The Delaware Science LSC: Building a World Class Science Program from Elementary to High School One Step at a Time

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Science education in Delaware changed forever with the advent of the Delaware Local Systemic Change (LSC) (known locally as The Smithsonian Project). As a direct result of the LSC, Delaware now has a science education system with:

A statewide Science Coalition that continues to work to improve the teaching and learning of science;

A common K–10 science curriculum that is being expanded to K–12, with a capstone 12th grade course tied to higher education;

A comprehensive on-going professional development program for all science teachers;

A centralized Resource Center with a sound financial base and the capacity to provide classroom supplies and professional development to more than 5000 teachers;

Full time Science Specialists (both at the state level and in every school district) focused on strengthening science teaching and learning;

An active program of teachers-on-loan to the Coalition to access special talents and develop new teacher leadership; and

Strong links with higher education and with the technical business community.

As a result of the LSC, students in Delaware public schools are getting more science instruction than before, using a challenging standards-based curriculum that is taught by teachers who are better prepared and who have greater access to the use of modern technology in the classroom. Student achievement in science has increased steadily since testing began, and the achievement gap between races has been reduced.

These improvements would not have happened without the vision of the team that conceived and pioneered this project, the active support of the business community and the Delaware legislature and tireless work of many, many dedicated educators.

The Context

While Delaware is a small state, it has many of the political, bureaucratic, and geographical complexities of larger states. In the last decade, the school system has been undergoing constant change as a result of a growing, more diverse population, and as it moves to increase the achievement of all students.

The Delaware school system is made up of 15 comprehensive K–12 districts and 1 district where students attend Grades K–6 in Maryland and Grades 7–12 in Delaware. Three county-wide 9–12 Vocational-Technical districts overlap and serve the regular districts. In 2003–04, 63 percent of education funding came from the state, a much higher proportion of the total than in most states. An equalization formula is used for state money to level funding among the richer and poorer districts.

Statewide, 57 percent of K–12 students are White, 32 percent Black, 8 percent Hispanic, and 3 percent Asian. While most middle and high schools have demographics similar to that of the state, about one-third of the elementary schools have a predominance of either White or Black students.

Delaware began a process of education reform in 1991 by hiring a new State Superintendent committed to establishing state standards for all major subjects. His plan was strongly supported by the legislature and the business community but was viewed skeptically by many school administrators.

Development of state standards took three years (1992–95) during which the Superintendent led an active campaign to engage public understanding and support. Science and mathematics were key components of the reform agenda driven by business concerns about the widely reported poor performance of American students on international tests. The commission that developed the science standards was co-chaired by an award-winning high school science teacher and the Director of DuPont Research and Development. The commission included curriculum directors, education administrators, teachers from all grade clusters, and representatives from higher education, key professional, and community organizations.

The standards development process led to a widely shared state-wide vision of science education and, for those of us who came from outside the education system, an opportunity to build relationships with leading science educators across the state and to better understand many of the complex organizational dynamics in the system. The State Systemic Initiative that Delaware had at the time (discussed more fully in the Manon Case Study) played a valuable role in establishing a foundation for the introduction of standards and for supporting some early innovative science and mathematics initiatives.

When the Science (and other) Standards were adopted in June 1995, implementation was deliberately left to the individual districts. The new standards required that every student have science instruction every year and emphasized inquiry-based instruction as fundamental to good science education, creating quite a challenge for Delaware districts. Historically, science had not been a critical subject in the state's elementary schools and was largely dependent on the

interests and initiative of individual teachers. A survey of Delaware science teachers in 1995 indicated that elementary science, if taught, was done through a literature-based approach, with the same topics of interest year after year (e.g., butterflies, dinosaurs). The average time devoted to science instruction was less than 45 minutes per week, and special education students were routinely excluded from science classes.

Most schools and districts did not have the capacity to develop a standards-based elementary curriculum, nor to provide the professional development that teachers would need to teach such a curriculum. The majority of elementary teachers had a weak science background, typically one or two courses, and many middle school teachers did not have sufficient science background to meet the new grade 6–8 science standards.

Prior to the LSC, there was little collaboration among districts on curriculum and/or teaching. As a result, the science curriculum varied among the districts, among different schools in the same district and even among teachers in the same school. Teachers did not have reliable access to the classroom materials required by an inquiry-based curriculum, so teachers had to purchase supplies with their own money.

