ILLINOIS SURVEY of CRITICAL TECHNOLOGIES

SUMMARY REPORT

MARCH 2006

Illinois State Board of Education • Northern Illinois University

CONTACT INFORMATION

For questions about the purpose and follow-up of the survey —

Gwen Pollock
Illinois State Board of Education
gpollock@isbe.net

For more about identification of the critical technologies —

Kristin Ciesemier
Illinois Mathematics and Science Academy
kciesem@imsa.edu

For questions about the report —

Marilyn McConachie
NIU Outreach
Northern Illinois University
mcconachie@niu.edu

For technical questions regarding the survey —

Karen Schnite
Public Opinion Lab
Northern Illinois University
kschnite@niu.edu

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PREFACE

Nanotechnology, gene therapy, green technology, artificial intelligence – concepts such as these are becoming important to our economy and daily lives at an increasingly rapid pace. With rapid technological changes come important questions about how to best provide opportunities for students and workers to learn about them, and how best to identify "the new basics" that are transforming science, technology, engineering, and mathematics. Illinois' commitment to innovation requires that we find ways for ensuring success of students and workers in the technology-driven global marketplace. This premise implies the need for frequent updates in school and job-training curricula.

Every level of the education continuum shares some baseline questions when considering changes in curriculum, especially in highly dynamic subject areas such as mathematics and science. What technologies are "critical" to success in the economy of the future? What do our teachers know about emerging technologies? What instruction in these concepts is occurring now? What barriers affect our ability to infuse learning of new technologies into instruction?

These questions have figured in a series of discussions around the state about the need for an Illinois coalition that would address issues related to science, technology, engineering, and mathematics (STEM) education. National reports about the declining quality and quantity of STEM professionals in the U.S. contributed a sense of urgency. When a Kentucky report on what that state's teachers knew about new technologies appeared in 2004, Illinois leaders saw it as a model for inquiry on the baseline questions at the P-12 level.

In December 2004, the Illinois State Board of Education arranged to lease the Kentucky survey for distribution in Illinois. The Illinois Mathematics and Science Academy (IMSA®) took responsibility for revising Kentucky's list of "critical technologies" in consultation with Illinois businesses and researchers. In 2005, Northern Illinois University surveyed Illinois middle school and high school teachers of science and mathematics to determine what they knew and were teaching about 26 concepts deemed critical to Illinois' future economic success.

The results of the Illinois survey should initiate state-wide conversations about how, when, or whether new technologies should be introduced into P-12 and higher education classrooms. With the quality of Illinois' current and future talent pool at stake, the conversation must include representatives of business, government, and education. Connections between education and economic development are everybody's business.

We are grateful to the 1241 Illinois teachers who participated in this survey. Additional thanks go to the Kentucky Science and Engineering Foundation for sharing their survey and report template.

Illinois State Board of Education

Northern Illinois University

SUMMARY OF FINDINGS

Executive Summary

In 2005, Northern Illinois University (NIU) surveyed Illinois science and mathematics teachers to measure knowledge and classroom use of 26 cutting-edge concepts identified as critical to the state's future in the global economy. Overall, 52% of teachers were aware of at least half of the advanced concepts. Some Illinois students are already learning about these concepts – 38% of teachers have incorporated at least one of the 26 concepts into their teaching. The concepts most likely to be taught in Illinois classrooms are Alternative Fuels, Algorithms, Biotechnology, and Recombinant DNA. The survey spotlights a need to identify "the new basics" in science and mathematics for P-12 and higher education and to decide what should be taught and when. Further, the state needs to address educational, financial, and policy barriers that prevent teachers from learning more about and teaching new technologies. Concerted action by educators, businesses, and policymakers is needed to strengthen the connection between education and economic development.

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About the Survey

At the request of the Illinois State Board of Education (ISBE) in 2005, NIU conducted an online survey of teachers of science and mathematics at the middle school and high school levels. This baseline survey assessed what teachers knew and were teaching about 26 "critical technologies," new and emerging concepts identified as drivers of Illinois' future innovations and economic vitality. Based on a similar survey leased by ISBE from the Kentucky Science and Engineering Foundation, this project adapted survey items, methodology, and report design with permission granted by terms of the lease.[1] The results of the Illinois survey will help Illinois educators, businesses, and policymakers determine ways to prepare Illinois citizens as well as our future scientists, technologists, engineers, and mathematicians to meet the challenges of the global marketplace.

"Critical Technologies"

The Illinois Mathematics and Science Academy (IMSA) identified the 26 science and mathematics concepts in consultation with educators, researchers, engineers, and representatives of business and industry. Participants in the identification process agreed that these concepts are now or are becoming growth areas in Illinois' economy. Definitions of the concepts, which are similar to 25 concepts identified in Kentucky in 2004, can be found in Appendix B. The concepts are listed below and grouped into five categories.

Biosciences
- Astrobiology
- Biomaterials
- Biomechanics
- Biotechnology
- Natural Products
- Recombinant DNA

Environmental and Energy Technologies
- Alternative Fuels
- Bioremediation
- Fuel Cell
- Green Technology

Human Health and Development
- Biodefense
- Bioinformatics
- Gene Therapy
- Genomics
- Proteomics
- Stem Cells

Information Technology and Communications
- Artificial Intelligence
- Algorithms
- Data Warehousing and Mining
- Graph Theory
- Modeling Complex Nonlinear Systems
- Quantum Computing

Materials Science and Advanced Manufacturing
- Biopolymers
- Celestial Mining
- Nanotechnology
- Smart Materials

[1]

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Participants

A total of 1241 Illinois teachers participated in the Critical Technologies Survey. They constitute a representative sample of Illinois' 16,000 teachers of science and mathematics. The sample included urban, suburban, and rural locations; large and small schools, and all socio-economic levels. Here is a snapshot:

Levels	54% high school, 41% middle school, and 5% teaching at both levels
Gender	65% female and 35% male
Assignment	41% teach science; 37% teach mathematics; and 22% teach both subjects
Experience	75% of survey respondents have taught longer than 5 years.
Geography	All areas of the state were represented.

Themes

Three themes with corresponding implications for action emerged from responses to the Critical Technologies Survey.

1. ***Classroom implementation is limited.***
   Few Illinois students in grades 6-12 have opportunities to learn about more than one of 26 science and mathematical concepts that businesses and researchers say are emerging as drivers of the new economy.
   - Comparable information is needed about higher education faculty knowledge and instruction as well as workplace needs for training in applications of advanced concepts.
2. ***It is time to define the "New Basics" in science and mathematics.***
   The survey spotlights a need to identify the "new basics" in science and mathematics and to decide what should be taught and when.
   - A broad-based dialogue is needed to certify which concepts are most critical.
   - Decisions on the "new basics" should result in revisions of content standards and assessments for students at all levels.
3. ***Barriers limit classroom implementation and teacher training.***
   Teachers who want to learn about emerging topics are constrained by time, lack of financial resources and teaching materials, state and local policies, and shortage of opportunities to acquire knowledge and teaching skills.
   - Local and state level educators and policymakers will need to collaborate to address the barriers and provide new options for teacher training.

A fuller discussion of each of the themes and implications follows. In addition to charts and tables, selected comments from participating teachers appear throughout the report.

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1. Illinois Classrooms and the Critical Technologies

Teachers' knowledge of content and skills in teaching constitute the most important variables in what students learn at school. Most of the concepts examined in this report are so new that only a few are included in teacher preparation programs. On the whole, teachers showed themselves to be inquisitive and willing to introduce new material into their classes. As one teacher commented, "We're being derelict in our duty as educators if we don't at least begin to address these issues to all students, not just those who seek them out independently." In order to assess what teachers knew and were teaching about the 26 concepts, this survey measured five factors – awareness, familiarity, understanding, classroom use, and barriers to implementation.

- **Awareness**
  Teachers indicated awareness if they had heard of a concept. For instance, 93% of teachers were aware of Stem Cells, a subject often covered in both the popular and the professional press, but only 8% knew of Proteomics. Overall, 52% of teachers were aware of at least half of the 26 concepts.

- **Familiarity**
  When teachers were aware of an advanced concept, 60% took the initiative to learn more. Those who indicated awareness were asked to indicate a degree of familiarity with scientific or mathematic principles surrounding a concept. Of the teachers who indicated awareness, the largest number were familiar (extremely, very, or somewhat) with Alternative Fuels (77%). The least familiar concept was Quantum Computing (36%). Both high school (63%) and middle school (55%) teachers who were aware of the concepts were also familiar with more than half of the critical technologies.

- **Understanding**
  Teachers who said they were "extremely," "very," or "somewhat" familiar were then asked whether they understood a concept well enough to teach it. Of teachers who indicated they were familiar with the concepts, more than 60% indicated that they understood Alternative Fuels and Graph Theory well enough to teach them. The least understood concept was Quantum Computing (19%). Reflecting the levels they teach, high school teachers consistently showed a higher level of awareness, familiarity, and understanding than did middle school teachers.

- **Classroom Implementation**
  As might be expected, few teachers are prepared to instruct their students in these new concepts. About 20% of science and math teachers included three or more concepts in their teaching, but 62% do not offer instruction in ***any*** of the 26 technologies. The most frequently taught concepts are Algorithms, Biotechnology, and Recombinant DNA. Only 8% of teachers familiar with Quantum Computing were actually teaching it.

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- **Classroom Implementation (continued)**

  For high school teachers who understood concepts well enough to teach them, 68% taught one or more to their students. Eighty-four percent of these knowledgeable teachers indicate that they will add at least one more concept to course work next year. In the case of middle school teachers who were confident in their understanding of the advanced concepts, 62% teach one or more, and 83% will add at least one more next year.

Summary by Category

Some categories were more familiar and more often integrated into class work than others.

Among the five categories, teachers are most likely to be aware of Biosciences (55%) and Environmental and Energy Technologies (54%). Conversely, teachers said they were least aware of Materials Science and Advanced Manufacturing concepts.

Percentage of Category Awareness

Biosciences	55%
Environmental and Energy Technologies	54%
Human Health and Development	49%
Information Technology and Communications	45%
Materials Science and Advanced Manufacturing	38%

Those who teach high school tend to be aware of more items in each category than those who teach middle school.

Percentage of Category Awareness By Type of School

	Middle School	High School	Both MS & HS
Biosciences	51%	59%	58%
Environmental and Energy Technologies	48%	58%	62%
Human Health and Development	45%	51%	53%
Information Technology and Communications	40%	49%	49%
Materials Science and Advanced Manufacturing	32%	43%	44%

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Summary of Concept Awareness

Predictably, concepts that have been in the public consciousness for 10 years or more were best known to educators. Conversely, newer concepts were far less well-known. Concepts with the highest awareness were consistent across both high school and middle school.

Concepts with Highest Awareness

	(% Aware)
Stem Cells	93%
Artificial Intelligence	84%
Alternative Fuels	81%
Gene Therapy	81%
Algorithms	77%
Biotechnology	74%

Concepts with Lowest Awareness

	(% Aware)
Proteomics	7%
Bioinformatics	15%
Bioremediation	20%
Celestial Mining	22%
Modeling Complex Nonlinear Systems	25%

Summary of Concept Familiarity

As teachers progressed through the survey, the filters of awareness, familiarity, understanding, and classroom integration reduced the number of participants responding to each concept. To clarify what the percentages mean, the tables in this report show two columns – valid percentage and total percentage.

Valid percentage refers to the number of qualified teachers responding to an item. In the table at the bottom of page 11, teachers who said they were aware of Alternative Fuels were qualified to indicate their level of familiarity. Seventy-seven percent of teachers who were aware of Alternative Fuels were also extremely, very, or somewhat familiar with the scientific principles surrounding this concept.

"Total" percentage refers to all survey participants. In the case of Alternative Fuels, that means 52% of all teachers who completed the survey.

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Summary of Concept Familiarity (continued)

General Familiarity

As the table below shows, 60% of all survey respondents who were aware of concepts were also familiar with at least half of the 26 concepts. As noted previously, high school teachers were familiar with more concepts than middle school teachers, but strength at both levels implies dedication to professional currency, especially considering the highly technical nature of the more advanced technologies.

Familiarity with Concepts By Type of School

	Middle School	High School	Both MS & HS	% Aware and Familiar
Familiar with fewer than 50%	45%	37%	32%	40%
Familiar with 50% or more	55%	63%	68%	60%

Concepts with Most Familiarity

Three of the five most familiar concepts are related to agriculture, which may be a reflection of teachers' response to real-world issues of interest to students.

Concepts with Most Familiarity
(% Extremely/Very/Somewhat Familiar)

	*Valid %	**Total %
Alternative Fuels	77%	52%
Graph Theory	72%	18%
Natural Products	72%	41%
Green Technology	72%	33%
Stem Cells	71%	70%

*Valid % = % of ONLY participants who indicated awareness
** Total % = % of ALL participants in survey

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Summary of Classroom Integration

Conscientious teachers introduce advanced concepts to students only when they are satisfied with their own mastery. The valid percentage includes only teachers who were aware and familiar with the concepts. The total percentage covers all survey respondents.

Concepts Understood Well Enough to Teach

	*Valid %	**Total %
Alternative Fuels	64%	29%
Graph Theory	61%	8%
Green Technology	59%	15%
Algorithms	58%	19%
Bioremediation	58%	6%
Natural Products	57%	18%
Fuel Cell	54%	18%
Recombinant DNA	53%	17%
Proteomics	51%	2%

*Valid % = % of ONLY participants who indicated awareness & familiarity
**Total % = % of ALL participants in survey

When teachers understood them well, these concepts were most likely to be taught in Illinois classrooms.

Concepts Taught Most Often

	*Valid %	**Total %
Algorithms	55%	14%
Biotechnology	47%	12%
Recombinant DNA	46%	10%
Alternative Fuels	42%	16%
Genomics	40%	5%
Graph Theory	39%	4%

Concepts Being Added Next Year

	*Valid %	**Total %
Fuel Cell	24%	6%
Biomaterials	23%	3%
Smart Materials	22%	2%
Bioremediation	21%	2%
Celestial Mining	21%	1%
Nanotechnology	20%	4%

*Valid % = % of ONLY participants who indicated awareness, familiarity, and enough understanding to teach
**Total % = % of ALL participants in survey

SUMMARY OF FINDINGS

2. Defining the "New Basics" in Science and Mathematics

Clearly, advanced and innovative concepts are making their way into Illinois classrooms, but overall penetration is limited. At one end of the continuum, each concept is being taught in at least a few schools somewhere in the state. At the other end, the concepts are so new or their applicability so limited that the words themselves are unknown.

