What Does Research-Based Really Mean?

IT's ABOUT TIME®
HERFF JONES EDUCATION DIVISION

Every American student should have a good working knowledge of science and technology, thereby being better prepared to meet the demands of the 21st century's school, workplace, social and home environments. *It's About Time* is dedicated to publishing cutting-edge *research-based* programs that are designed to ensure that all students can become successful in the learning of math and science. Each of these programs has been funded by the National Science Foundation (NSF) and exemplifies the NSF's goals and objectives to improve science, mathematics, and technology education for all students. Each of its science curricula programs is aligned with the National Science Education Standards (NSES) and follows the guidelines of the NSES to improve science content knowledge, thinking skills, and problem-solving abilities for all students, regardless of background or ability.

The National Science Education Standards were guided by certain principles:

- Science is for all students
- Learning science is an active process
- School science reflects the intellectual and cultural traditions that characterize the practice of contemporary science
- Improving science education is part of systemic education reform

Adhering to these principles, *It's About Time's* curricula programs rely on the rigorous research of the NSF development process as well as incorporating into its instructional model the most up-to-date research on pedagogy and learning theory. *It's About Time* curricula consequently promote positive student attitudes toward science and positive perceptions of the student as learner. They engage students through their use of real-world contexts and provide a deeper understanding of the role of science and technology in the workplace.

The NSF Research-Based Curriculum Development Process

The NSF Instructional Materials Development Program ensures that each of the curriculum development programs it has funded follows strict *research-based* criteria throughout the development process. The projects are extremely competitive and only awarded to development teams who have established themselves to be distinguished leaders in science education. For example, the initial development grant for *Active Physics* was awarded to the American Association of Physics Teachers, and the development grant for *EarthComm* was awarded to The American Geological Institute. The embedded *research-based* development process with the strict criteria and standards for all NSF funded programs usually takes at least three to four years to complete.

Project Evaluation and Research Design

A crucial component to all NSF development projects is the ongoing research and evaluation of the development process and materials by a nationally recognized independent evaluation team. The research and evaluation of these projects is comprehensive and provides both formative and summative information to the development teams as well as to the NSF for review. The formative feedback and information is used to optimize the curricular revision process, and the summative evaluation examines the effectiveness of the curricular materials on teachers and students throughout the three-year process.

First Year of the Curriculum Development Process — Content Specialists, Master Teachers

Under the direction of a distinguished, active, and dynamic Advisory Board (that meet twice yearly over a three-to four-year period), the program's Principal Investigators select and then oversee teams of writers chosen from top university science education departments, content-based science departments, and specially selected high school teachers, and industry scientists to collaborate on the development of the first drafts of the curriculum materials. These lead authors, each a distinguished content specialist and/or educator from a leading university, also serve as part of the Review Committee to assess each other's works for pedagogical strategies and content accuracy. The curriculum is then reviewed and evaluated by other leading educational specialists for pedagogy, content, safety, equity, readability, cognitive effectiveness, and efficacy, and then the curriculum is revised again based on those results.

All new materials proceed through the following system for development and revision:

- Approved by Content Review Committee comprised of leading content experts
- Approved by the following consultants: science educator, master teachers, and cognitive scientist
- Micro-tested by the development group. A micro-test is a series of tests of a few students with careful observation and follow-up interviews by the developers

Second Year of the Curriculum Development Process — Content Specialists Pilot to Ensure Curriculum is Correct and Rigorous.

The curriculum is then ready to be pilot tested by a select group of high school teachers from across the country. After an extensive summer training, these teachers spend the next year piloting the program in their classrooms.

- Pilot tested by master teachers in their classrooms
- Pilot materials, classes, teachers, and students are studied and evaluated based on an established evaluation and research design model
- Materials are also reviewed by leading content experts and science educators to evaluate if the materials appropriately prepare students for their later study in these subjects
- Materials are then revised based on the pilot feedback, experts' reviews and evaluation and research reports

Third Year of the Curriculum Development Process — Diverse Classrooms to Ensure Approach is Appropriate for All Students

The curriculum is now ready to be field tested by a broad range of high school teachers from across the country. After an extensive summer training, these teachers spend the next year field testing the materials in their classrooms.

Like the pilot test, the research/evaluation component of the revision process is designed to inform the next iteration and revision of the materials.