Measuring student achievement in science was limited and highly fragmented. Science was not tested by the state or by individual districts, especially in the elementary grades. Individual schools gave science grades in middle and high school but there were no bases for comparisons among them. The lack of a common curriculum made it difficult to compare different programs and limited the scope and effectiveness of professional development initiatives. Finally, little or no attention was given to the use of assessments to help teachers understand student misconceptions and use this information to improve student learning.

Preparing for the LSC: The Pilot Program (1995–96)

A pilot program to prepare elementary teachers to meet the state standards began as an initiative of the Delaware Science Coalition, soon after the adoption of the standards, and was comprised of six small rural districts in the south of the state and one large urban district in the industrialized north. This pilot program laid the foundation for the LSC and all that followed.

The K–6 pilot was designed by a team of 19 educators and community representatives after attending a Leadership Institute in Elementary Science Education Reform offered by the National Science Resource Center (NSRC)[1] in Washington, DC. The Delaware pilot program was based on the NSRC model for systemic reform, which emphasizes the need to deal with all aspects of the education system in order to improve science education. The model includes the usual core educational requirements of establishing an inquiry-based curriculum and providing ongoing teacher professional development so that teachers understand the science and build expertise in inquiry teaching. It adds the very practical requirements of building capacity to supply the classroom materials that teachers will need in order to implement an inquiry-centered

[1] Leadership and Assistance for Science Education Reform, (LASER), National Science Resource Center. www.si.edu/nsrc

curriculum; and of building the organizational and political support in the district, in the state education system, and in the external community.

At the Institute, each district team was expected to develop a five-year strategic plan for implementing an elementary science curriculum in their district. While the Delaware group was officially composed of several teams, all participants worked together to draw on the range of expertise available in the whole group. This led to one common plan and laid the foundation for a statewide effort.

The Delaware pilot program was designed to determine how effective a modular (i.e., kit-based) inquiry-centered curriculum would be in enabling K–6 science instruction to meet the state standards. DuPont committed to fund 50 percent of the cost of the initial science kits, and the participating districts agreed to fund the other 50 percent. The state legislature, recognizing the merits of an initiative with the goal of implementing the standards they had just approved, provided a special one-time grant.

In the first year, the Coalition implemented one curriculum unit in each grade, providing professional development to about 50 teachers per grade, engaging about 7,000 students in inquiry-centered science instruction, and enlisting teachers and other volunteers to refurbish the kits.

The program was revolutionary in many ways. The curriculum units (purchased from FOSS, STC or Insights) were new to the majority of teachers, especially those in the early grades where little science had previously been taught. And the requirement that special education students be included in science represented a significant change in practice at many schools. Moreover, the fact that a kit with all the materials they needed for an entire unit would be provided to their classroom was a new experience for all of the teachers. Many were reluctant to return the kit for refurbishing when the unit was finished because they did not believe that they would get it back the following year!

The in-depth professional development was very different from the usual short "make-and-take" workshops they were familiar with. A typical group of 20–25 grade-level teachers (coming from different schools) met after school with a master science teacher for a total of 30 hours of professional development over an 8–10-week period. Teachers worked through the student lessons, focusing on both the science content and the inquiry pedagogy. Because the teachers were implementing the unit in their classrooms while they were engaged in professional development, they were able to share their classroom experiences and identify and discuss problems that arose. Each group thus became a small learning community.

The pilot was an instant success. Students and teachers alike responded enthusiastically to the hands-on science. Special education students did especially well; in fact one of the initial test schools in which the program was extremely successful was primarily for students with such needs. Administrators agreed that the professional development was effective in preparing teachers to meet the state's Standards.

Curriculum Directors from the smaller rural school districts recognized that there was no way that they could provide comparable materials and professional development if they had to do it by themselves. This recognition led to strong district and school support for continuing and expanding the pilot. The fact that something visible was being done to "implement the standards" so soon after their passage had a favorable impact on the legislature and was noted by the news media. An outstanding Grade 6 science teacher who was being recognized for winning the Presidential Award for science and who had taken part in the pilot enthusiastically described the program to the State School Board as "the best professional development I have had in my 25 years of teaching."