At both P-12 and the higher education levels, educators tend to argue that adding more content is very difficult, because curricula are already bursting at the seams. Given general agreement on that complaint, complete redesign of science and mathematics curricula may be in order. As one teacher explained, "If the goal is truly to integrate the curriculum to include more of these topics, we need to pare down the span of topics covered and start covering topics more in-depth to allow true exploration and more student-directed learning." Another teacher put the problem more simply. "Our curriculum is so jammed that I feel I am just brushing the surface of all topics I teach."

These observations from the field highlight a fundamental problem: How can we keep science and mathematics curricula current at a time when new areas of knowledge are expanding rapidly? Who will decide what the "new basics" are for P-12 and higher education? Who will decide what's appropriate at what level and will that process be timely? A highly de-centralized system exists in Illinois with individual school districts, colleges, and departments making their own curricular decisions. The piece-meal approach ensures local control and academic freedom, but does not always ensure strong connections between education and the challenges of the global marketplace. In their survey comments, many teachers seemed to be asking for guidance regarding what to include in the curriculum.

The Kentucky survey report developed a useful method called "traction analysis" for identifying which concepts teachers think are most important for their students. Since Illinois teachers are making decisions about adding content to their curricula, they are establishing new directions. After all, 38% were already teaching at least one of the concepts and 44% planned to add at least one more concept into their classes next year. Illinois teachers' responses to two specific questions provide the best indicators of current status and a context for devising next steps in curricular development.

- Which concepts are you currently teaching?
- Which concepts are you interested in learning more about?

When answers to these two questions were analyzed, the concepts fell into four groups – Traction, High Potential, Less Potential, and Tough Sell. These are arrayed in the quadrants of Table A along two axes – the horizontal one indicating teachers' interest in learning more, and the vertical showing level of classroom use. Further explanation of each group follows Table A.

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Table A

Highest Levels of Classroom Use

"Less Potential" Concepts	"Traction" Concepts
Algorithms	Biotechnology
Recombinant DNA	Alternate Fuels
Genomics	Graph Theory
Modeling Complex Non-linear Systems	Gene Therapy
Bioremediation	Natural Products
Proteomics	Green Technology
	Fuel Cell

Lowest Levels of Interest In Learning More

Highest Levels of Interest In Learning More

"Tough Sell" Concepts	"High Potential" Concepts
Biopolymers	Stem Cells
Astrobiology	Smart Materials
Bioinformatics	Nanotechnology
Biomaterials	Artificial Intelligence
Data Warehousing and Mining	
Celestial Mining	
Biomechanics	
Biodefense	
Quantum Computing	

Lowest Levels of Classroom Use

Category Key

- Biosciences
- Environmental and Energy Technologies
- Human Health and Development
- Information Technology and Communications
- Materials Science and Advanced Manufacturing

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"Traction" Concepts

Concepts in the "Traction" group attracted above average interest from teachers and the highest level of attention in Illinois classrooms. Although the survey questions did not ask how much students learn about these concepts, the results suggest that teachers are shaping curriculum to address real-world issues. The majority of the concepts are connected to agriculture, manufacturing, and energy -- all major factors in the state's economy.

"Traction" Concepts

- Biotechnology
- Alternate Fuels
- Graph Theory
- Gene Therapy
- Natural Products
- Green Technology
- Fuel Cell

Teachers' enthusiasm for learning more about the "traction" concepts suggests a starting point for conversation with teacher preparation and professional development programs about increasing content knowledge and creating curricular materials. Two questions are likely to arise immediately – how do these topics align with the Illinois Learning Standards, and how will teaching them impact student performance on the state's science and mathematics assessments? Results in both subject areas will count toward Adequate Yearly Progress in coming years.

"High Potential" Concepts

The topics in this group are interesting to teachers who already know something about them, but are not taught to their students as often as the "traction" concepts. Teachers' willingness to learn more about them may suggest a willingness to introduce them to students once they have mastered the content themselves. A high percentage of teachers who were familiar with or understood Artificial Intelligence (75%) and Nanotechnology (63%) planned to teach them next year. Data on how these teachers get information about new technologies imply that many are teaching themselves. Helping these teachers develop their expertise in emerging technologies would seem to be an important role for higher education, regional offices of education, and other providers of professional development.

"High Potential" Concepts

- Stem Cells
- Smart Materials
- Nanotechnology
- Artificial Intelligence

SUMMARY OF FINDINGS

"Less Potential" Concepts

Teachers who have some understanding of the concepts with "less potential" say that they are teaching them, but are not much interested in learning more. Further research is needed to understand the dynamics, which may be unique to each concept.

"Less Potential" Concepts

- Algorithms
- Recombinant DNA
- Genomics
- Modeling Complex Non-linear Systems
- Bioremediation
- Proteomics

"Tough Sell" Concepts

The "tough sell" concepts do not generate much interest among teachers and are rarely taught in Illinois classrooms. At this time, teachers may lack familiarity and/or do not see the applicability of this group to what students should know and be able to do. Some of the "tough sell" concepts, however, have been singled out by business and industry as high priorities for the state's future. The most influential barriers for this group of concepts are – not appropriate at these grade levels, lack of teacher preparation, and not in textbooks.

"Tough Sell" Concepts

- Biopolymers
- Astrobiology
- Bioinformatics
- Biomaterials
- Data Warehousing and Mining
- Celestial Mining
- Biomechanics
- Biodefense
- Quantum Computing

SUMMARY OF FINDINGS

3. Barriers to Classroom Implementation and Teacher Training

Participants in the survey identified barriers for all 26 concepts. From the five choices offered, three barriers made the biggest difference in preventing introduction of new content.

Most Influential Barriers to Integration

- Inappropriate at this grade level
- Not enough time in the curriculum
- Lack of teacher preparation

In their written comments, teachers explained the barriers and described others that block both classroom implementation and expansion of their own content knowledge.

First of all, teachers made clear that some of the 26 concepts are simply not appropriate for their students, especially at the middle school level. Their open-ended comments clarified what "not appropriate" meant to them – too difficult for students who have not yet mastered fundamental concepts, not included in the Illinois Learning Standards or Professional Teaching Standards, and not tested by the ISAT and PSAE. According to one teacher, "Many students who enter high school have very little experience with science. Some have only memorized facts; others have experienced science as projects. Many have very poor reading skills. The disparity in reading levels and science experiences make it difficult to make science engaging and relevant."

Teachers' written comments also clarified problems with time. Not only over-crowded curricula, but also teaching assignments get in the way. "Since I am in a small school, I teach five different courses – Algebra II, Geometry, Calculus, Advanced Mathematics, and Physics. As much as I would like to integrate emerging technologies into my curriculum, I simply do not have the prep time." Moreover, "…requiring only two years of science for graduation makes an impossible dream out of learning all that is and should be expected."

State and local policies can also prevent implementation of new material. As one teacher explained, "No Child Left Behind has produced a curriculum that is driven by the PSAE. Most people believe that if a topic is not on the PSAE, then it isn't important."

Lack of materials and equipment made teaching advanced mathematics and science extremely difficult. One teacher's poignant question, "What do I do when my skeleton only has one leg and half an arm?" was echoed by dozens of teachers who lacked resources for graphing calculators, software and hardware, and tools for hands-on science.

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Barriers to Classroom Implementation and Teacher Training (continued)

Additional barriers included state and local policies such as the content on state tests, the emphasis on reading and math to the exclusion of science, and cumbersome curriculum and textbook review processes. Teachers described experiences with ten-year old textbooks. One of the most significant barriers was lack of student preparation for middle school and then high school due to deficiencies in reading, mathematics, and lower level science.

Summary of Preferences for Learning More

Teachers expressed difficulty in finding training opportunities and teaching materials. Among all teachers who completed this survey, the number interested in learning more about specific concepts ranged from a high of 47% to a low of 8%. Their comments indicated that lack of interest also related to the concepts not being appropriate for the level of students they teach, the lack of resources to pay for professional development, and/or absence of connection with state standards and assessments.

Preferred Methods to Receive Information About Critical Technologies

Web site	36%
Special conference or seminar	25%
Written materials by mail	19%
In-service programs at school	18%

Teachers were clear, however, that they were willing to try a wide range of professional development methods. They were especially interested in the efficiencies of the Internet for learning about new content and finding teaching materials. A number asked for listservs that would share content and lesson plans about the critical technologies. Others preferred traditional methods such as professional journals and meetings. "With the cost of fuel and the distance I must travel to get to most conferences, it is difficult to expand my knowledge. The Internet is great, but it is nothing like a good presenter at a seminar." Science teachers were far more likely than mathematics teachers to use the Internet to gain knowledge about their fields.

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Implications of the Survey

Preparing Students for Tomorrow

This survey confirms an important strategic advantage for Illinois – our state has a professional corps of science and mathematics teachers who are interested in keeping their content knowledge up-to-the-minute and willing to introduce emerging technologies in their classrooms.

- 52% were aware of at least half of the 26 concepts.
- Teachers are most familiar with the Biosciences, a growth area in Illinois.
- Once aware, 60% of teachers took the initiative to learn more about new concepts.
- When teachers were knowledgeable about concepts, 66% introduced the new material to students.
- 38% of all participants are teaching at least one of the concepts despite an array of barriers.
- Teachers' comments indicate fundamental commitment to students mastering basic knowledge and skills.

To a certain extent, P-12 teachers are dependent on higher education for both adequate teacher preparation and for professional development. Comparable data showing what higher education faculty know and are teaching their students about the 26 concepts and workforce training on these topics needs to be collected to complete a comprehensive picture of what is happening and not happening across the system.

Defining the "New Basics" in Science and Mathematics

Keeping educational curricula up-to-date is an ongoing process. The "traction analysis" in this report tells us that seven concepts appear to be candidates for inclusion in P-12 curricula – Biotechnology, Alternate Fuels, Graph Theory, Gene Therapy, Natural Products, Green Technology, and Fuel Cell. The interdisciplinary nature of some of these concepts suggests that integration of several sciences and integration with mathematics will be necessary.

At the very least, these findings provide a foundation for conversation among all those concerned about the currency of education in Illinois and its appropriateness for the future. Stakeholders in the dialogue must include educators, researchers, business and industry representatives, parents, community members and policymakers.

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Defining the "New Basics" (continued)

Questions that should concern the stakeholders:

1. Which of the 26 concepts in this survey are really critical for success in Illinois' future? Are some of them fads? Which ones are more immediately important than others?
2. What are the "new basics"? Can the existing fundamentals be covered within next contexts? If not, what topics should be dropped? Which concepts should be covered in more depth?
3. When, at what level, should these new concepts be introduced into classrooms? What is appropriate for grade school students? High school? Higher education? Employees?
4. In addition to content knowledge, what new skills and tools do these concepts require?
5. What will be the new expectations for students along the P-20 continuum; i.e. what must students know at each transition point in order to be fully prepared for the next level?

Overcoming Barriers to Classroom Implementation and Teacher Training

A coherent P-20 process would help to connect the educational system as a whole with needs for workforce and economic development. The barriers cited by teachers have causes far beyond P-12 schools and must be addressed on a system-wide basis.

- Lack of teacher preparation at colleges and universities
- Lack of time to learn about new concepts and time to teach new concepts to students
- Shortage of professional development opportunities, both traditional and online
- Insufficient resources to purchase up-to-date equipment and materials
- Absence of lesson plans and learning activities related to new concepts
- Local curricula and textbook adoption processes that discourage innovation
- State standards and assessments that need to be updated
- Accountability systems that do not reward innovation
- Disconnects between education and needs for economic development

The findings of this survey present an opportunity to redesign curricula and the educational delivery system in ways that will bring vitality to both the educational system and the economy. As a result of these efforts, Illinois educators will be better positioned to prepare future scientists, technologists, engineers, and mathematicians to meet the challenges of both the global marketplace and citizenship in the 21st century.

RESEARCH METHODOLOGY

RESEARCH METHODOLOGY

Background and Objectives

The Illinois State Board of Education (ISBE) contracted with Northern Illinois University (NIU) to measure awareness and knowledge among middle and high school teachers of science and mathematics regarding concepts related to five categories of emerging and critical technologies.

- Biosciences
- Environmental and Energy Technologies
- Human Health and Development
- Information Technology and Communications
- Materials Science and Advanced Manufacturing

The objectives of the study were focused on determining the following:

- Awareness levels for each concept
- Familiarity, or lack thereof, with each concept
- Comfort level with integrating the concepts into the classroom
- Current or future plans for teaching these concepts to students
- Interest in learning more
- Barriers to integrating concepts into the classroom
- Profile of teachers by grade level taught and experience

Working from a list of critical technologies developed in Kentucky, the Illinois Mathematics and Science Academy identified the 26 concepts in consultation with researchers, educators, engineers, and business representatives. Between April and December 2005, NIU's Public Opinion Laboratory conducted an online survey of teachers.

Questionnaire Design

NIU Outreach and the Public Opinion Lab worked with ISBE to adapt a similar survey leased from the Kentucky Science and Engineering Foundation. For Illinois purposes, the Public Opinion Lab programmed the survey items for online administration. Participants took an average of 12 minutes to answer the survey items. As an incentive, ISBE offered professional development credits to teachers who filled out a form on completion of the survey. To protect the privacy and confidentiality of survey participants, NIU hosted the survey on a secure server.

RESEARCH METHODOLOGY

Sample Design

Three methods were used to acquire a representative sample of the 16,000 teachers of science and mathematics in Illinois. In the end, the sample consisted of 2881 unique email addresses and 1241 responses. Three methods were used to engage participants.

1) State Superintendent Randy Dunn sent a request to principals in 898 randomly selected schools and middle schools which represented eight geographical areas, various school sizes and income levels for both high schools and middle schools. Follow-up emails and phone calls solicited email addresses for teachers of science and mathematics. This method yielded a 33% response rate from principals, for a total of 625 schools. Unfortunately, between faulty email addresses, aggressive spam filters, and reluctance to participate in yet another survey, the number of actual respondents was not sufficient.

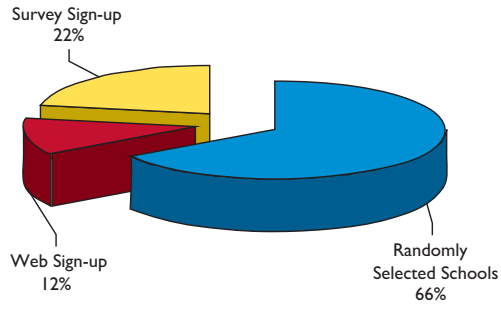
2) Organizations of science and mathematics teachers advertised a sign-up Web address where their members could register for access to the survey. About 85% of teachers who entered their email and county information completed the survey, a total of 290 participants.

3) A sign-up page was added to the end of the Math and Science Professional *Development* Survey that ran from September to December 2005. About 51% of teachers who signed up at this location completed the Critical Technologies Survey, a total of 326.