- Field testing of the materials conducted in a wide range of classrooms by teachers with a wide range of experience and expertise
- Field test materials, classes, teachers, and students are studied and evaluated based on the evaluation and research design model
- Materials are then revised again based on the field test feedback, experts' reviews and evaluation and research reports

Fourth Year of the Development Process

Additional consultant specialists in cognitive psychology, assessment, technology, science education and equity continue to be brought into the project to review the materials and secure its pedagogical approach and content basis. Finally, the product is turned over to the commercial publisher to mold into a commercial product.

The Active Learning Research-Based Instructional Model

Out of this rigorous *research-based* development process, the *Active Learning Instructional Model* has evolved. Much of the success of the *It's About Time Active Learning Model* is attributed to the adherence to such research and current thinking on how people learn, what motivates students intellectually, and the National Science Education Standards. The *Active Learning Model* resonates strongly with some of the key findings in the cognitive psychology research (Bransford, J.D., M.S. Donovan, Pellegrino, 1999 and Bransford, J.D., A.L. Brown, and R.R. Cocking, 2000) as well as in the motivational processes in learning literature (Marzano, R., D. Pickering, G. Blackburn, D. Arrendondo, 1997, H. Dembo, R.Rueda, 1995). Many of the key authors, advisors and consultants who work on *It's About Time's* curricula have also served as members on the committees that developed the National Science Education Standards (the Standards). Consequently, these curricula programs match the intent of the Standards in content, pedagogy, and assessment and are not retrofitted to meet the Standards.

Two of the central components to the *Active Learning Instructional Model* are the project-based learning model (Delisle, R., 1997) and a directed-inquiry approach (National Research Council, 2000).Each chapter centers around the need for the students to accomplish an authentic performance-task project that deals with real life situations. The students then do the directed inquiry-based activities within the chapter in order to learn the science necessary to complete their summative project. Although the cornerstone of the program is this authentic performance project – the "**Chapter Challenge**," more traditional assessment tools, such as quizzes, tests and prompts, journal writing and lab books, are also provided and encouraged.

"This past year, I introduced *Active Physics* to my physics class in the second semester, and it was a revolution! For the first time, 100% of the students were engaged in the act of learning physics—the directed inquiry approach that *Active Physics* takes clearly works for my students. It was difficult to end every class session, as students wanted to continue working on the activities."

(Hannah Sevian, Chelsea High School – an urban high school in the Boston area that serves a primarily immigrant and poverty-level population.)

The *Active Learning Instructional Model* has also built into its curriculum design a number of additional features that point to greater learning and deeper understanding such as:

- An approach to the curriculum design that assures student engagement in inquiry and promotes discovery in order to make understanding of the big ideas more likely
- Eliciting prior understandings from the students
- A continuum of methods for appropriately assessing the degree of student understanding
- Considering the role of predictable student misunderstandings that need to be incorporated into the design of curriculum and its assessment tools

Elaborating on the well known 5 E learning cycle instruction model (Bybee, 1997) with its discrete elements of: *engage, explore, explain, elaborate*, and *evaluate*, Dr. Eisenkraft, the Project Director of *Active Physics* and *Active Chemistry*, has proposed the 7 E model that expands the *engage* element into two components – *elicit and engage*. Similarly, he expands the *elaborate* and *evaluate* element into three components – to include *extend*, the transfer of knowledge from one domain to another (Eisenkraft, 2003). As stated by Dr. Eisenkraft, "The importance of eliciting prior understandings is ascertaining what students know prior to a lesson is imperative. Recognizing that students construct knowledge from existing knowledge, teachers need to find out what existing knowledge their students possess. Failure to do so may result in students developing concepts very different from the ones the teacher intends." In the *Active Learning* model, teachers elicit prior understandings from their students by the "**What Do You Think?**" question which initiates each activity. This direct and simple task asks students to jot down some of their thoughts and ideas about the content area they are about to investigate.

Comparing their prior ideas to the subject with the ideas learned during the investigation creates the environment for deeper and more meaningful learning.