The program expanded significantly in the second year. A second curriculum unit was introduced at every grade for the first cohort of teachers; and the first science unit was introduced to a new cohort of teachers. The addition of two more school districts (one rural and one urban) to the Coalition added to the number of teachers who would be participating. As a result, over 950 teachers participated in professional development during the second year. This dramatic increase placed great demands on the small staff, not only to plan and provide the professional development, but also to handle the distribution, return, and refurbishment of the science kits. While some additional funding was obtained from the legislature and the business community for the second year, it was clear that external funding and additional staff would be required to meet the need for more materials and more professional development.

Based on the experience gained from the pilot program, the Science Coalition submitted a proposal to the National Science Foundation (NSF) for a Local Systemic Change grant of $5.4 million covering 1,800 teachers in the nine school districts. This grant was funded for the 1997 school year.

The LSC

The LSC was the responsibility of the Delaware Science Coalition, a coalition of Delaware school districts in partnership with the Delaware Department of Education (DOE) and the Delaware Foundation for Science and Mathematics Education (DFSME). The overall goal of the LSC was to improve the teaching and learning of science so that all children in grades K–8 have the opportunity to obtain the skills and knowledge needed to meet or exceed the expectations of the Delaware Science Standards and transfer this knowledge to settings outside the classroom.

To achieve that goal, the LSC would work to build capacity at the school, district, and state levels, including:

> Establishing a materials support system so that teachers have the classroom materials needed for all children to participate in inquiry-centered instruction;
>
> Providing in-depth professional development to all K–6 teachers of science so they can become proficient instructors of inquiry-based science;

Developing a comprehensive assessment system that informs teachers and administrators of student learning;

Establishing and nurturing a network of teacher leaders who would lead and sustain science education reform at the school and district levels; and

Building and sustaining a process to ensure that school, district and state policies were supportive of systemic reform and that community support was focused on common programmatic objectives.

A key component of the LSC proposal was the Memorandum of Understanding (MOU) that all parties in the LSC signed, clearly defining the responsibilities and commitments of the Department of Education, the participating districts, and the Delaware Foundation for Science and Mathematics Education. To deal with district concerns about a state-mandated curriculum or other threats to district autonomy, one of the guiding principles in the MOU was that "adoption of curricula and implementation of this program are the responsibility of individual school districts."

Building the Organizational Capacity for Systemic Reform

Three different levels of leadership were established to support implementation. The organizational structure fortunately had the flexibility to adapt to the significant increases in accountability that occurred in the Delaware (and the national) education system over the course of the LSC.

Strategic Leadership: The Steering Committee

The Steering Committee was responsible for strategic planning and for monitoring progress toward LSC goals. The Steering Committee consisted of LSC project leaders and staff along with a representative from each district (typically a Curriculum Director) and a representative from each of the other partner organizations.

The Steering Committee met monthly and held an annual meeting with district superintendents, Department of Education Leadership, and business representatives to review progress and develop the strategic plan for the next year. The Steering Committee evolved over the course of the project becoming the key group for maintaining good communications with the wide variety of stakeholders throughout the state and also for resolving organizational or programmatic issues. The Steering Committee approved annual budgets and agreed to cost-sharing arrangements; it would play a central role in sustaining the Coalition after the LSC grant ended.

Program Leadership: Science Specialists

A Lead Teacher was appointed by the principal of each participating school to coordinate and facilitate implementation in their school. Lead Teachers worked closely with the district Science Specialists, Curriculum Directors and principals; the group met for four days for professional development related to the project during the school year and for a week in the summer for content reinforcement.

Lead teachers (sometimes with the Science Specialist) would report to school faculty on the progress of the project and the status of implementation in their school, including the number of teachers who had taken professional development and the number who still needed to. The LSC grant funded a full time Science Specialist in each participating small district and two in the larger districts. While these Specialists were primarily responsible for implementation in their district, they also worked closely with the PI and LSC staff on the overall program. Over time, the Specialists took on a larger role in guiding the project, e.g., leading the teams that selected, piloted, and upgraded the individual curriculum units, as needed, and taking significant responsibility for the development and dissemination of summative and formative assessments.

Science Specialists participated in up to three weeks of additional professional development each summer. These were designed to strengthen their content knowledge and to build their expertise in a new area, such as science assessment. One special note on the distribution of Specialists: we recognized that even with two Specialists in the larger districts, the ratio of teachers to Specialists was much higher in the larger districts than in the small districts. We examined the possibility of allocating all specialists centrally so each would serve a similar number of schools and teachers. We concluded that there was much greater value in decentralization so the district maintained its sense of ownership for their Specialist and the Specialist had a greater sense of responsibility for his/her teachers and students.