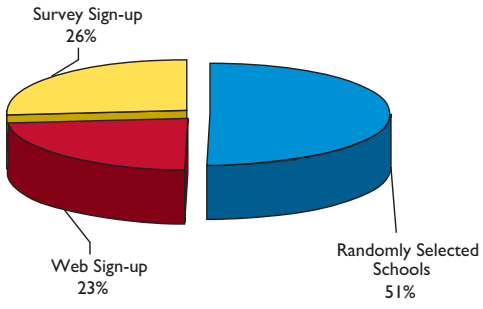
Sample Selection By Method

	Number in Sample	Number Completed	Raw Response Rate
Randomly Selected Schools	1897	625	33%
Web Sign-up	343	290	85%
Survey Sign-up	641	326	51%
TOTAL	2881	1241	43%

Percentage in Sample

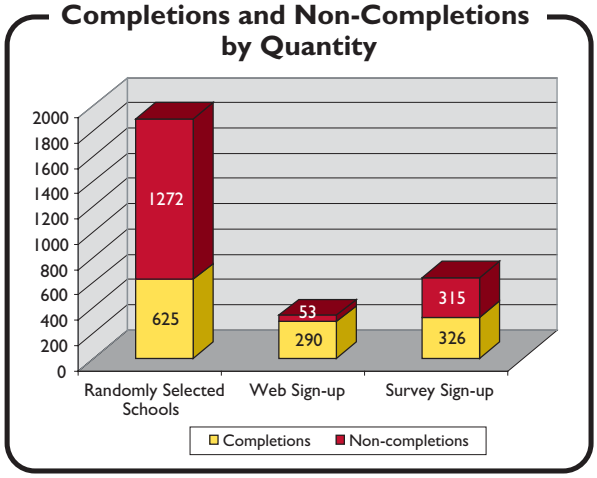


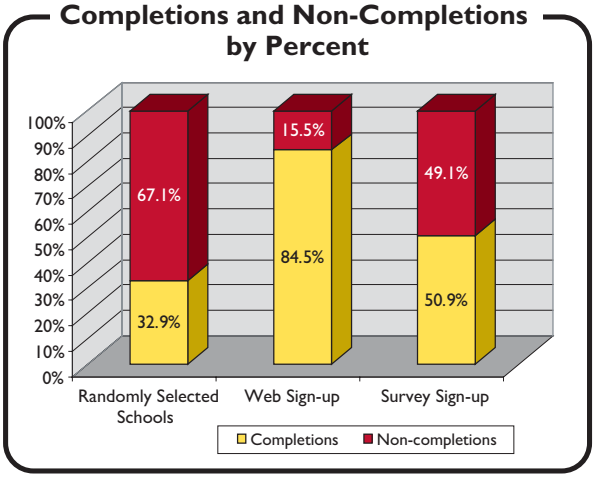
Percentage Completed



RESEARCH METHODOLOGY

To help with recruiting, ISBE, the Illinois Principals Association, regional offices of education, and other groups encouraged teachers to participate, especially in under-represented counties. One initial email and two reminders were sent to each of the email addresses supplied to the Public Opinion Lab. Tracking software ensured that participants could return to an unfinished survey and would receive no further reminders after completion.





The total of 1241 science and mathematics teachers represented all eight areas of the state. Chicago schools are under-represented, especially in high schools. Through random selection in the first sampling method and the distribution by areas representing the state, we believe that both school size and family income levels reflect the state profile.

The respondents' profile reflects state averages for gender, percentages of teachers of science and mathematics, length of service, and geographic distribution.

Percent of Teachers by Area

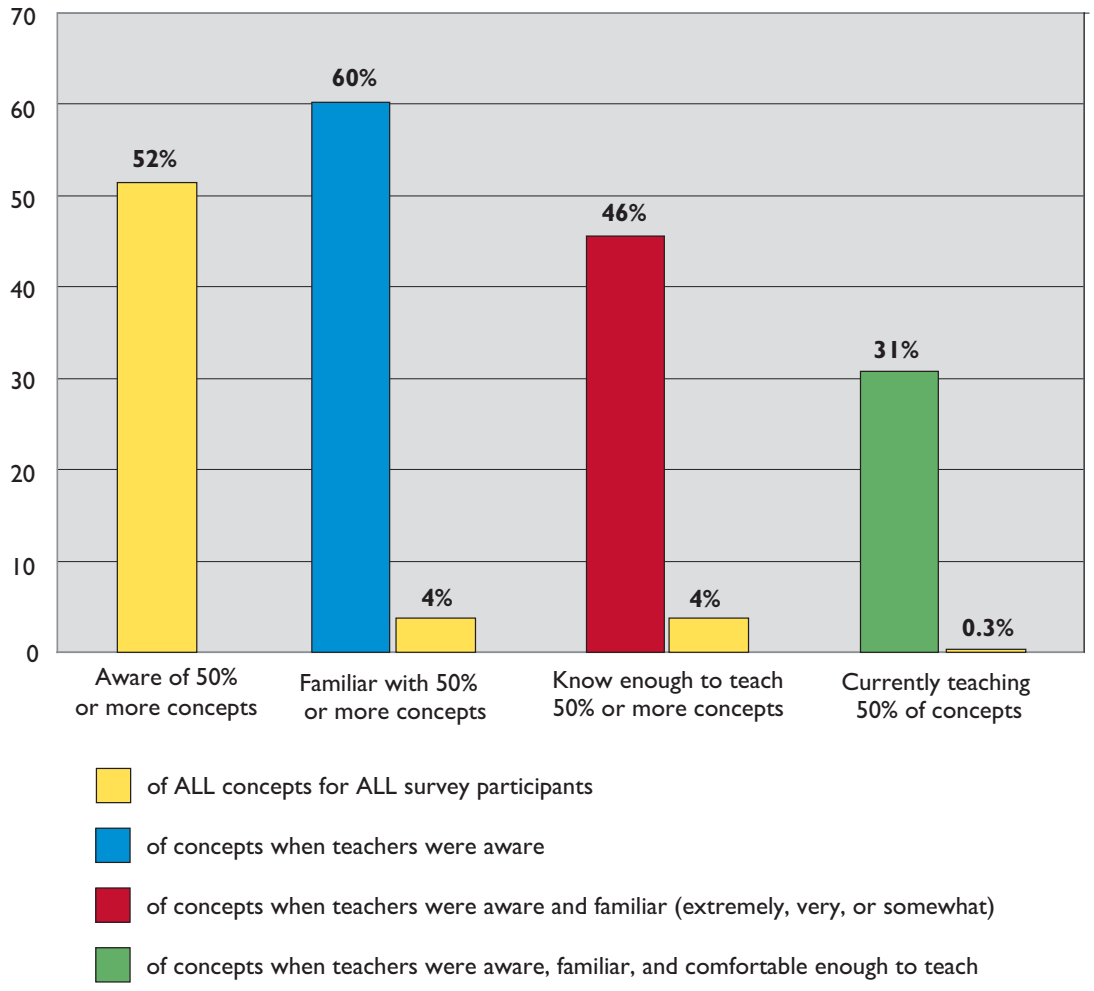
Area I:	Collar Counties	18%
Area II:	North/Northwest	15%
Area III:	West Central	15%
Area IV:	East Central	12%
Area V:	Southwest	12%
Area VI:	Southeast	7%
Area VII:	Cook County	13%
Area VIII:	Chicago	8%

Once the sample was complete, the Public Opinion Lab and NIU Outreach staff analyzed the data and prepared this report.

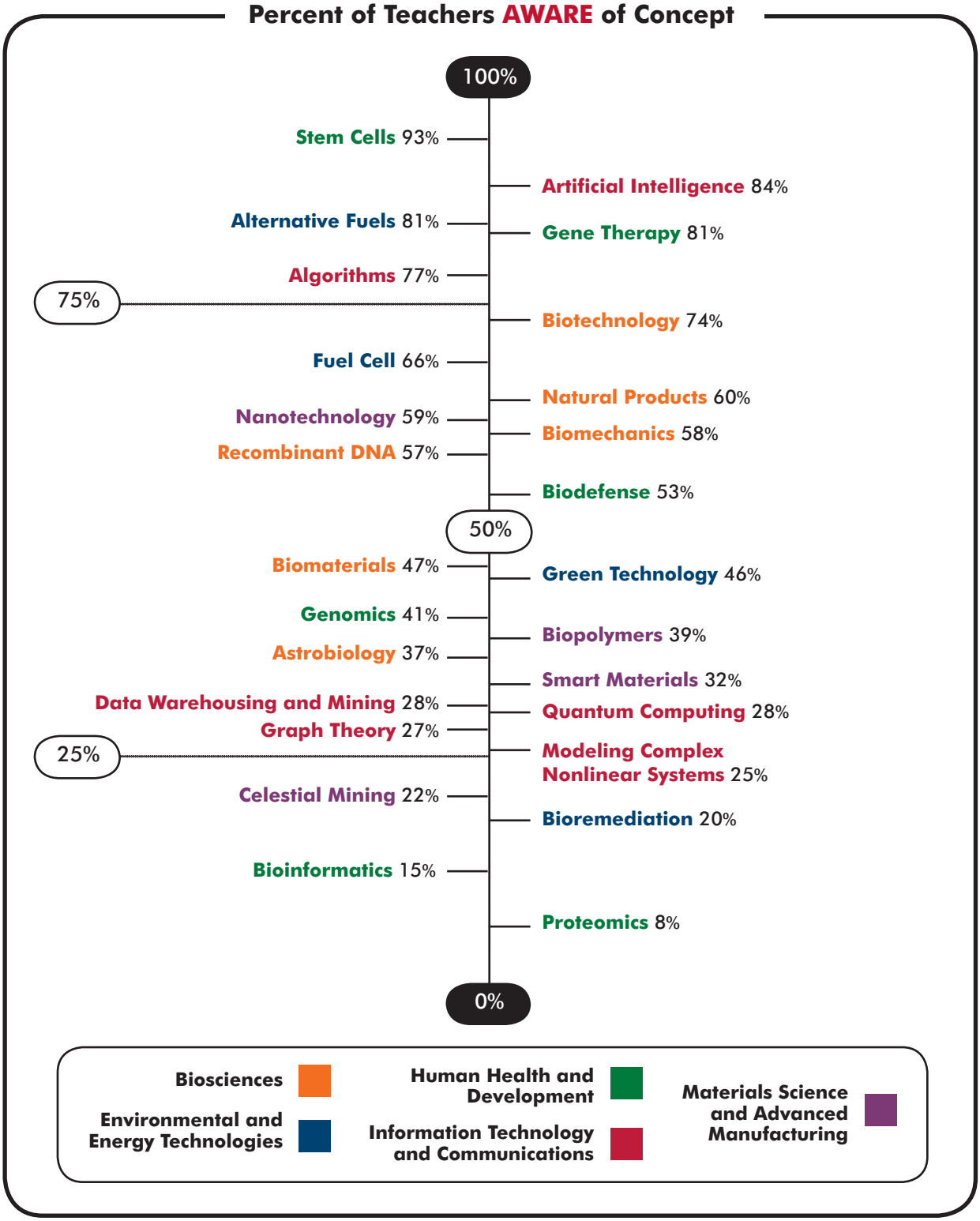
SUMMARY TABLES OF TOTAL RESULTS

SUMMARY TABLES OF TOTAL RESULTS

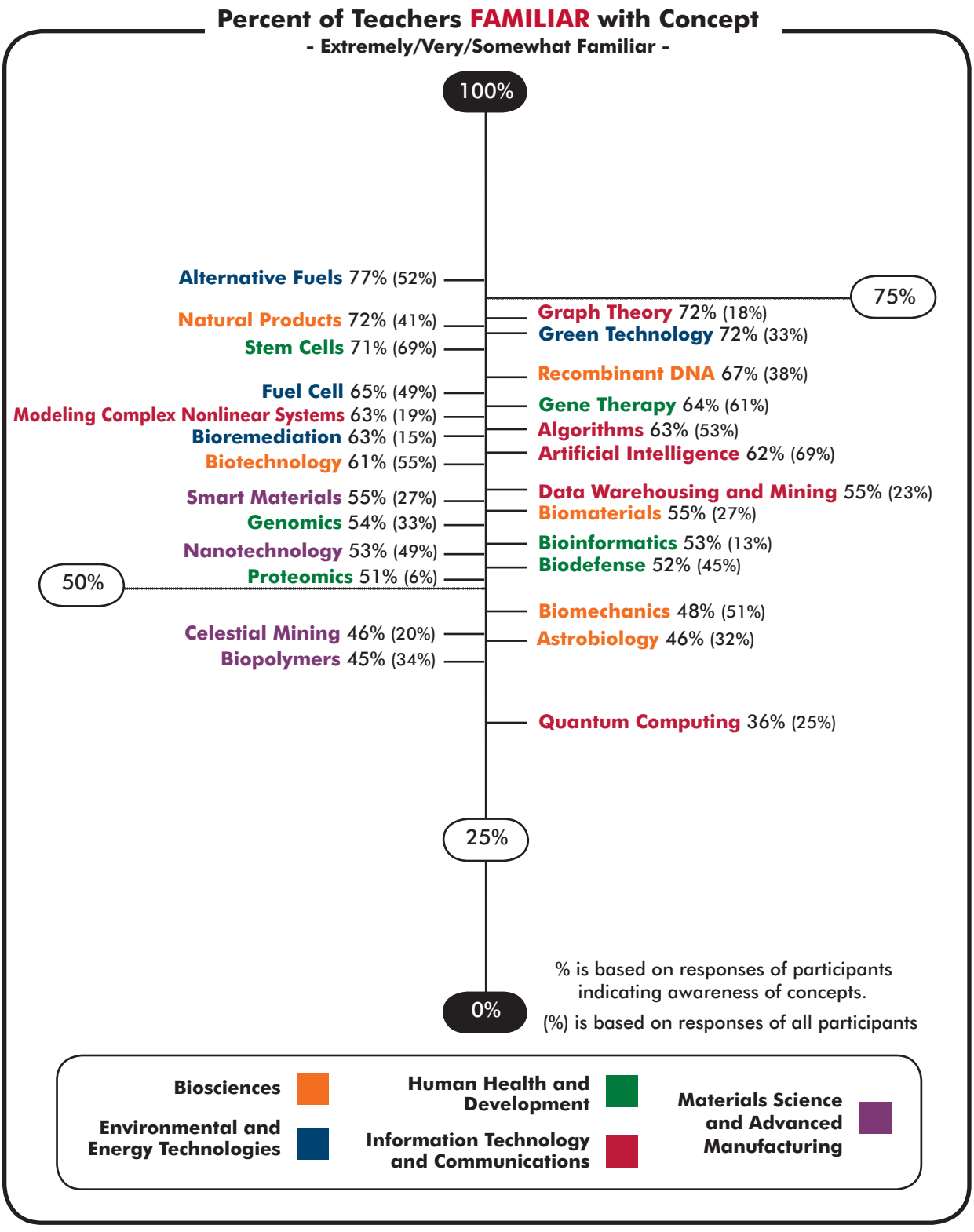
Total Concept Summary (All 26 Concepts)



