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school improvement planning. Currently, a pilot project is using the *Surveys of Enacted Curriculum*[155] to determine the usefulness of that tool in assessing the alignment of classroom instruction to the *Illinois Learning Standards* in mathematics, science, and career and technical education.

Because "what is tested" is often "what is taught," it is important to align state assessments with the most important knowledge and skills. The "Applications of Learning" and the list of workplace skills and career development competencies are not reflected in the state assessments except for the use of WorkKeys as part of the 11th grade assessment. Since state assessments are developed years in advance of actual administration, the critical technologies that will drive the Illinois economy for the future do not appear on the PSAE. If any of the "Applications of Learning" are to be assessed, local districts must take the initiative.

Instructional Approaches to Engage Students

Beyond alignment studies and the assessments that tend to direct instruction, practical applications of knowledge, such as those encouraged by the Applications of Learning, can help to engage students in learning science and mathematics. A common sense approach, perhaps, but one supported by research. In the last few decades, much has been learned on how we learn and the impact of different pedagogies on learning.[156] Unfortunately, it appears the research has not been widely implemented:

- The Bayer Survey of parents of under-represented students indicated that one of the challenges for their students is that science classes are boring or uninteresting (58% daughters, 51% sons).[157]
- The Gates foundation found 88% of high school dropouts have passing grades and many dropouts list "boredom" as the reason for leaving school.

In the past ten years, national studies focused on how to improve STEM education and have offered recommendations ranging from a total reorganization of the educational system to less comprehensive approaches such as changing how mathematics and science content is taught. Some, such as Bill Gates, have argued for a new concept of high school:

> When we looked at the millions of students our high schools are not preparing for higher education—we look at the damaging impact that has on their lives —we came to a painful conclusion: America's high schools are obsolete…By obsolete, I don't just mean that our high schools are broken, flawed, and under-funded—though a case could be made for every one of those points. By obsolete, I mean that our high schools—even when they're working exactly as designed—cannot teach our kids what they need to know today. Training the workforce of tomorrow with the high schools of today is like trying to teach kids about tomorrow's computers on a 50-year-old mainframe. It's the wrong tool for the times.[158]

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Although a full study of instructional alternatives is beyond the scope of this paper, several basic themes recur frequently in analyses of mathematics and science instruction at both school and college levels:

- Increased use of relevant, practical, application-based approaches
- Integration of content across disciplines from the early grades
- A focus on depth of learning and thinking as opposed to rote memorization

For example, college students have limited opportunities to participate in authentic situations they might encounter in the workplace. Experiential learning projects are most likely to be found in colleges of business, engineering, and health sciences; and in homeland security courses. These projects may include cross-functional teams with students from engineering, marketing, financial investment, and psychology working together on a real-world task to identify what consumers need and to develop and market a product using "consumer to market" strategies. This teamwork exercise differs from a group project of like majors who may know and process information similarly. The experiential approach allows the college major to understand his role in the larger picture of an organization, hone teamwork skills, apply the abstract knowledge acquired in the classroom, and develop an understanding of the need for an interdisciplinary perspective. Authentic, experiential learning projects are also being used in some middle schools and high schools.

At the school level, another approach is the integration of mathematics and science with a focus on critical thinking beginning in the early grades. Such an approach is hands-on and accommodating to a wider range of student abilities.[159] An integrated curriculum is being implemented in a small number of schools around the country.

A related instructional methodology is "problem-based learning." The Illinois Math and Science Academy and some of the Illinois teacher preparation programs train teachers and preservice teachers to use "problem-based learning," which emphasizes multi-disciplinary approaches to solving complex problems. They are part of national and international efforts to replace formulaic methods of teaching math and science with more engaging instructional activities.[160]

Research on high-scoring countries in international competitions shows that the instructional materials of these countries build deeper levels of understanding, whereas the pervasive U.S. approach is one more attuned to definitions and formulae.[161] The U.S. approach is to show students an example of a problem which represents the material to be covered in the standards and then have the student do multiple problems of the same type. A perusal of Japanese instructional materials shows a focus on applying concepts, where problems build on previous ones, and students are encouraged to solve unrehearsed, dissimilar problems.[162] Related research has shown that students given such challenging work in a highly varied curriculum are more successful on standardized tests than those who have undergone narrowly focused test prepping.[163]