Expanding the LSC throughout the State

As part of the LSC grant, the Delaware Department of Education committed to fund a centralized Resource Center to handle the distribution and refurbishment of science kits. The Resource Center was opened in the spring of 1997, concurrent with the receipt of the NSF grant. The Coalition took advantage of the opportunity to celebrate the event and to publicize progress in science education with a public ceremony to which the governor, legislators, business representatives, and the public were invited. This event provided an opportunity for these constituencies to see the types of science and the curriculum units that were being introduced into the classroom through the pilot program.

Two more districts joined the Coalition in 1997, including the largest district in the state, increasing the number of participating teachers to well over 2,000 and allowing the LSC to apply for additional funding from NSF to bring the total grant to the $6 million maximum.

The LSC offered a number of incentives for districts to participate. Business commitments were available to cover the costs of attending the Leadership Institute and 50 percent of the initial costs of the additional kits that would be needed. The LSC guaranteed that the professional development program and Science Resource Center would be expanded to serve their teachers. Funding was available to allow a district to release a teacher to serve as their district Science Specialist, and their Curriculum Director would have a role in the program direction by participating on the LSC Steering Committee.

The program continued to get good feedback from teachers and districts administrators. It was recognized by the Chamber of Commerce in 1997, with a "Superstars in Education" award as an innovative program and became the best known example of progress in establishing a standards-based education system in the state. In 1998, the legislature provided additional funding for 3.5 additional Science Specialists, to allow the program to expand to the remaining three districts. With the addition of these districts, the LSC was being implemented by 14 of the 15 Delaware school districts that included K–6 schools.

Each new district had to first send a team to the NSRC Leadership Institute, which provided the district an opportunity to build their internal team and to develop a five-year plan. It also ensured that districts joined the Coalition with an understanding of the principles behind the program and a common vision of excellence in elementary science education. Each district Superintendent had to sign the Memorandum of Understanding that the original nine districts had agreed to as part of the LSC application, which included the commitment to provide all teachers of science with professional development and to include all students in the program.

Only one district that participated in the NSRC Leadership Institute training did not join the Coalition elementary program. We understand that this was due to a union issue related to requiring all teachers of science take the specified hours of professional development. However, this district cooperated with the LSC Coalition informally. It adopted the same curriculum; purchased and managed their own kits; in addition, teachers from this district could and did attend the professional development offered.

The Elementary Program: Challenges and Adaptations

The professional development process used in the pilot program was strengthened and formalized for the LSC, requiring each teacher to participate in 30 hours of professional development for each curriculum unit.

Providing professional development to so many teachers became the main focus of the program. All courses would be offered both upstate and downstate during the fall and spring semesters, and week-long sessions would be offered during the summer to reach teachers who could not or would not attend after school.

We expected that the level of teacher training would decrease over time, but it stayed in the range of 1,200–1,400 teachers per year even beyond the end of the LSC funding. A primary factor was that teacher turnover averaged more than 20 percent per year, including both teachers leaving and teachers who changed grade levels. In addition, expanding the curriculum from three units to four units per grade, for most grades, and replacing some units over time as better alternatives were identified, required teachers to take professional development in the new units.

Similarly, the development of summative assessments opened a whole new topic for professional development. While this material was later integrated into the curriculum unit training for new teachers, the initial introduction required current teachers to take additional professional development. In addition, changes in state licensure regulations required all teachers to complete

90 hours of professional development every five years, providing a financial incentive (2 percent salary increase) for teachers who complete an approved cluster of courses (such as all the 5th grade units), leading some teachers to retake courses in the units they were teaching to take advantage of this salary incentive. The net result was that the LSC helped establish a new expectation of continuous professional development for science teachers in the state.

Ensuring the quality of implementation was a major challenge. The main measures of implementation during the first three years of the LSC were operational: the number of trained teachers, the progress in establishing the curriculum, the number of professional development sessions scheduled, and the number of kits being used. Much attention was paid to the logistics of classroom implementation. Progress in meeting these objectives was reviewed regularly with the Steering Committee.