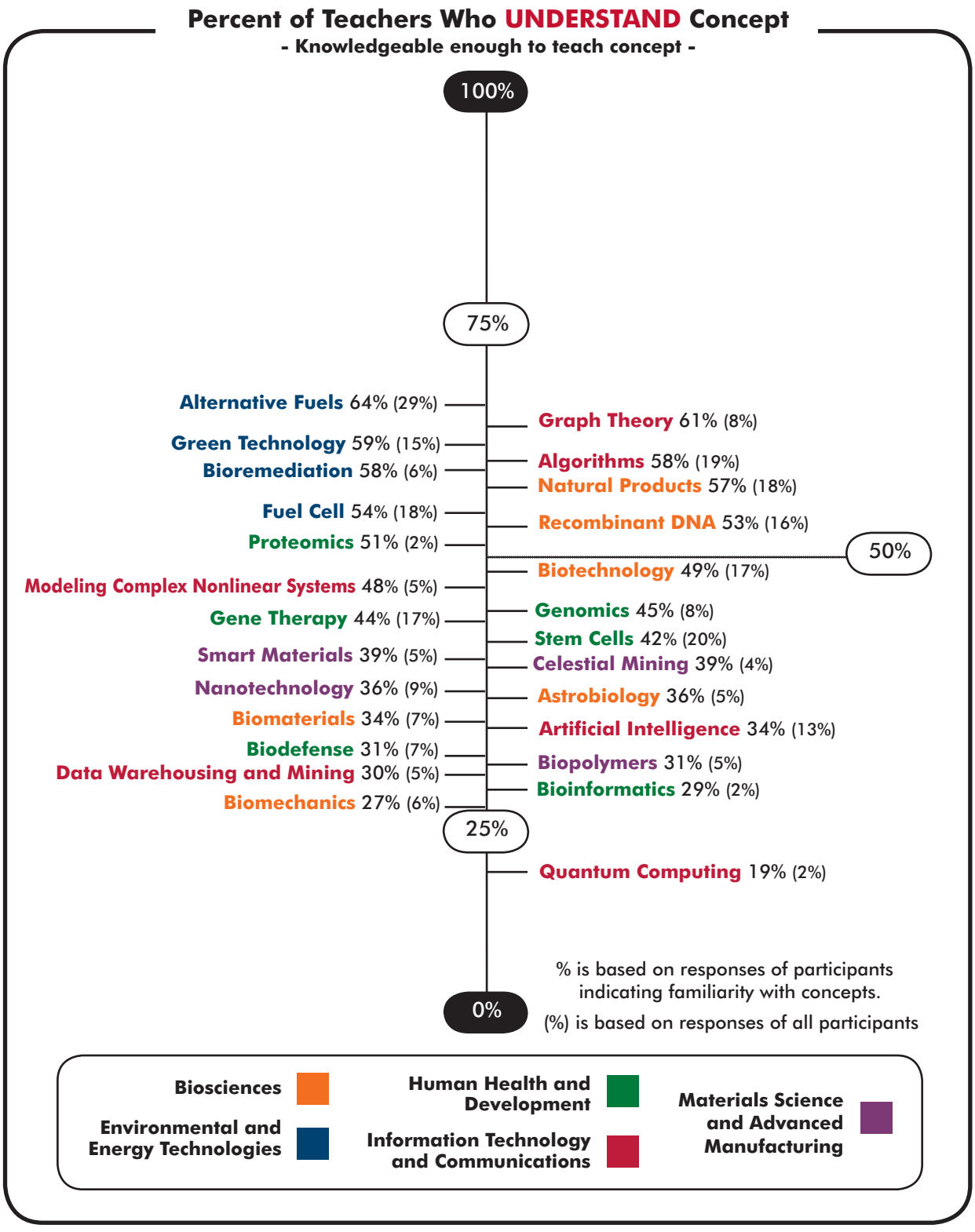
SUMMARY TABLES OF TOTAL RESULTS



SUMMARY TABLES OF TOTAL RESULTS

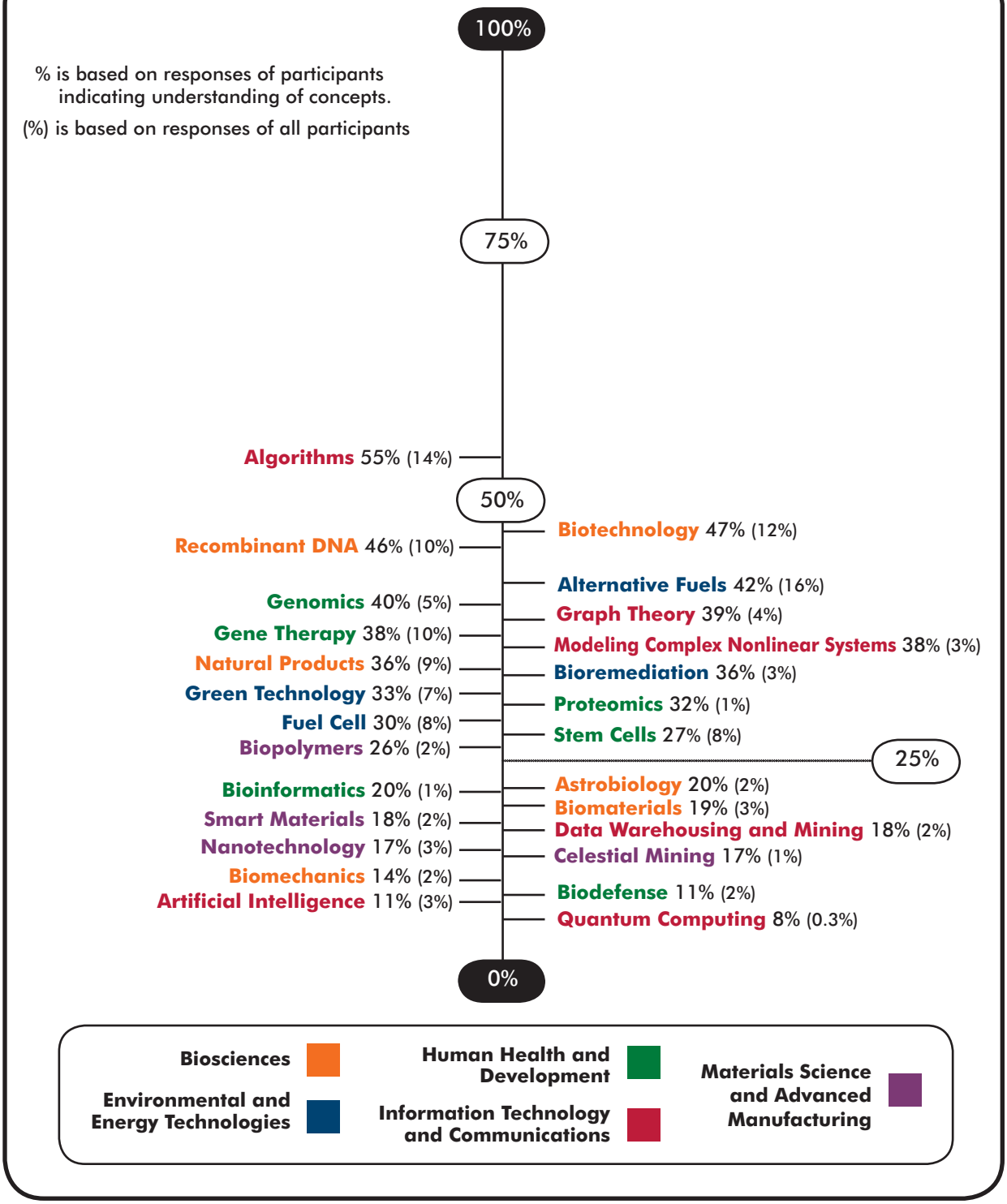


SUMMARY TABLES OF TOTAL RESULTS



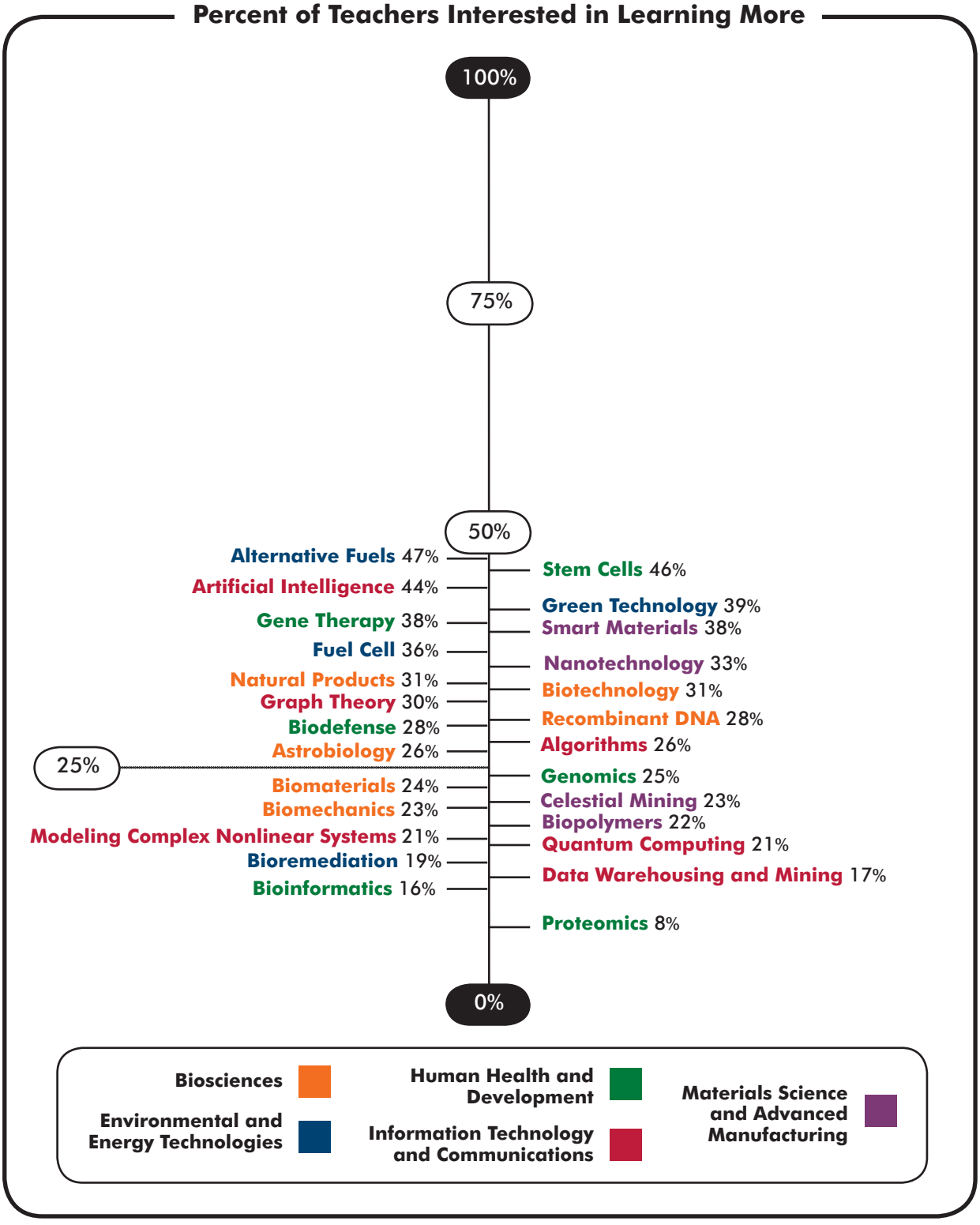
SUMMARY TABLES OF TOTAL RESULTS

Percent of Teachers CURRENTLY TEACHING Concept



SUMMARY TABLES OF TOTAL RESULTS

Percent of Teachers Interested in Learning More



WHAT TEACHERS TOLD US*

About...

Classroom Implementation of Critical Technologies

"This is so vital to the current generation yet we still work with curriculum that isn't technology based."

"The emphasis in elementary/middle schools has to shift to one that values science as a core curriculum. Especially in urban schools, most time/support/financial resources are directed to reading (literacy), math, and more recently technology. However, science does not receive the same level of support. Change is crucial, because students in the 21st century who are not scientifically literate are at a big disadvantage."

"Too many school districts are in the red and cannot afford to purchase the new equipment needed to keep their students ready for the experiences they will encounter in college. It is unfair to expect these students to get ahead and be well prepared for the technological world if they do not get the proper instruction."

"As a science educator in a rural community, I would love to expose my students to the latest technology. Unfortunately, funding is always an issue…."

"The new topics that were asked about are interesting. I would love to add something like that to the curriculum. At the current rate our supply funds are being depleted, we won't have enough supplies to adequately fund our labs and teach the basics. It is very frustrating to have a Masters degree and be able to teach dual credit courses at my high school in accordance with our community college, but I can't offer that option to my students because the college says we don't have enough equipment to offer the courses."

"Please continue to push for having these topics incorporated into the K-12 curriculum."