The emphasis in the 7 E learning cycle of asking students to apply their knowledge in a new context, a new domain, (transfer of learning) is a central component to all *It's About Time* curricula. Each chapter begins with a **Chapter Scenario** and **Challenge**. For example, in the chemistry chapter called *The Periodic Table,* the students are asked to design a game based on Mendeleev's Periodic Table of the Elements. They then work with their classmates and teacher to create a rubric for how they will assess each other's games. Nine activities (guided-inquiry hands-on labs) then follow, with each activity taking a day or two to complete, which will help the students learn the chemistry necessary to complete their challenge. The students then transfer the content knowledge learned in their lab experiences to a new domain, the **Chapter Challenge**, in this case a game based on the periodic table.

The public display of these games by each group of students, as well as playing each other's games, engages the students creatively and intellectually. It also serves as a format for multiple exposure and review of the content.

> "What an AWESOME week! We 'kinda' finished Activity 8 in *The Periodic Table*. The reason I say 'kinda' is because I could hardly contain my kids enthusiasm! It was as if they all had a breakthrough in understanding all the concepts covered up to this point. Suddenly electron configuration was a concept they understood and the kids that didn't understand it were overwhelmed by peer teachers eager to share their new found understanding. Not only do they understand e- configuration, but NOW the arrangement of the periodic table makes sense to them. They also started (on their own) to predict how different elements would react with other elements to form compounds. It was incredible!"
> ***(Riggs, Rosemary, Roosevelt H.S., San Antonio, Texas)***

A 1997 study (Dimensions of Learning) conducted extensive examination on what constitutes students' positive responses toward certain characteristics of instruction and curriculum. This study revealed a listing of attributes titled: "What Engages Students Intellectually."

Key attributes from this study include:

- Students help define content and task
- They had time to wonder – to find a particular direction that interested them
- Teachers permitted – even encouraged – different forms of expression and respected student view.
- Students created original and public products
- Students sensed that the results of their work were not predetermined or fully predictable

Although students in the *Active Learning Model* do not define the science or content they will be asked to learn, they will be encouraged to use the science, transferring the knowledge learned, in creative and unpredictable ways.

> "As a veteran chemistry teacher of 22 years, and after having tried numerous programs, I feel that I have the experience to identify quality programs. *Active Chemistry* is a quality program for several reasons. It's engaging, it develops higher order thinking skills, and it's

applicable to students' lives. I am excited about this new and different approach. But more importantly, my students are excited! And that is really a testimony when you consider the population that I teach. (My students come from a very rural, poverty-stricken area where education is not valued.) I whole-heartedly endorse the program."
(Diane Johnson, Chemistry Teacher, Lewis County High School, Kentucky Department Head, KSTA President)

The Active Learning Model also follows the theoretical approach that advocates a "Backward Design Process," (G. Wiggins and J. McTighe, 2001). The developers first identify the desired learning results, then determine what would be considered acceptable evidence toward demonstrating those results, and then design the curriculum to orchestrate learning experiences that will best lead toward those desired learning outcomes.

"My student teacher and I have found the **Reflecting on the Activity** and the **Chapter Challenge** section of each activity to be an enormously helpful wrap-up and review of each activity. One of my students put it into his own words as "What did we do?" "What did we see?" "What does it mean?" I feel like we are building meaningful relationships between the investigations, students' observations and interpretations."
(Karen Tokos Newton North High School, Newtonville, Massachusetts)

Thus, the *It's About Time* curricula is accessible and engaging to all students, including students who are historically low achieving and those who have previously shown little interest in science.

It is a blueprint for learning that takes a content subject and shapes it into a format for effective teaching and learning for students of a diverse range of abilities.

Indicators of Success

Important indicators of success are the studies on student performance. In the Cincinnati Public Schools, for example, where *Active Physics*, *Active Chemistry* and *EarthComm* make up the 9th grade science course, Dr. Robert Endorf from the University of Cincinnati, Physics Department, has conducted a study of effectiveness on students in the course. His data is preliminary, but the initial results show significant promise. This study included the administering of the FCI (Force Concept Inventory) exam to these 9th students, on a pre-and-post basis, as well as to the entering first-year college engineering students, and the study shows the *Active Learning* instructional model to be remarkably effective.