Once state testing of science began in 2001, the main measure of the effectiveness of implementation became student achievement as measured by the Delaware Student Testing Program. With the development of the science assessments, attention became increasingly focused on instruction and student learning.

As the number of professional development courses increased, evidence (both anecdotal and from our evaluators) indicated that the quality of the professional development was slipping. Finding a sufficient number of effective professional development providers became a major challenge. We also began to get evidence that classroom implementation was being compromised as some teachers began to cut corners on the teaching, leaving out critical lessons or using the kits as an "activity" rather than a way to learn science through inquiry. It is possible that we were seeing the impact of poor professional development and/or were now reaching teachers who were less enthusiastic about the science than the early adopters.

LSC staff worked on several fronts to improve the quality of elementary professional development. The professional development requirements were modified to better reflect the difficulty of the various units, e.g., providing less time for professional development on the Grade 2 butterflies unit than on the Grade 5 motion and design unit. Manuals were written to clarify responsibilities and expectations for the professional development instructors, providing detailed outlines of the material to be covered and a suggested timeline for covering it. Instructors were asked to sign contracts committing them to meet specific measurable goals in order to get paid. The project formalized an evaluation procedure to monitor the quality of the professional development sessions, which included gathering feedback from participating teachers and establishing an audit process to identify and replace ineffective instructors.

Similarly, new requirements for teachers were put in place, with teachers expected to attend all of the professional development sessions held for each unit and to get written approval for absences from their principals. Criteria were also established for a reflection paper that each teacher had to submit for review by the teacher's Curriculum Director and the LSC staff.

The teacher guidebook in each unit was upgraded to provide teachers with more specific guidance, including documenting the standards the unit covered and the big conceptual ideas that students needed to understand. Examples of higher order questions that could be used to engage

students in these concepts were provided, along with a pacing guide to ensure that the critical lessons were taught. Some of the supplementary reading materials that had been added to the K–4 kits to promote the integration of science and literacy were removed when it became clear that some teachers were using the reading materials to teach about science rather than doing the lessons.

Finally, the development of a comprehensive assessment system became a major effort of the LSC. The goal was to provide teachers with timely feedback about what students are or are not learning and also to build their understanding of assessments as a way to improve student achievement.

Expanding the LSC to Middle School

The effort to expand to middle school began in 1998 and was driven largely by concerns from district Curriculum Directors. They observed that some of their Grade 5 and 6 students who had had very positive experiences with inquiry-based science were being turned off by what they met in Grade 7 classrooms. The Curriculum Directors saw great value in extending the Coalition process to align the middle school curriculum with the standards and foster the introduction of inquiry-based instruction.

Improvement of science instruction at the middle school level provided very different challenges. While the LSC program was well known and respected by many administrators, the typical middle school science teacher knew little about it; many were strongly opposed to a kit-based approach, viewing it as somewhat childish. Some teachers wanted to hang onto the comfort of a textbook; others, including highly experienced, often outstanding, teachers with science degrees and many additional credit hours, saw no need to change what and how they had been teaching for years.

External pressures eventually helped the process. The results of the 1999 international TIMSS-R test, in which 32 of the 35 Delaware middle schools participated, were released in early 2001. While Delaware was statistically at the national and international average, it still had lower performance than many other states and large consortia. Detailed analyses of the performance of Delaware students on the individual TIMSS released items identified significant gaps in the existing curricula.

The first Grade 8 statewide science scores reinforced the TIMSS findings. These showed that only 42 percent of Grade 8 students were meeting the Delaware Standards, compared to 65 percent of students at the end of Grade 5 and 85 percent at the end of Grade 3—grades where the LSC was being implemented. Financial support for the initiative was provided in the form of a three-year grant from Agilent Technologies to help fund curriculum materials and teacher professional development. The fact that the LSC had already established a Grade 6 curriculum as part of our current program allowed us to focus on Grades 7 and 8.

Based on our experience in the elementary program, we planned to introduce one new curriculum unit each year into each grade. Because the number of commercial inquiry-based

units available was very limited in 1998, the initial effort focused on developing a home-grown Grade 7 unit on Delaware Watersheds and a homegrown Grade 8 unit on Weather. At the same time, other teams were piloting units that were being developed commercially.