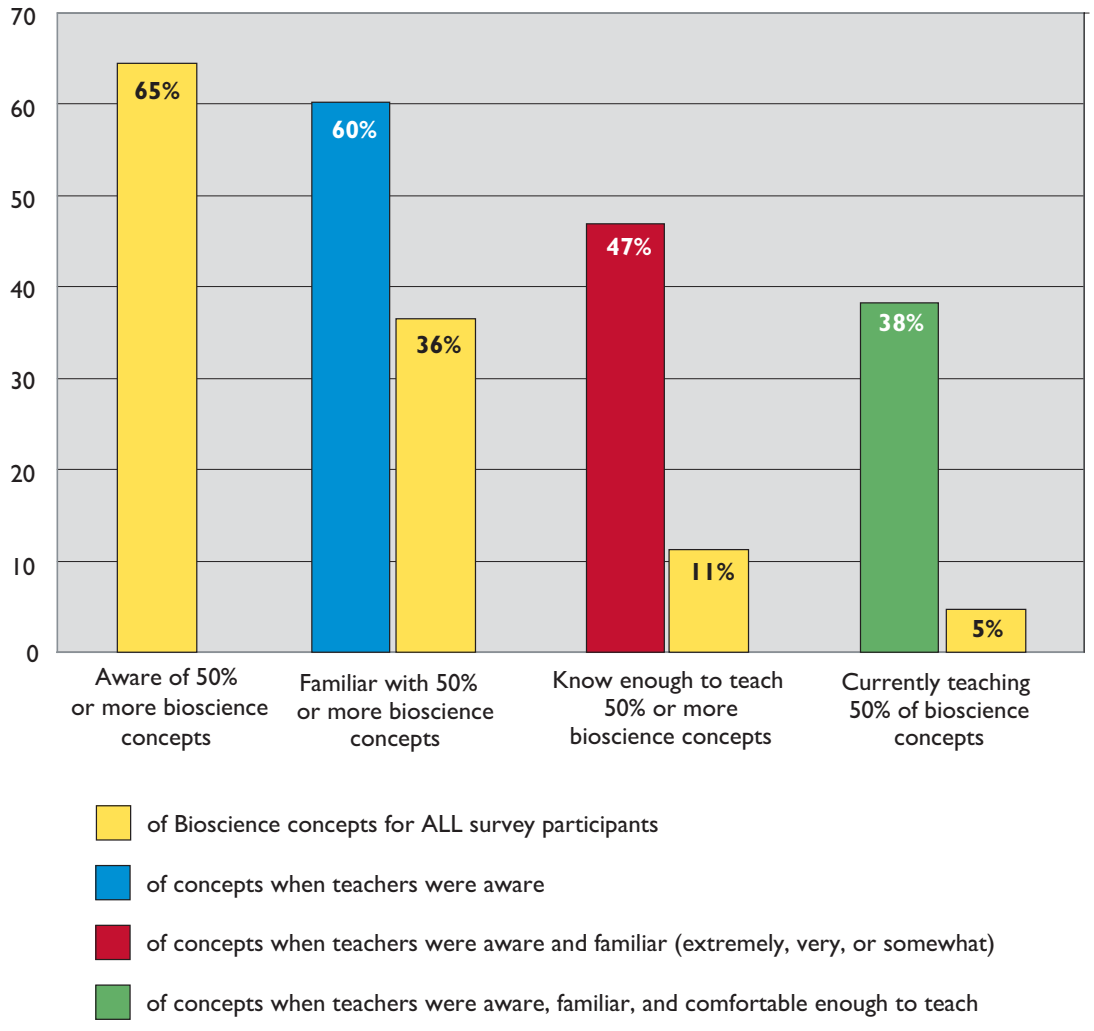
*Selected Quotations from Open-Ended Response Item

SUMMARY TABLES BY CATEGORY

SUMMARY TABLES BY CATEGORY

BIOSCIENCES

Bioscience Concepts Summary



SUMMARY TABLES BY CATEGORY

BIOSCIENCES

Middle School/High School Comparison - Bioscience Concepts

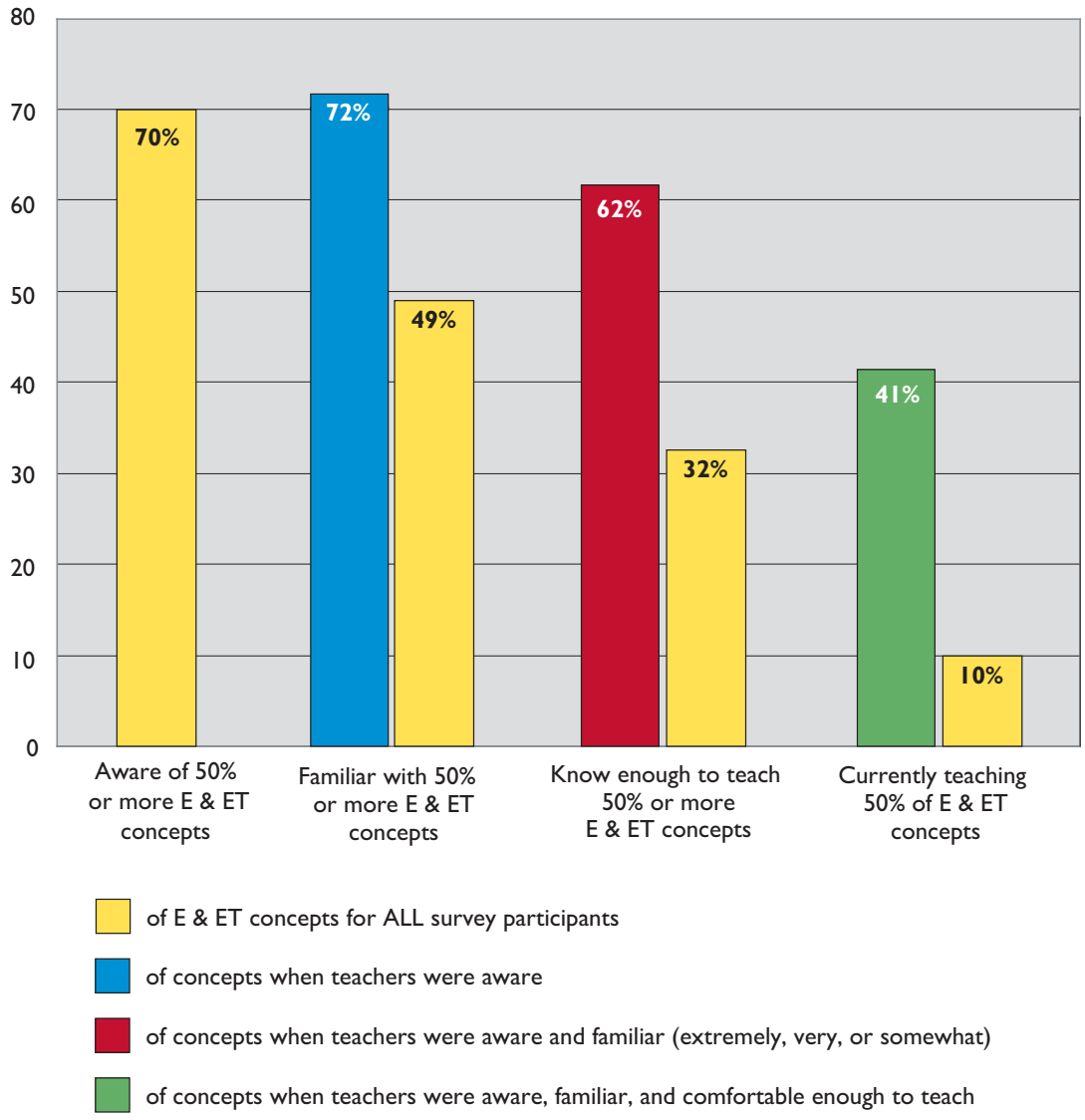
	Awareness		Extremely/very/ Somewhat Familiar		Enough Understanding to Teach		Currently Teaching	
	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)
Astrobiology	36	37	46	43	33	36	**24**	**16**
Biomaterials	**43**	**50**	49	56	30	36	22	17
Biomechanics	**50**	**64**	46	48	20	30	9	17
Biotechnology	**67**	**80**	**53**	**66**	**37**	**53**	**34**	**53**
Natural Products	61	60	74	69	61	55	39	33
Recombinant DNA	**47**	**65**	**56**	**72**	**29**	**64**	37	50

Pairs of columns in **BOLD** are significantly different from each other ($p<.05$)

SUMMARY TABLES BY CATEGORY

ENVIRONMENTAL AND ENERGY TECHNOLOGIES

Environmental and Energy Technology Concepts Summary



SUMMARY TABLES BY CATEGORY

ENVIRONMENTAL AND ENERGY TECHNOLOGIES

Middle School/High School Comparison - Environmental and Energy Technologies Concepts

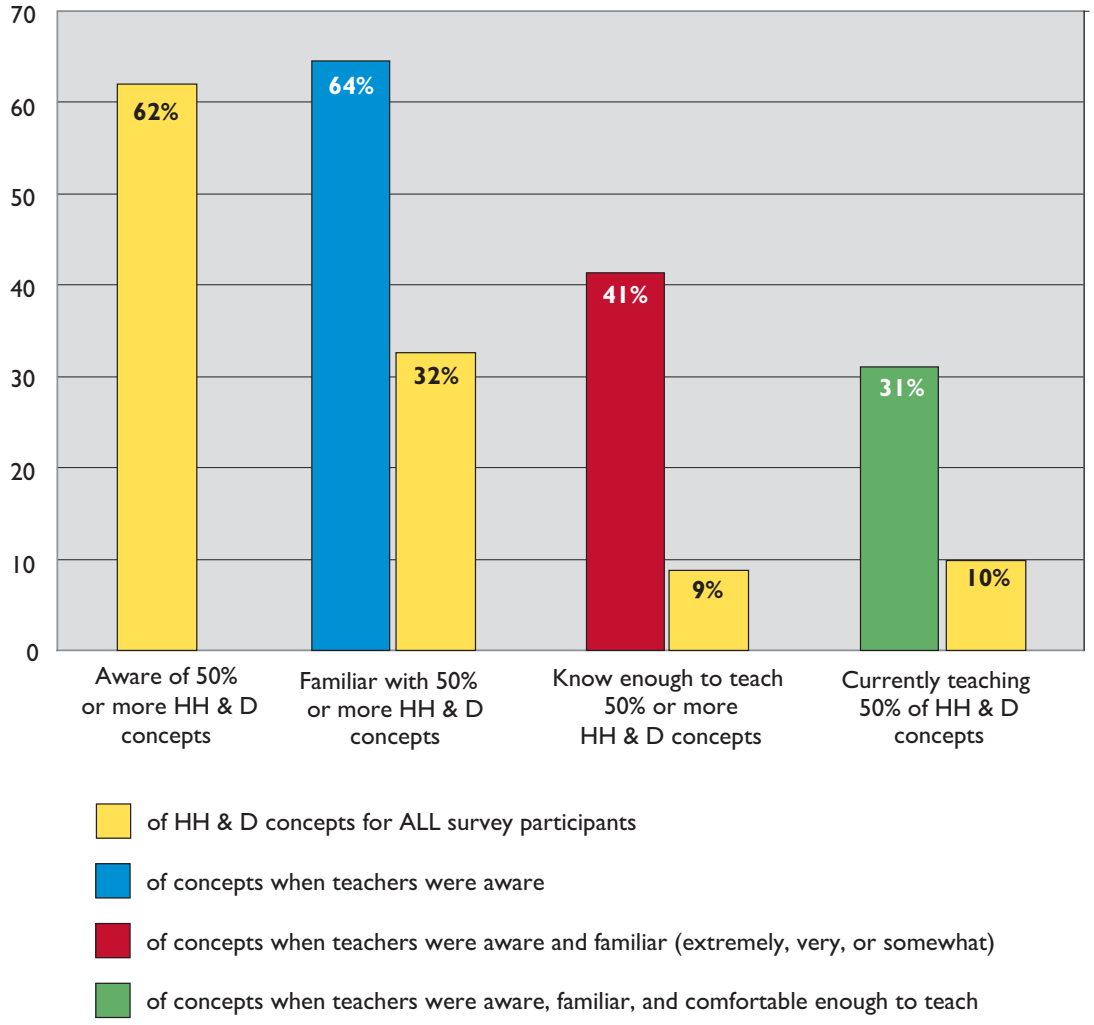
	Awareness		Extremely/very/ Somewhat Familiar		Enough Understanding to Teach		Currently Teaching	
	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)
Alternative Fuels	**77**	**85**	78	76	63	65	43	41
Bioremediation	**16**	**24**	57	66	**55**	**61**	45	35
Fuel Cell	**59**	**72**	62	67	47	56	29	29
Green Technology	**39**	**52**	74	70	61	56	38	29

Pairs of columns in **BOLD** are significantly different from each other ($p<.05$)

SUMMARY TABLES BY CATEGORY

HUMAN HEALTH AND DEVELOPMENT

Human Health and Development Concepts Summary



SUMMARY TABLES BY CATEGORY

HUMAN HEALTH AND DEVELOPMENT

Middle School/High School Comparison - Human Health and Development Concepts

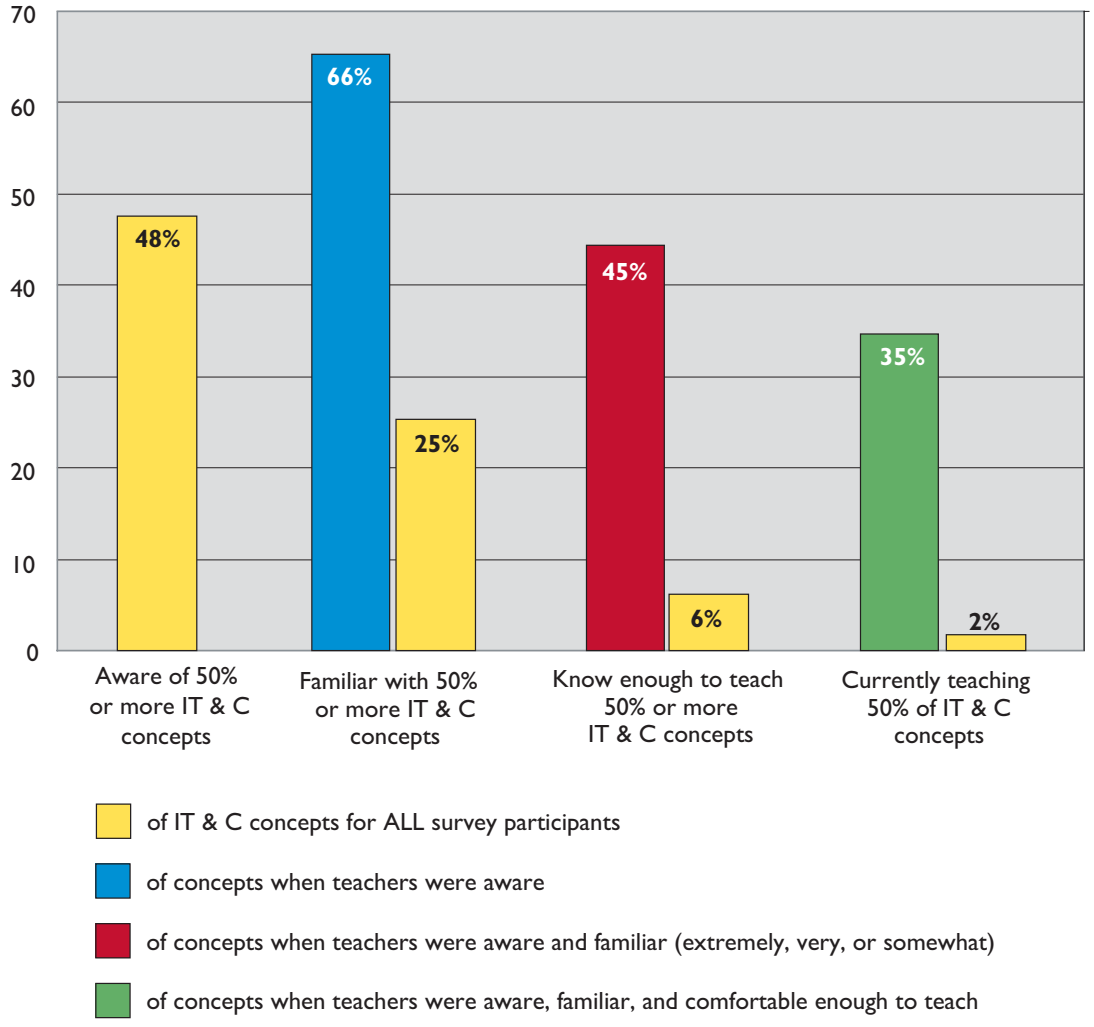
	Awareness		Extremely/very/ Somewhat Familiar		Enough Understanding to Teach		Currently Teaching	
	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)
Biodefense	**49**	**57**	49	53	**24**	**36**	13	12
Bioinformatics	**7**	**20**	46	56	13	32	0	24
Gene Therapy	81	82	**60**	**67**	**33**	**51**	**32**	**42**
Genomics	**35**	**45**	**47**	**58**	**25**	**55**	**29**	**46**
Proteomics	**6**	**9**	41	53	**0**	**69**	0	36
Stem Cells	93	94	68	73	**34**	**47**	21	32