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Perhaps the U.S. Department of Education Secretary's Summit on Science Education summarized the concerns with science education the best:[164]

- At all grade levels we try to teach too many disconnected concepts and less may be more.
- In current classrooms, many topics are covered superficially.
- There are too few student investigations of real and simulated systems.
- There is no systematic way to fundamentally change instructional practice in response to science advances.
- Science standards are a decade old and need to be revised to be based on a few core areas, incorporate current advances, and make better use of technology.
- Increase the number of qualified teachers for science and provide professional development, especially for those in urban and rural schools.
- Increase the use of better and more sophisticated online, simulation, and real-time data acquisition probeware.

In summary, *Illinois Learning Standards* present a traditional discipline-focused approach to student learning and the state assessments are aligned to these standards. Two sections of the standards—the "Applications of Learning" and an appendix on workplace skills and career competencies—provide a glimpse of the knowledge and skills needed by students in the 21st Century. At this time, the state assessments are not overtly aligned to these two sections of the standards, nor are there systematic processes in place to address new and emerging fields of study or to measure the alignment of classroom instruction to the standards.

Alignment of High School Requirements to College and Workplace Readiness

Several major national projects, such as the *American Diploma Project* and *High Schools That Work*, offer methods of improving high school education that promise to improve the level of STEM education performance. These projects are important, especially in light of data presented by the 2005 National Education Summit on High Schools: 40% of high school students say they are just going through motions and one-third did not try hard.[165]

On the other hand, no matter what the curricula is for high school or how rigorous the graduation requirements, if only slightly more than half of all 8th grade students are meeting the Illinois mathematics and science standards, they are not "high-school ready." For high schools, the challenges seem conflicting – how can they remediate nearly half of the students while trying to make the high school curriculum more rigorous and aligned to the expectations of postsecondary institutions and the workplace?

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The Illinois State Board of Education is convening a meeting in June 2006 intended to forge consensus that raising the quality of Illinois high schools should move to the front burner.[166] As part of the efforts to improve high schools, ISBE joined the *High Schools That Work* consortium several years ago. Twenty of Illinois' 668 high schools participate in this nationally-regarded program. The state also participates in nationally researched programs that bring engineering curriculum modules to middle schools and high schools. Multiple projects in Chicago support the Mayor's and Chicago Public Schools' efforts to improve high school, including the development and implementation of mathematics and science instructional support programs, the creation of smaller high schools, and other initiatives funded by the Bill & Melinda Gates Foundation.

Among national reports on high school reform and improving STEM education, a prominent agenda item is alignment of high school graduation, college admissions, and workplace expectations. As noted on the chart below, Illinois took a small step in that direction last year in increasing the graduation requirements, but our state's requirements are still well below University of Illinois admissions standards and recommendations of national groups such as the *American Diploma Project* and ACT.

Table 13 Comparison of Illinois Graduation Requirements to ACT and UIUC

Discipline	Illinois Graduation Requirements (2005 Legislation)[167]	University of Illinois Admission Requirements	ACT Recommendation[168]
English/ Writing	4 years, with at least 2 in writing intensive courses	4 years	4 years
Mathematics	3 years, including Algebra I and 1 year with a course that includes geometry content	3 – 3.5 years	3 or more years including Algebra I, Algebra II, Geometry and at least one other advanced course beyond Algebra II
Science	2 years	2 years laboratory	Biology, chemistry, physics
Social Sciences	2 years, one to be U.S. history or combination of U.S. history and American government	2 years	--
Electives	1 year, includes art, music, foreign language, or vocational education	2 years foreign language and 2 years fine arts	1-2 years of foreign language