Every effort was made to make middle school teachers central to the development and change process. A middle school Lead Teachers group was formed to assist in the process. Teams of middle school teachers reviewed the standards and the recently completed Performance Indicators that define grade-level expectations of student knowledge. They learned in detail what was now being covered in K–6 as a result of the LSC. Elementary teachers were engaged to review specific Grade 5 and 6 curriculum units and share examples of student work to demonstrate what students were learning. The recognition that a favorite Grade 7 topic such as Mixtures and Solutions was now being taught and learned successfully by Grade 5 students forced middle school teachers to acknowledge a need to change.

The program began slowly, with only a limited number of middle schools and middle school teachers participating. With time, the availability of high quality middle school units from commercial sources such as FOSS and STC helped speed up the process. Selected units were piloted by discipline-specific teams and, if needed, adapted to meet Delaware Standards. Content experts from the University of Delaware and Delaware State University were included on each team. The Grade 6 curriculum was upgraded as required to provide a seamless transition through K–8.

The process gathered momentum; as more units moved past the pilot stage, teachers recognized how well the curriculum met the standards and administrators began to push participation. Many of these new units included some technology components that middle school teachers found attractive. Support grew as more teachers found they liked the classroom materials and benefited from the professional development.

Emulating the elementary program, summative assessments were developed and piloted for each unit. The professional development, co-taught by a classroom teacher and an external content expert, were initially offered by the universities as summer courses and qualified for university credit toward a master's degree and certification for those teachers still teaching middle school on an elementary certificate.

As the demand for professional development grew beyond what the universities could provide, non-credit professional development courses were developed that could be offered through the school year to the many middle school teachers who could not attend summer school.

Dealing with Teacher Resistance

Teacher resistance was not a big factor in the early part of the elementary program because there were so many teachers to train that it didn't matter if some didn't participate. It did, however, become more important with time.

Dealing with resistors was mainly a local school problem, and district personnel developed a number of strategies to handle it. The Science Specialist or Lead Teacher would typically keep the principal informed of how many teachers had been trained and who still needed to take professional development, so he or she could get involved if needed. One of the more effective approaches was to take advantage of the high rate of teacher turnover in most elementary schools and focus on engaging all new teachers in science professional development as soon as they started. One district took this an extra step by enrolling newly hired teachers in the professional development courses held before their first school year started.

A large district with a substantial number of teachers who objected to taking professional development (either after school or in the summer) scheduled science professional development as a series of in-service days, which the teachers had to attend.

We found evidence of a tipping point, estimated to be where more than half of the teachers in a school were using the kits regularly. At that point, the science training had become embedded as a part of the school cultural expectations; resistors now became more obvious and felt more pressure to conform.

With increased school accountability and the inclusion of science scores in the process, principals became more actively involved in finding ways to overcome teacher resistance. The licensure regulations adopted in 2001 helped by requiring teachers to take regular professional development.

Improving Student Achievement

Reducing the Gap between Regular and Special Education Students

The LSC began with the principle that all special education students had to be included in science instruction to counteract the practice of pulling these students out of science for remedial work on reading or other subjects. The results were very positive; special education students responded very well to the hands-on science, and their parents became vocal advocates for the science program. The impact was confirmed by the Grade 4 state test results showing that the achievement gap between regular and special education students was lower in science than in any other subject.[2]

Nevertheless, the first year of student testing showed that the achievement of special education students at Grade 4 was still quite a bit lower than that of regular students and that this gap increased in Grade 6 and Grade 8. To attack this problem, the LSC used the test results to identify schools that were making above average progress in raising achievement of special education students. This process provided valuable discussion topics for Lead Teacher meetings at which successful strategies could be shared. The LSC also hired a middle school Science

[2] Student Achievement data are available on the Delaware Department of Education website, www.DOE.k12.de.us. Detailed analyses of the data for K–8 science through 2003 are reported in the final LSC report to NSF entitled A Systemic Partnership to Improve the Teaching and Learning of Science for All Children. The Delaware Local Systemic Change Initiative (Sept 2004) authored by Rachel E. Wood and John W. Collette.

Specialist with expertise in special education to work with other Specialists and to provide professional development to Lead Teachers on techniques for working with special education students. Finally, the LSC initiated a program to recruit special education teachers in every school to take the science professional development along with the teachers they teamed with so that they gained a better understanding of the science content their students had to learn. The NCLB requirement that all teachers be highly qualified has reinforced these efforts and led to a significant increase in the number of special education teachers taking science professional development.

