proposal. This is ineffective in a rural state where the only significant scientist population is around the three urban centers. This is also a zero-sum strategy: any diversion of scientists to education decreases work in research and industry.
10. **Increase AP coursework** is also part of the Bush proposal and requires a diversion of science teachers from regular courses. This requires more science teachers to implement. There is evidence that AP diverts some students out of the science pipeline since it earns students an exemption from college science courses.
11. **Current teachers adding science teaching fields merely by taking the ETS science tests** and not completing any science coursework is also proposed. This was proposed following Redesign and only gained three votes on the Board. The argument recognized then and repeated here is: you cannot take the medical board exams or the lawyer bar exam unless you have completed medical or law school. The test is to help confirm that you have learned certain concepts. But the test does not in any way evaluate all the skills you develop, and you cannot develop those skills by mere test preparation classes. A lawyer learns his or her courtroom skills in coursework and a surgeon learns surgical skills in medical school, not by test. As teacher shortages begin to develop in other areas, it is obvious that there will not be a substantial pool of other teachers who will be able to add science by mere ETS testing without causing a shortage in their original field. However, several states have adopted this approach; it falsely labels unqualified teachers as qualified.
12. **Hiring science teachers from overseas.** The magnitude of the shortage would require dramatic changes in credentialing.

ACKNOWLEDGEMENTS

I am thankful for data provided by a variety of sources: Martha Gage and Susan Helbert at KSDE, DeWayne Backhus and Kenneth Thompson at E.S.U., Amy Prettejohn at K.U., Paul Adams at F.H.S.U., and Dixie Smith at P.S.U. Responsibility and blame for all analyses is mine. -JRS