Pairs of columns in **BOLD** are significantly different from each other ($p<.05$)

SUMMARY TABLES BY CATEGORY

INFORMATION TECHNOLOGY AND COMMUNICATIONS

Information Technology and Communications Concepts Summary



SUMMARY TABLES BY CATEGORY

INFORMATION TECHNOLOGY AND COMMUNICATIONS

Middle School/High School Comparison - Information Technology and Communications Concepts

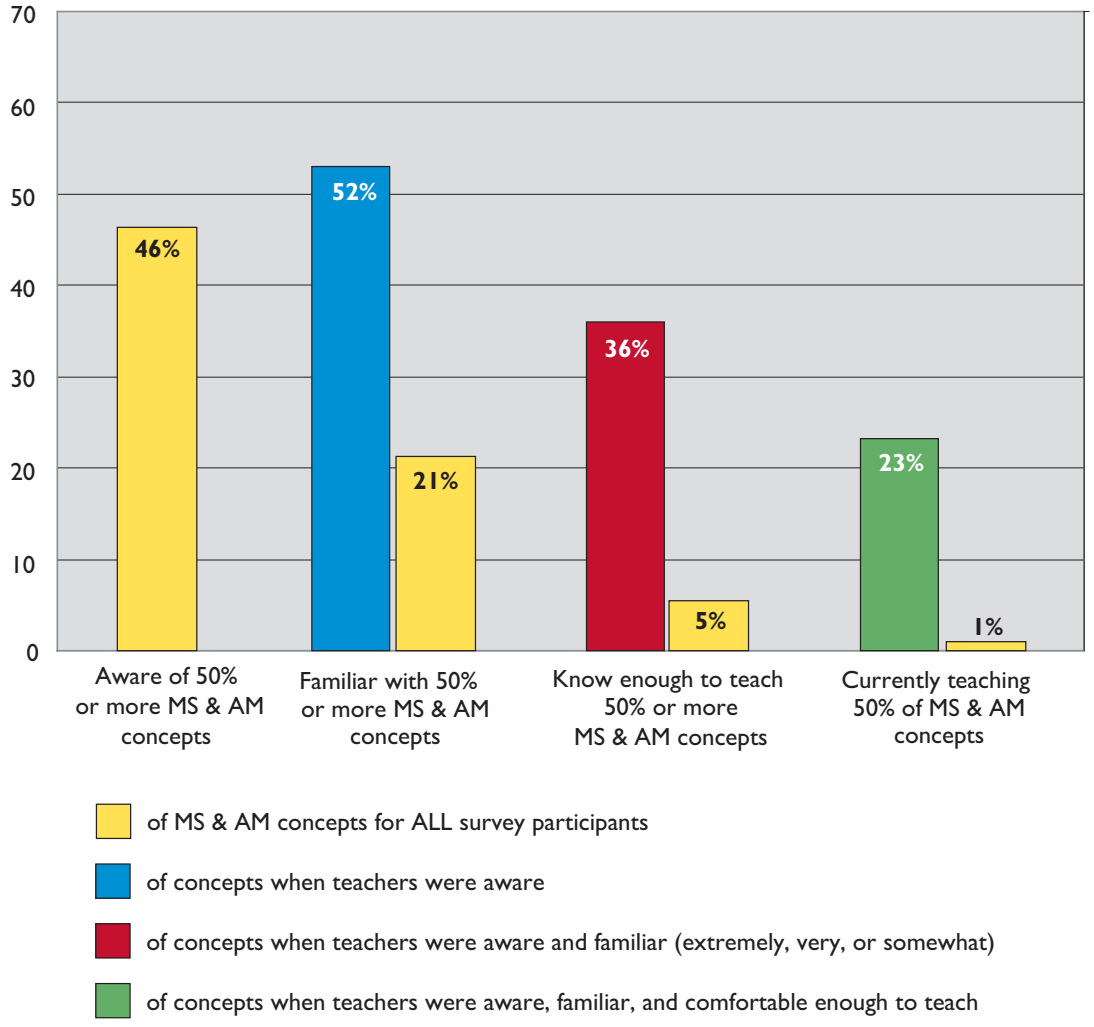
	Awareness		Extremely/very/ Somewhat Familiar		Enough Understanding to Teach		Currently Teaching	
	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)
Artificial Intelligence	**79**	**88**	61	63	**33**	**33**	12	10
Algorithms	80	76	61	64	**54**	**59**	**66**	**49**
Data Warehousing & Mining	**22**	**32**	50	58	**23**	**33**	15	17
Graph Theory	**18**	**34**	65	73	**42**	**66**	42	39
Modeling Complex Nonlinear Systems	**16**	**32**	**49**	**68**	**23**	**54**	33	33
Quantum Computing	**23**	**30**	29	73	**4**	**21**	0	13

Pairs of columns in **BOLD** are significantly different from each other ($p<.05$)

SUMMARY TABLES BY CATEGORY

MATERIALS SCIENCE AND ADVANCED MANUFACTURING

Materials Science and Advanced Manufacturing Concepts Summary



SUMMARY TABLES BY CATEGORY

MATERIALS SCIENCE AND ADVANCED MANUFACTURING

Middle School/High School Comparison - Materials Science and Advanced Manufacturing Concepts

	Awareness		Extremely/very/ Somewhat Familiar		Enough Understanding to Teach		Currently Teaching	
	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)	Middle School (%)	High School (%)
Biopolymers	**34**	**43**	39	48	**24**	**35**	24	26
Celestial Mining	20	24	41	48	42	39	24	13
Nanotechnology	**44**	**70**	**43**	**57**	**32**	**37**	21	17
Smart Materials	**27**	**34**	**44**	**60**	40	39	9	21

Pairs of columns in **BOLD** are significantly different from each other ($p<.05$)

WHAT TEACHERS TOLD US*

About...

Identifying the "New Basics"

"When new topics need to be added to a curriculum, (and that SHOULD happen), one cannot simply add to the topic list already taught. Our days are filled! If new topics are chosen to be introduced, then it is of equal importance that some of the currently taught topics are removed to make room!"

"If there is a way to improve Science Education, most teachers would be more than willing to take part. But considering we have only a 2-year science requirement in high school, according to latest reports, there is no way all that needs to be learned can be learned by an average student. Since students should be educated in Biology, Chemistry, Earth Sciences and Astronomy, how can you expect 2 years to suffice in high school? We are not even considering the integrating of science with math."

"I would like to see more incorporation of vocational training classes to increase our students' ability to solve problems and apply math and science in real-world-of-work situations. The improvement in their overall skills will better prepare them for the world of work after high school and better prepare them for college and the advanced training that everyone will eventually need."

"We need a discussion of what can be or should be taught at the primary grade and middle grade levels to better prepare students for high school and college."

"Take a stand on including geology and environmental science in high school curriculums as a valid science for acceptance into state universities as are chemistry, physics, and biology!"

*Selected Quotations from Open-Ended Response Item

BARRIERS TO TEACHING CRITICAL TECHNOLOGIES

BARRIERS TO TEACHING CRITICAL TECHNOLOGIES

Grade Appropriate - Not Enough Time in the Curriculum

Alternative Fuels	30%
Natural Products	30%
Algorithms	30%
Green Technology	30%
Artificial Intelligence	29%

Grade Appropriate - Not Taught for Other Reasons

Proteomics	30%
Bioinformatics	26%
Bioremediation (tie)	26%
Recombinant DNA (tie)	26%
Algorithms (tie)	25%
Genomics (tie)	25%
Data Warehousing and Mining (tie)	25%

Grade Appropriate - Teacher Preparation Lacking

Graph Theory	28%
Nanotechnology	27%
Quantum Computing	26%
Modeling Complex Nonlinear Systems	26%
Smart Materials	26%

Grade Appropriate - Not in Textbooks

Celestial Mining	19%
Biodefense	19%
Bioinformatics	18%
Green Technology	18%
Biomaterials	17%

Grade Appropriate - Lack of Equipment or Materials

Biotechnology	16%
Fuel Cell	15%
Recombinant DNA	15%
Alternative Fuels	14%
Nanotechnology (tie)	12%
Gene Therapy (tie)	12%

WHAT TEACHERS TOLD US*

About...

Barriers to Classroom Implementation and Teacher Training

"Time is the critical ingredient. With state testing requirements and curriculum requirements, it is hard to squeeze in more than we already cover. Time to get more information for the teachers is just as precious."

"My background is in medical technology with a specialty in hematology. I now teach at the local high school and have been assigned mostly physics and some chemistry classes. I teach a life science, biology, once in a while."

"I am retiring at the end of this school year. But if I were teaching next year, I would love to learn more about several of the topics listed. Even if we get the information and grasp the concepts enough to incorporate the topic into the curriculum, finding a place that doesn't exclude other important topics may prove difficult!"

"I feel that my school does not have enough technology that I can use with my classes. With only three labs in the building, I sometimes wait over a month to get a lab to work on something interesting for my class. This discourages use of good websites and technology."

"As a math teacher, I would not only like basic information on some of these topics, but would also like to have information on the related math needed to perform in these areas and how it relates to what students learn in Algebra. We also use older math books, and these new technologies are not included."

"Our textbooks are out of date and more educational opportunities for science teachers to learn up-to-date activities that can be applied in the classroom would be very beneficial."

*Selected Quotations from Open-Ended Response Item

WHAT TEACHERS TOLD US*

About...

Barriers to Classroom Implementation and Teacher Training

"Since science is ever changing, educators must be informed of the advancements so that they can better prepare their students for the future. This can be achieved through a variety of means but seminars with small groups of science teachers and the experts in the field would be greatly beneficial."

"Everyone promotes and encourages hands-on work/experiments within the classroom; however, the materials needed for these activities are seldom available. There is a serious lack of financial support to promote the hands on activities that all students need."

"Legislative mandates make it difficult to find time to enrich our student's education with topics that are more relevant to their futures like the ones listed in this survey."

"My school does not have the equipment nor do I have the training to include the concepts listed in this survey. Perhaps I could learn how to incorporate these concepts using inquiry-based learning. That will require time, money, and equipment."

"In the question regarding why I don't currently teach these, I checked "Other," because the critical technologies are not part of the Illinois Learning Standards."

"Involving all subject areas in a cross-curricular approach would help students see and understand the rapid changes they are facing. That will be very tough because of department turf issues, existing curriculum, and state tests. If there are any rewards for trying this, they must be in a parallel universe."