Increasing Student Achievement at the Middle School Level through Teacher Professional Development

The summative assessments provide valuable professional development tools for helping teachers examine how to improve student achievement. The most definitive evidence for the value of this approach comes from an intensive professional development program held for Grade 6–8 teachers that used assessment of student work as the central element. The initial sessions examined each school's student achievement data from the previous year as a springboard for discussions on science assessment reform as outlined by the National Research Council. Teacher questions developed from the data led to discussions of the depth of student understanding and how to measure it. Participating teachers then administered the summative assessment developed for the unit they were teaching to their students. Scoring of these provided a framework for further discussions of the big ideas and central science concepts in the middle school curriculum. The process helped strengthen teacher content knowledge and their understanding of student misconceptions and helped inform instructional improvement.

Sustaining the LSC

In the fourth year, the Coalition developed a new five-year strategic plan to sustain the reform efforts beyond the end of NSF funding. NSF approved a no-cost extension that provided additional time to transition to a sustainable system.

As a first step in implementing the new plan, the LSC leadership was restructured to provide increased attention to the unique needs of the elementary and middle schools and to make more effective use of the varied talents and expertise of the Science Specialists. As a result, the LSC Staff was expanded to include three Science Specialists as Teachers on Special Assignment focused on grades K–5, including one with a Special Education background, and three Science Specialists focused on middle school curriculum and assessment. A Math Specialist was engaged to build links between middle school mathematics and science curricula and teachers.

School districts assumed responsibility for funding Science Specialists and Lead Teachers, and the responsibilities of the district Science Specialists were changed so that they could devote more time to support teachers in the classroom and to strengthening teacher professional development.

The statewide Science Resource Center took over full responsibility for logistic support of science kits, a task that previously been handled by the Specialists. In addition to sustaining the

K–8 program, the Coalition agreed to expand to high school. This meant adding the three Vocational Districts to the Coalition. A new five-year Memorandum of Understanding was developed for the enlarged Coalition and signed by all districts and other partners. This agreement represented a significant endorsement of the Coalition program by its most important customers.

Expanding to High School after the LSC

The high school program began in 2000 with the support of an NSF planning grant and a DuPont grant. The Coalition chose to focus initially only on the Grade 9 curriculum as an entry point for working at high school, because the context at high school had so many unique issues.

First, there was strong resistance to an externally "imposed" curriculum by many teachers who, as content experts, had significant autonomy and influence in their schools. Second, there was variation in the organization of the curriculum (e.g., some districts started the high school sequence with physical science in Grade 9 and biology in Grade 10, and others the reverse) and considerable uncertainty about how the high school curriculum should be organized. Decisions would have to be made about what should be covered in Grades 9–11 and what should be left to Grade 12, given that the Standards covered Grades 9–12 while the state science test was administered at the end of Grade 11. High school teachers were already dealing with these issues, but each district/school was proceeding independently. The 2000 state test results, showing that only 48 percent of the Grade 11 students were meeting the standards, increased the sense of urgency.

The Coalition's high school program was greatly facilitated by the Science Van project, a Joint Department of Education/Delaware Foundation for Science and Mathematics Education program initiated in 1995 to speed up the introduction of modern computer technology into high school science labs. Competitive grants were offered to encourage schools to establish their own computer labs. The combination of professional development, classroom assistance, and computer-probe investigations proved very successful and created a sizable group of high school teachers throughout the state familiar with and committed to inquiry-based science. By the time the Coalition's high school curriculum program started, over 30 investigations had been developed covering such topics as photosynthesis, cellular respiration, velocity, acceleration, freezing and melting, acid-base titration, sickle-cell disease, and water quality. Further, virtually every high school in the state had established and stocked a computer/probe lab for science investigations.

The first objective of the Coalition high school program was to develop an inquiry-based Grade 9 curriculum that would ensure a smooth transition from the K–8 curriculum to the first year of high school. The curriculum was redesigned to focus on physical and earth science topics using three distinct curriculum units (Motion, Force, and Mechanical Energy; Foundations of Chemistry; and the Earth Systems). Some of these were based on commercial units; others were developed locally. Grade 9 teachers were actively involved in analyzing the standards, selecting the materials, and developing and piloting each unit. Every unit includes a summative assessment.