Cincinnati Pubic Schools (FCI Study)

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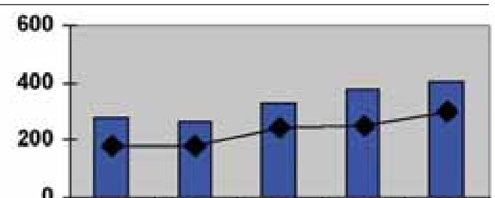
Newton's 3rd Law

Question of FCI	Pre-Test – 9th grade *Active Physics* students	Post-Test – 9th grade *Active Physics* students	1st year college engineering students pre-test
Item # 4	13%	67%	27%
Item # 15	25%	48%	20%
Item # 16	13%	70%	64%
Item # 29	13%	26%	32%

There are also some districts, such as Little Rock, Arkansas, that have been able to note statistically significant increases in student scores on Standardized Tests such as the SAT 9 in both math and science after *Active Physics* has been implemented.

Another important indicator of successful impact is the increased number of students taking higher-level science and advanced placement courses, after completing an earlier *Active Learning* course. Such increases have been noted in many districts including Little Rock Public Schools and in Fairfax County Public Schools.

Increase of Students Taking Upper Level Science Courses



	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002
Total Enrolled	279	266	331	378	407
Successful	183	179	245	248	302

"Today *Active Physics* is offered in all of our 19 schools and is taken by over 2000 students a year… At this point we have more than doubled the number of students in Fairfax County taking physics... The number of kids taking and being successful in AP courses has more than doubled because of our science/math initiatives."
(Nancy Sprague, Assistant Superintendent of Instructional Services for Fairfax County Public Schools (Sprague, 2002)

Another noteworthy indicator of success consists of teacher responses. In Seattle, for example, on a survey administered to teachers who have completed a year of their Integrated Program (*Active Physics*, *Active Chemistry* and *EarthComm*), 70% responded that these programs had "supported and/or facilitated their teaching."

Comparison of Seattle Teacher Survey for 2002 and 2003

Chi-square test of significance on the percentage differences between 2002 and 2003 survey responses

2002 Seattle 9th grade teachers used a formerly adopted traditional approach text
2003 Seattle 9th grade teachers used Active Physics, Active Chemistry and EarthComm

The data below represents teacher responses to the following question in an end of the year survey.
Question: How does the Curriculum provided by Seattle schools affect your ability to teach?

Reported Score	% Teachers Reporting This Score in 2002	% Teachers Reporting This Score in 2003	Chi-square Value	Level of Significance	Significant Difference Due to Curriculum
1) Hinders	09.5	00.0	8.0	.01	Highly Significant
2) Fails to Support	28.5	12.5	3.2	.05	No
3) Neutral	28.5	25.0	0.098	.05	No
4) Support	33.3	37.5	0.08	.05	No
5) Facilitates	00.0	25.0	18.00	.00	Very Highly Significant

Supports the argument that the It's About Time materials significantly increases the number of teachers that feel their teaching is facilitated by the materials and reduces to zero those that feel the materials hinder teaching.

From Florida:

"This year at my school, my Dean of Faculty is using me as one of the models for our Faculty Recognition Program since I'm using innovative, research-based models in my classroom (yes, my administrators are up to date on the research!). I can also report that I am LOVING Active Chem and I have never enjoyed teaching more in my life! I can't remember a school year that I worked this hard but was THIS happy!"
(Stephanie Levens, North Broward Preparatory School, Florida)

And in San Diego:

"At an end of the year teacher survey, 74% of the teachers agreed that the curriculum helped students gain conceptual understanding of the physics that they learned and that the students received a good foundation in physics concepts. They also responded that they believed students gained a better appreciation for the process of science by learning science via inquiry rather than via direct instruction. 85% of the respondents said they enjoyed teaching the *Active Physics* Curriculum".
(Progress Report on the Implementation of Physics for 9th grade; San Diego City Schools, Office of the Superintendent, October, 2, 2002)

A final indicator of success is the endorsement by higher educational academic communities for these courses as a full lab high school science course.

> "The faculty who reviewed the materials submitted….observed that the new curriculum, using *Active Physics* as its core text, taken at the 9th grade level would provide a solid foundation for students in preparation for work at the college level. In particular, they liked the way in which the proposed curriculum helps students to develop a deeper conceptual understanding of physics, as opposed to the traditional approach to physics instruction, which emphasizes solving numerical problems." (***Carla M. Ferri, Director, Undergraduate Affairs and Student Academic Services, University of California)***

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