*Selected Quotations from Open-Ended Response Item

TEACHERS' PREFERENCES FOR LEARNING

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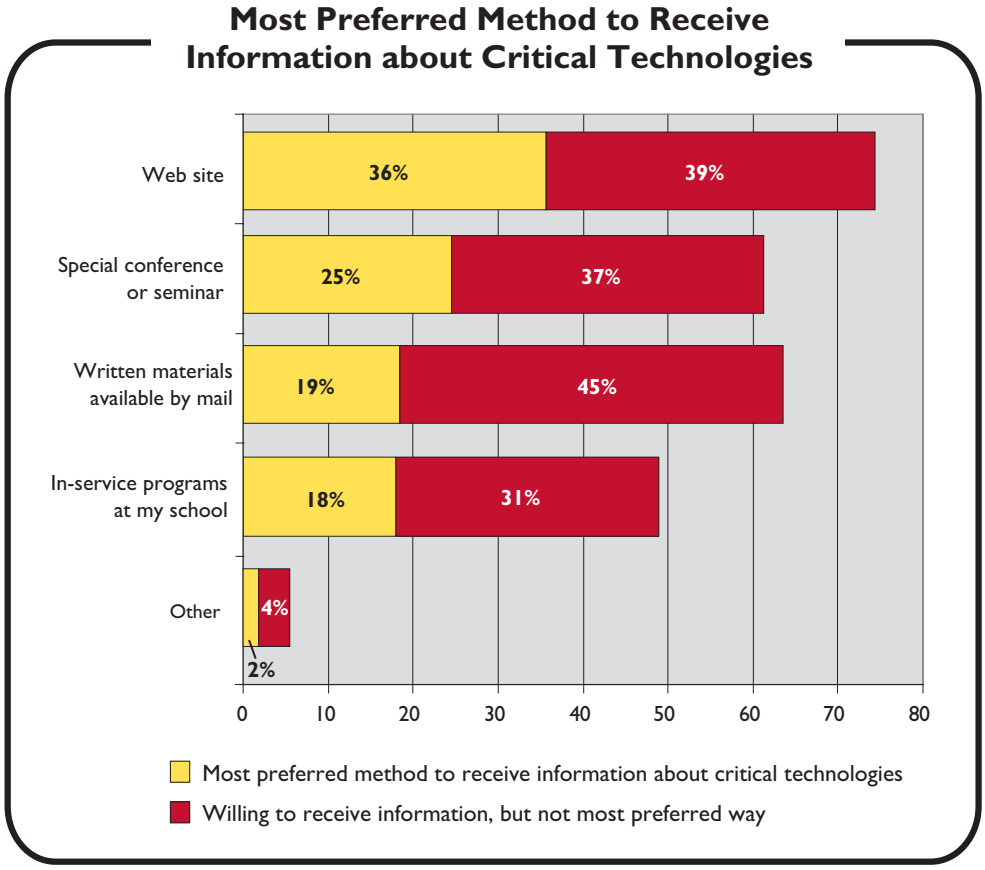
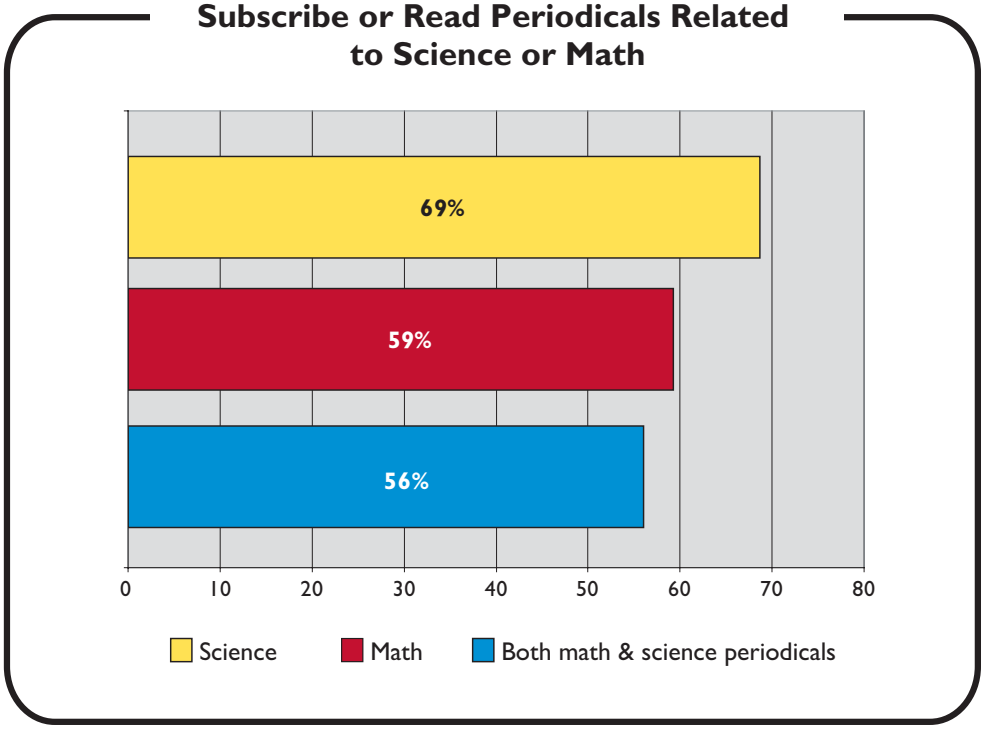
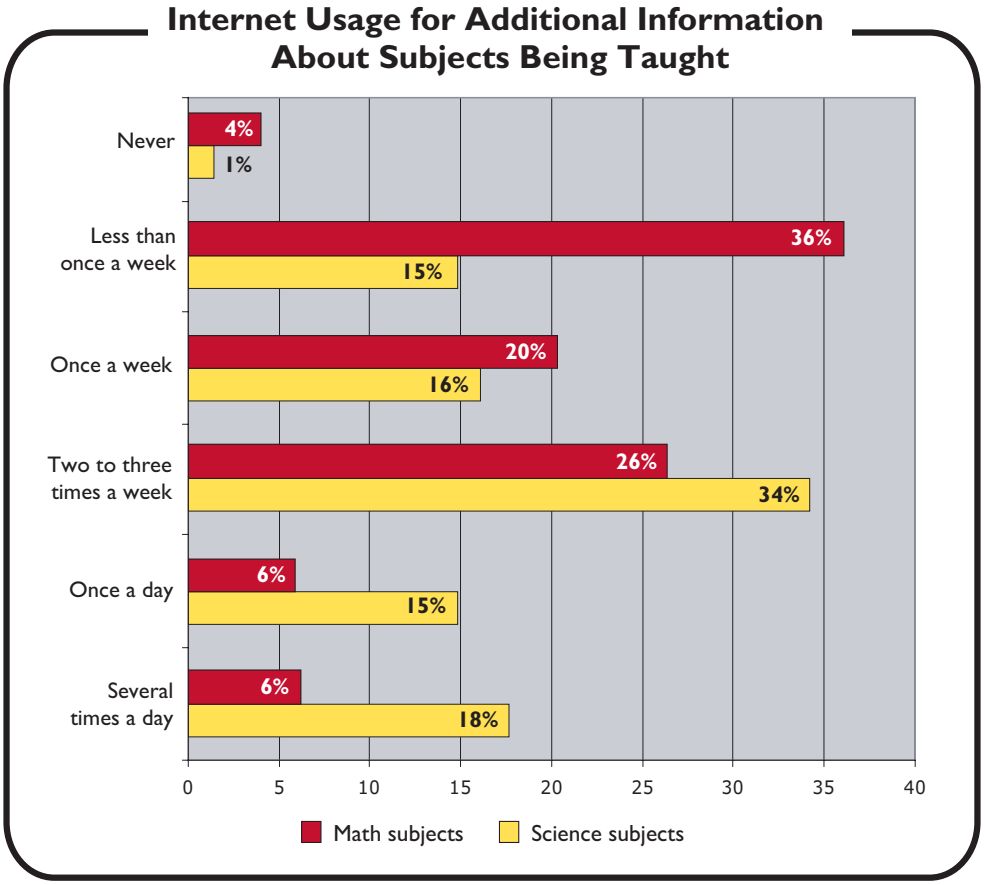


TEACHERS' PREFERENCES FOR LEARNING



TEACHERS' PREFERENCES FOR LEARNING



PROFILE OF RESPONDENTS

PROFILE OF RESPONDENTS

Respondent Gender

	Survey	State
Male	35%	41%
Female	65%	59%

Type of School

	Survey	State*
High School	54%	67%
Middle School	41%	33%
Both	5%	

* State numbers reflect percentage based on number of schools

Length of Time Teaching

	Survey	State
1 thru 5	26%	32%
6 thru 10	19%	20%
11 thru 15	17%	15%
16 thru 20	11%	10%
21 thru 25	9%	7%
26 thru 30	10%	8%
31 thru 35	8%	7%
Over 35 yrs	2%	2%

Average Students Per Class Per Day

Minimum	17
Maximum	27

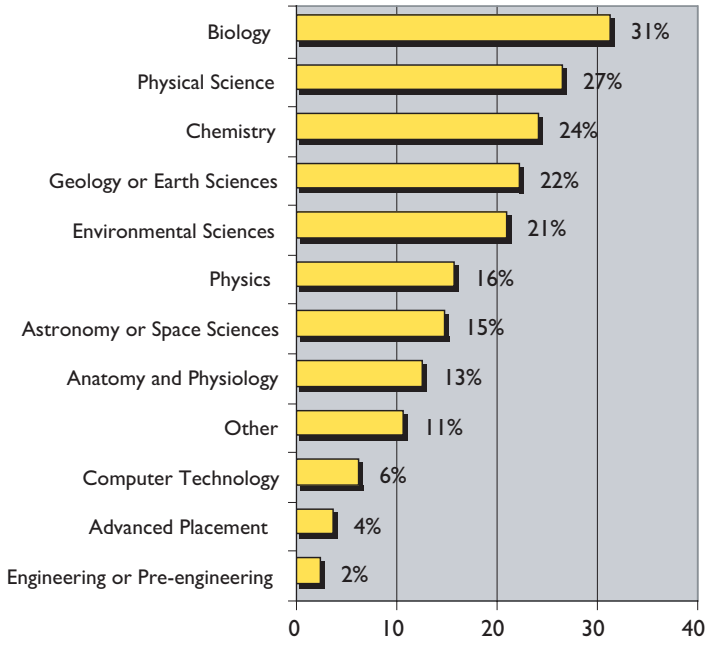
Grade(s) Taught*

Sixth	23%
Seventh	21%
Eighth	23%
Ninth	40%
Tenth	45%
Eleventh	47%
Twelfth	44%

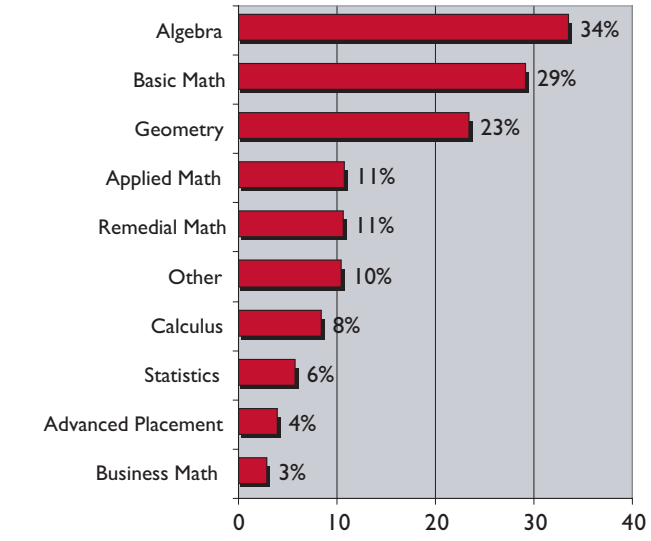
* Teachers were allowed to indicate more than one grade. These percentages indicate that many teachers teach multiple grades.

PROFILE OF RESPONDENTS

Science Subjects Taught

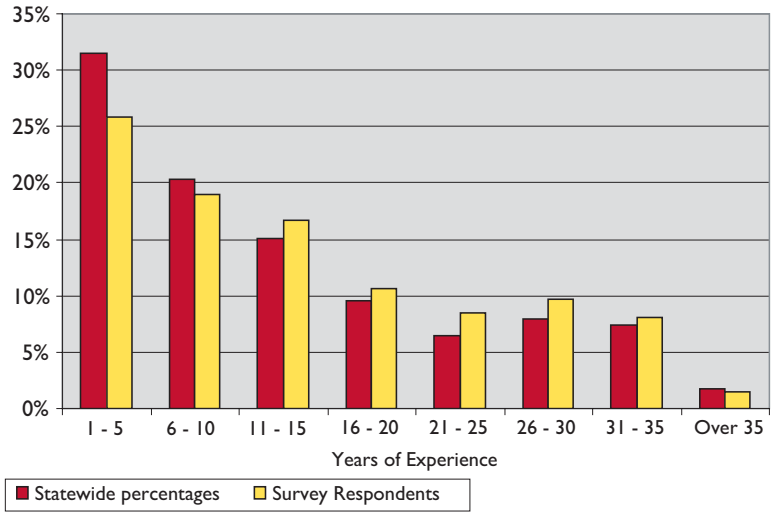


Math Subjects Taught



PROFILE OF RESPONDENTS

Math and Science Teachers By Years of Experience



Percentage of Survey Respondents By Years of Experience and Subject Area

	Math	Science	Both	Total
First year	2%	2%	.6%	5%
1 thru 5	8%	9%	4%	21%
6 thru 10	7%	9%	3%	19%
11 thru 15	6%	7%	4%	17%
16 thru 20	3%	5%	3%	11%
21 thru 25	3%	3%	3%	9%
26 thru 30	4%	4%	2%	10%
31 thru 35	3%	3%	2%	8%
Over 35 yrs	.7%	.7%	.1%	2%
Total	37%	42%	22%	100%

PROFILE OF RESPONDENTS

Profile of Survey Respondents By Subject Area and Level Taught

Subject	*Middle School*	*High School*	*Both JR & HS*
Anatomy and Physiology	16%	10%	13%
Astronomy or Space Sciences	27%	5%	11%
Biology	38%	26%	33%
Chemistry	28%	22%	21%
Computer Technology	9%	3%	16%
Engineering or Pre-engineering	2%	3%	3%
Environmental Sciences	33%	11%	25%
Geology or Earth Sciences	39%	9%	18%
Physical Science	42%	15%	25%
Physics	14%	17%	18%
Advanced Placement	1%	7%	0%
Other Science	7%	12%	24%
Algebra	35.6	35%	41%
Applied Mathematics	12.2	8%	19%
Basic Mathematics	54.1	9%	30%
Business Mathematics	0.6	4%	11%
Calculus (including pre-calculus)	0.0	15%	11%
Geometry	21.3	24%	27%
Remedial Mathematics	15.0	6%	16%
Statistics	4.3	7%	8%
Advanced Placement	0.4	6%	10%
Other Mathematics	6.5	13%	14%

WHAT TEACHERS TOLD US*

About...

Preferences for Learning New Content and Teaching Skills

"The most valuable professional development experience of my career was the Museum in the Classroom project. It networked us with professional scientists in the field both physically and through Internet connections."

"Argonne Labs, Museum of Science and Industry, and Brookfield Zoo have wonderful on-site training, great websites, and immediately useable curriculum packets."

"Yerkes Observatory and the Sofia Project teach teachers about astronomy and high powered telescopes. This has had a powerful affect on my teaching."

"The multicast capabilities such as Access Grid (Argonne) support real-time audio and video communications between students, teachers, and experts around the world."

"We need conferences and seminars about technologies and information available for integrated science to keep on the vanguard of the science curriculum."

"Interaction with experts from other fields at conferences and seminars are the most valuable for me. Thanks for asking about our future."

Teachers recommended state support for these opportunities to learn more:

- *One annual subscription to a professional magazine for every interested teacher*
- *Funding for undergraduate and graduate courses in advanced topics and teaching*
- *Evening, weekend, and summer seminars (1-2 days) that combine content knowledge and teaching packets*
- *An Eisenhower National Clearinghouse subscription for every school*
- *Internet or DVD/Video or CD-ROM for bimonthly or quarterly training*
- *E-mail newsletters with content information, labs, activities, and sample problems.*
- *Recommendations for websites like NSTA and ISTA that provide excellent teaching materials and help you narrow your searches.*
- *A training system built on the agricultural education model.*

*Selected Quotations from Open-Ended Response Item

APPENDIX A: SURVEY QUESTIONNAIRE

Administered for the Illinois State Board of Education by

The Public Opinion Lab at Northern Illinois University, DeKalb, IL

The Illinois State Board of Education (ISBE) appreciates your participation in this survey. The results will help serve as a guide for shaping educational planning in Illinois for the years to come. This survey, which takes about 12 minutes to complete, is designed to help us learn about teacher familiarity, or lack thereof, with some of the new developments in math, science, and technology.

We are including a list and definitions of the technologies that are of particular interest (e.g., nanotechnology) and ask general questions about your awareness of these concepts and ideas. There are no questions about the nature of the technologies, so please don't be concerned if, for example, you have heard of nanotechnology but don't really know much about it.

The survey, which is being conducted for ISBE by Northern Illinois University, also includes questions that will help us understand the extent to which these concepts and ideas are being taught in Illinois schools, whether you think these new fields of knowledge should be taught at your level, and, if so, what it would take to provide professional development for teachers that would help them introduce emerging technologies into the curriculum.

Although we ask for the county where your school is located, the survey is confidential. We know you are very busy at this time of year, but this should be virtually painless – and it would be of significant value to the State Board of Education and others in planning for the future.

Your responses to this questionnaire will not be shared with anyone but the independent researchers who are conducting the survey on behalf of ISBE. After analyzing the information received from all survey respondents, those researchers will provide ISBE only with a summary of that information, not with the individual responses received.