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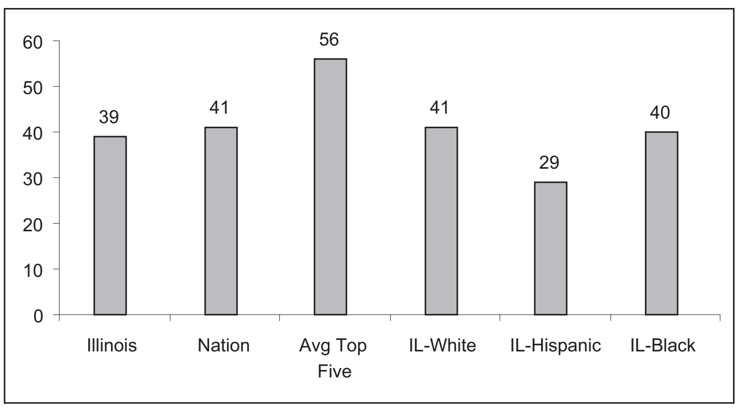
Debate over the numbers and titles of courses tends to obscure the most critical issue, which is the actual content of the courses. Unless courses are rigorous enough to enable students to meet the Learning Standards, the requirements are simply a game of numbers. The next section of this report looks at the controversy around courses for just one subject – mathematics.

To meet the mathematics requirements set forth by ACT, *American Diploma Project*, and others, some Illinois schools would need to reorganize mathematics curriculum so that students could complete Algebra I in middle school and find qualified teachers to teach higher levels of mathematics in high school.

There is increasing debate over the appropriate mathematics courses for all students to complete in high school. At the low end, Algebra I appears to be the mandatory gateway course. In 2005, 39% of the Illinois 8th graders took algebra, as compared to 41% nation-wide, and an average of 56% in the five top-performing states.

Figure 35 Percentages of Eighth Grade Students Taking Algebra in 2005[169]



Several research studies correlated college success with courses taken in high school and concluded that Algebra II is important to student success in college.[170] [171] [172] [173] Other researchers and practitioners are questioning the usefulness of Algebra II for all students, especially if taught in traditional ways. A first point of contention is that the research that led to the recommendation only showed a relationship between students' success and taking Algebra II, and correlation does not mean causation. Other factors related to taking Algebra II could be playing a larger role in the students' success. In fact, research has found that just taking the mathematics courses does not automatically lead to college readiness, and the outcomes are much weaker for black and Hispanic students.[174] Other possible factors contributing to the increased white students' success could be that they have more rich, varied background experiences and higher quality teachers.

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A second point of contention is that "more of the same" of an old model is not the answer. Algebra II is the next step in the traditional sequence leading to calculus. Few occupations require a knowledge of calculus, but many do require other topics such as data analysis, statistics, discrete mathematics, and mathematical modeling. Some mathematics educators contend that rather than abstract mathematics, such as calculus, greater numbers of students need more applied mathematics such as statistics.[175]

In the same line of reasoning, there are advocates to less mathematical and more applied approaches to science, such as in Physics First. The traditional sequence of science courses is biology, chemistry, and physics. Physics First, as the name implies, would put physics in the high school curriculum first, because biology requires an understanding of chemistry which requires physics knowledge.[176] Advocates of Physics First say that the course content is simpler than biology and can be learned by younger students. Opponents of alternative science models usually prefer the traditional, calculus-based, college prep curriculum now expected by higher education. The pervasiveness of the 19th and 20th Century college prep programs is evident in both the American Diploma Project and ACT's new core.

As the debate continues between the traditional and pedagogical newer models and content, it will be important to ensure that graduation requirements meet the expectations of postsecondary institutions. For Illinois, aligning the state standards to college expectations is difficult because each institution of higher education has its own unique requirements, placement testing, and criteria for remediation. Other states such as "California, Kentucky, and Oklahoma have established 'remediation-free' standards to clarify what incoming students need to know to place into credit-bearing courses,…[and] Oregon has identified the level of knowledge and skills needed for college entry and aligned this with the state's high school standards."[177]

Illinois has some under-utilized mechanisms in place which could help with the alignment of high school, community college, and university standards. Public colleges and universities provide feedback reports to high schools on the success of students who matriculated to their institutions from the high school. Universities provide similar feedback information to community colleges. The Illinois Public Community College Act describes a college-ready background for students but it is not universally implemented. Perhaps a coordinated P-20 approach to improving high schools (and mathematics and science also) would initiate conversations between institutions that would put available tools to work.

In summary, Illinois raised high school graduation requirements in 2005, but not to a level expected by the state's own public universities. High school reform faces a dual challenge of trying to remediate students while increasing the rigor of instruction. Further work is needed to ensure the level of rigor truly matches the expectations of colleges and the workplace.