APPENDIX A: SURVEY QUESTIONNAIRE

Q1 Listed below are several statements and concepts that relate to some critical technologies in science and mathematics. The areas include biosciences, environmental and energy technologies, information technologies and communications, human health and development, and materials science and advanced manufacturing.

Please read through the list below and check any of which you have heard.

Randomize list of technologies for each respondent

- ○ Astrobiology
- ○ Biomaterials
- ○ Biomechanics
- ○ Biotechnology
- ○ Natural Products
- ○ Recombinant DNA
- ○ Alternative Fuels
- ○ Bioremediation
- ○ Fuel Cell
- ○ Green Technology
- ○ Biodefense
- ○ Bioinformatics
- ○ Gene Therapy
- ○ Genomics
- ○ Proteomics
- ○ Stem Cells
- ○ Artificial Intelligence
- ○ Algorithms
- ○ Data Warehousing and Mining
- ○ Graph Theory
- ○ Modeling Complex Nonlinear Systems
- ○ Quantum Computing
- ○ Biopolymers
- ○ Celestial Mining
- ○ Nanotechnology
- ○ Smart Materials

APPENDIX A: SURVEY QUESTIONNAIRE

Ask Q2 for all concepts marked 'Aware' at Q1: Randomized

Q2 Please indicate how familiar you are with the scientific or mathematical principles surrounding critical technology.

	Extremely Familiar	Very Familiar	Somewhat Familiar	Not Very Familiar	Not At All Familiar
Astrobiology	○	○	○	○	○
Biomaterials	○	○	○	○	○
Biomechanics	○	○	○	○	○
Biotechnology	○	○	○	○	○
Natural Products	○	○	○	○	○
Recombinant DNA	○	○	○	○	○
Alternative Fuels	○	○	○	○	○
Bioremediation	○	○	○	○	○
Fuel Cell	○	○	○	○	○
Green Technology	○	○	○	○	○
Biodefense	○	○	○	○	○
Bioinformatics	○	○	○	○	○
Gene Therapy	○	○	○	○	○
Genomics	○	○	○	○	○
Proteomics	○	○	○	○	○
Stem Cells	○	○	○	○	○
Artificial Intelligence	○	○	○	○	○
Algorithms	○	○	○	○	○
Data Warehousing and Mining	○	○	○	○	○
Graph Theory	○	○	○	○	○
Modeling Complex Nonlinear Systems	○	○	○	○	○
Quantum Computing	○	○	○	○	○
Biopolymers	○	○	○	○	○
Celestial Mining	○	○	○	○	○
Nanotechnology	○	○	○	○	○
Smart Materials	○	○	○	○	○

APPENDIX A: SURVEY QUESTIONNAIRE

Ask Q3 for all concepts marked "Extremely," "Very," or "Somewhat" familiar in Q2

Q3 Do you think you understand these topics well enough to integrate them into your curriculum?

Please indicate if you feel it is not educationally grade appropriate.

	Yes	Unsure	No	Not Grade Appropriate
Astrobiology	○	○	○	○
Biomaterials	○	○	○	○
Biomechanics	○	○	○	○
Biotechnology	○	○	○	○
Natural Products	○	○	○	○
Recombinant DNA	○	○	○	○
Alternative Fuels	○	○	○	○
Bioremediation	○	○	○	○
Fuel Cell	○	○	○	○
Green Technology	○	○	○	○
Biodefense	○	○	○	○
Bioinformatics	○	○	○	○
Gene Therapy	○	○	○	○
Genomics	○	○	○	○
Proteomics	○	○	○	○
Stem Cells	○	○	○	○
Artificial Intelligence	○	○	○	○
Algorithms	○	○	○	○
Data Warehousing and Mining	○	○	○	○
Graph Theory	○	○	○	○
Modeling Complex Nonlinear Systems	○	○	○	○
Quantum Computing	○	○	○	○
Biopolymers	○	○	○	○
Celestial Mining	○	○	○	○
Nanotechnology	○	○	○	○
Smart Materials	○	○	○	○

APPENDIX A: SURVEY QUESTIONNAIRE

Ask Q4 for all concepts marked "yes" or "unsure" in Q3

Q4 Which of the following, if any, are you currently personally teaching or planning on adding to your instruction for next year?

	Currently Teaching	Not Currently Teaching Planning to in the Next Year	Not Currently Teaching Do Not Plan to Next Year
Astrobiology	○	○	○
Biomaterials	○	○	○
Biomechanics	○	○	○
Biotechnology	○	○	○
Natural Products	○	○	○
Recombinant DNA	○	○	○
Alternative Fuels	○	○	○
Bioremediation	○	○	○
Fuel Cell	○	○	○
Green Technology	○	○	○
Biodefense	○	○	○
Bioinformatics	○	○	○
Gene Therapy	○	○	○
Genomics	○	○	○
Proteomics	○	○	○
Stem Cells	○	○	○
Artificial Intelligence	○	○	○
Algorithms	○	○	○
Data Warehousing and Mining	○	○	○
Graph Theory	○	○	○
Modeling Complex Nonlinear Systems	○	○	○
Quantum Computing	○	○	○
Biopolymers	○	○	○
Celestial Mining	○	○	○
Nanotechnology	○	○	○
Smart Materials	○	○	○

APPENDIX A: SURVEY QUESTIONNAIRE

Ask for all concepts - RANDOMIZED

Q5 Which of the following concepts would you be interested in learning more about?

Please check all that apply.

- ○ Astrobiology
- ○ Biomaterials
- ○ Biomechanics
- ○ Biotechnology
- ○ Natural Products
- ○ Recombinant DNA
- ○ Alternative Fuels
- ○ Bioremediation
- ○ Fuel Cell
- ○ Green Technology
- ○ Biodefense
- ○ Bioinformatics
- ○ Gene Therapy
- ○ Genomics
- ○ Proteomics
- ○ Stem Cells
- ○ Artificial Intelligence
- ○ Algorithms
- ○ Data Warehousing and Mining
- ○ Graph Theory
- ○ Modeling Complex Nonlinear Systems
- ○ Quantum Computing
- ○ Biopolymers
- ○ Celestial Mining
- ○ Nanotechnology
- ○ Smart Materials

APPENDIX A: SURVEY QUESTIONNAIRE

Ask for all concepts - RANDOMIZED

Q6 Which is the ***most influential barrier*** to including these topics in the curriculum at your school?

	Inappropriate at my level	Lack of teacher preparation	Not in the textbook(s)	Not enough time in the curriculum	Lack of equipment or materials	Other
Astrobiology	○	○	○	○	○	○
Biomaterials	○	○	○	○	○	○
Biomechanics	○	○	○	○	○	○
Biotechnology	○	○	○	○	○	○
Natural Products	○	○	○	○	○	○
Recombinant DNA	○	○	○	○	○	○
Alternative Fuels	○	○	○	○	○	○
Bioremediation	○	○	○	○	○	○
Fuel Cell	○	○	○	○	○	○
Green Technology	○	○	○	○	○	○
Biodefense	○	○	○	○	○	○
Bioinformatics	○	○	○	○	○	○
Gene Therapy	○	○	○	○	○	○
Genomics	○	○	○	○	○	○
Proteomics	○	○	○	○	○	○
Stem Cells	○	○	○	○	○	○
Artificial Intelligence	○	○	○	○	○	○
Algorithms	○	○	○	○	○	○
Data Warehousing and Mining	○	○	○	○	○	○
Graph Theory	○	○	○	○	○	○
Modeling Complex Nonlinear Systems	○	○	○	○	○	○
Quantum Computing	○	○	○	○	○	○
Biopolymers	○	○	○	○	○	○
Celestial Mining	○	○	○	○	○	○
Nanotechnology	○	○	○	○	○	○
Smart Materials	○	○	○	○	○	○

APPENDIX A: SURVEY QUESTIONNAIRE

Q7 How would you **MOST** like to receive information about these critical concepts and new technologies?

RANDOMIZE
(Select one)

- ○ Written materials available by mail
- ○ Web site
- ○ In-service programs at my school
- ○ A special conference or seminar
- ○ Other_____

Q8 In what other ways would you be willing to receive information?

List response options NOT selected in Q7: RANDOMIZE

(You may choose more than one.)

- ○ Written materials available by mail
- ○ Web site
- ○ In-service programs at my school
- ○ A special conference or seminar
- ○ Other_____

Q9 The following questions are to ensure that we get a good demographic cross-section of teachers.

Are you

- ○ Male
- ○ Female

APPENDIX A: SURVEY QUESTIONNAIRE

Q10 What grade(s) do you teach?
(Please check all that apply.)

- ○ Sixth or below
- ○ Seventh
- ○ Eighth
- ○ Ninth
- ○ Tenth
- ○ Eleventh
- ○ Twelfth

Q11 How long have you been a teacher?

- ○ This is my first year
- ○ 1 - 5
- ○ 6 - 10
- ○ 11 - 15
- ○ 16 - 20
- ○ 21 - 25
- ○ 26 - 30
- ○ 31 - 35
- ○ More than 35

Q12 What is the **minimum** number of students you have per class during a normal day?

_____

Q13 What is the **maximum** number of students you have per class during a normal day?

_____

Please enter a value for both the minimum and maximum number of students.

Q14 Do you teach:

- ○ Math
- ○ Science
- ○ Both

APPENDIX A: SURVEY QUESTIONNAIRE

Q15 What science subjects do you teach? (Please check all that apply.)

- ○ Anatomy and Physiology
- ○ Astronomy or Space Sciences
- ○ Biology
- ○ Chemistry
- ○ Computer Technology
- ○ Engineering or Pre-engineering
- ○ Environmental Sciences
- ○ Geology or Earth Sciences
- ○ Physics
- ○ Advanced Placement
- ○ Other_____

Q16 Do you personally subscribe to, or regularly read, any periodicals, magazines, newsletters etc. that are specifically related to science or science education?

- ○ Yes
- ○ No

Q17 How often do you visit the Internet for additional information about science related topics or concepts you are teaching or discussing in your classes?

- ○ Several times a day
- ○ Once a day
- ○ Two to three times a week
- ○ Once a week
- ○ Less than once a week
- ○ Never

APPENDIX A: SURVEY QUESTIONNAIRE

Q18 What math subjects do you teach? Please check all that apply.

- ○ Algebra
- ○ Applied math
- ○ Basic math
- ○ Business math
- ○ Calculus (including pre-calculus)
- ○ Geometry
- ○ Remedial math
- ○ Statistics
- ○ Advanced placement
- ○ Other_____

Q19 Do you personally subscribe to, or regularly read any periodicals, magazines, newsletters etc. that are specifically related to mathematics or math education?

- ○ Yes
- ○ No

Q20 How often do you visit the Internet for additional information about math related topics or concepts you are teaching or discussing in your classes?

- ○ Several times a day
- ○ Once a day
- ○ Two to three times a week
- ○ Once a week
- ○ Less than once a week
- ○ Never

Q21 Please use the space below to provide any additional comments or suggestions you would like to provide the Illinois State Board of Education.

APPENDIX B: CONCEPT DEFINITIONS

Biosciences

Astrobiology The scientific study of life in the universe – its origin, evolution, distribution, comparability to earth and human habitation, and future prospects.

Biomaterials Synthetic or natural materials that can replace or augment tissues, organs or body functions.

Biomechanics The use of the principles of mechanics to explore and engineer solutions to biological problems.

Biotechnology The use of microorganisms, live plant or animal cells or their parts to create new products or to carry out biological processes aimed at genetic improvement for the benefit of people.

Natural Products Chemical compounds, naturally produced in plants or by microbial species that are harvested for use in health care and drug development.

Recombinant DNA DNA that has been altered by joining genetic material from two different sources to study the expression of a gene.

Environmental and Energy Technologies

Alternative Fuels Study of alternative ways to produce energy for both stationary (e.g. power plant) and non-stationary (e.g. automobiles and aircraft) applications. Alternative fuel sources include wind and solar power, hydrogenated biofuels, and fuel cell, among others.

Bioremediation The processes by which naturally occurring or modified organisms act to degrade or transform hazardous organic contaminants.

Fuel Cell Devices for generating electrical energy directly from chemical energy. It differs from a battery in that the chemicals are not stored in the cell. Rather, they are fed into it as power is needed.

Green Technology Industrial technologies and applications modified to reduce, prevent, or eliminate environmental damage.

Human Health and Development

Biodefense Use of various biotechnologies to respond to the intentional use of pathogens (bioterrorism) by detecting, identifying, assessing, and neutralizing pathogens.

Bioinformatics Use of computers in biology-related sciences to organize, interpret, and predict biological structure and function. Bioinformatics is usually applied in the context of analyzing DNA sequence data.

Gene Therapy Introducing a normal, functional copy of a gene into a cell for the purpose of correcting defective, disease-causing genes.

Genomics The study of an organism's full complement of genes to enable understanding of their expression and sequencing.

APPENDIX B: CONCEPT DEFINITIONS

Human Health and Development (Continued)

Proteomics The study of the totality of proteins in an organism. Studying the form and functions of proteins with the aid of supercomputers complements the scientific advances being made by the mapping of the genomes.

Stem Cells The study and application of undifferentiated (stem) cells that can be grown and maintained to differentiate into a variety of different cell types with select biological functions.

Information Technology and Communications

Artificial Intelligence Computers and hardware that can make intelligent decisions based on sensory feedback.

Algorithms A finite set of step-by-step instructions for problem solving or computational procedures, especially ones that can be implemented by a computer.

Data Warehousing and Mining The process of collecting, processing, filtering, extracting and refining useful knowledge from large databases.

Graph Theory The study of graphs either for their own sake or as models of such diverse things as groups (in pure mathematics) or computer networks.

Modeling Complex Nonlinear Systems Systems which are not characterizable by linear or first-order equations, but are governed by any variety of complex, reciprocal relationships or feedback loops.

Quantum Computing Information processing that can be performed only by harnessing physical phenomena unique to quantum physics, with performance expected to exceed a billion times faster than today's most powerful supercomputer.

Materials Science and Advanced Manufacturing

Biopolymers Polymeric material produced from or by biological sources, for example, biodegradable plastics that are synthesized by living organisms.

Celestial Mining The search for, excavation and processing, or essential elements and materials on extra-terrestrial bodies (planets, asteroids, etc).

Nanotechnology Development and use of materials, structures, or devices that have a size of less than 2000 nanometers. Production of devices on this small scale saves space and resources, resulting in improved efficiency and processing speed.

Smart Materials Materials that have imbedded sensors and actuators so that they can sense and react to their environments.

ILLINOIS SURVEY of CRITICAL TECHNOLOGIES

SUMMARY REPORT

Illinois State Board of Education

Survey Research
Public Opinion Lab at Northern Illinois University

Report
NIU Outreach and Public Opinion Lab

Critical Technologies Concepts
Illinois Mathematics and Science Academy