As the Grade 9 program became established, work was started on three Life Science units for Grade 10 (Nature of Science and Evolution; Chemical Biology; and Transmission and Expression of Genetic Material). Many of the inquiry-based activities developed by the Science Van project were incorporated into the curriculum, which helped gain the support of many key teachers and speeded up the successful dissemination of the curriculum. By 2006, many Grade 9 and 10 teachers had completed professional development in their units, with few schools not participating.

The Grade 11 and Grade 12 curricula include a Grade 12 Biotechnology based unit (being developed in cooperation with the Delaware Biotechnology Institute at the University) as a capstone high school experience, blending knowledge and skills from grades 9–11 in a research-based format that ties to higher education.

The Delaware Science Coalition: 2006 Status

The Delaware Science Coalition now serves all districts in the state (as well as 16 Charter schools), all of which have continued to support Science Specialists, with increased emphasis on secondary Specialists.

In 2004, the Science Resource Center was incorporated into a larger Education Resource Center (ERC) that includes laboratory facilities that are in constant use for secondary teacher professional development and other teacher meetings. The ERC has become a multi-million dollar operation that is the most visible and well-known symbol of the joint state, district and community commitment to improving student achievement in science. It currently stocks 8,900 kits and, last year, distributed 21,000 units to more than 5,000 teachers. The ERC houses the state science education staff including the Science Van project and Teachers on Special Assignment from districts. It also houses the state Information Technology group, which facilitates introduction of new educational technology into the science program.

The access to a wide range of curricular materials that the Education Resource Center provides to teachers, and its dependability, have been important in gaining teacher support for the science program at all levels. It also ensures equity across the state. The Center has formalized a fee structure with the school districts and charter schools that will allow it to continue to provide both the materials and the professional development needed for all teachers of science.

Student achievement has increased in all grades since the Delaware State Testing Program began in 2000. Achievement is highest in Grade 4 having increased from 85 percent of the students meeting the standard in 2000 to 92 percent in 2005. The achievement gap between Whites and African Americans in Grade 4 has decreased from more than 20 percent in 2000 to less than 10 percent in 2005. A detailed study of the 2002 Grade 4 data showed that the achievement gap in science is lower than in other disciplines.

Student achievement at Grade 8 has increased from 42 percent to 53 percent of students meeting the standard. However, the achievement gap between White students and minorities and between special education and regular students is much higher that it is at Grade 4.

Student achievement at Grade 11 increased slowly from 48 percent meeting the standard in 2000 to 54 percent in 2004. In 2005, it jumped encouragingly to 59 percent. However, the racial gap is still much higher than in Grade 4, indicating that there is still much to do**.**

The Role of Business

The business community was an important factor in the success of the Delaware LSC Led by DuPont, the Delaware business community played a major role in education reform in the early 1990s by supporting and facilitating the development of the Delaware Standards. After the standards were approved, a number of local businesses, working either through the Delaware Foundation for Science and Mathematics Education or individually, built a strong, effective partnership with the K–12 community by their active involvement in the LSC and their general support for implementation of the science and mathematics standards.

This partnership (including DuPont, Astra-Zeneca Pharmaceuticals, and Agilent Technologies, a former division of Hewlett Packard) continued after the LSC funding ended, with increasing attention to secondary science education. As a result, business and the workforce perspective are well represented on the Science Coalition Steering Committee. The process keeps business informed about the progress and the difficulties of developing a challenging secondary science program while providing the K–12 community with access to leading edge science and scientists.

More recently, the partnership has broadened to include the Delaware Biotechnology Institute at the University with increased emphasis on preparing students for post-secondary science, technology, engineering, and mathematics education.

Specific examples of some of the externally supported Coalition initiatives include:

Development of a more rigorous Grade 7 Genetics unit with support of DuPont and the Delaware Biotechnology Institute;

Development of summative assessments with support from Agilent Technologies;

Support for the high school curriculum such as the development of a Grade 12 Astronomy/Physics unit and an Ecology/ Engineering Physics unit that will be used mainly in Vo-Tech schools;

Support for a program to train community college students in the high school units who can then serve as classroom aides to high school science teachers;

Funding for NSTA workshops by DuPont so Delaware teachers can present their experiences with these assessments to national audiences;

An annual one-day Biology teacher workshop that supports the Coalition curricular units and allows high school teachers to meet and talk with Biotechnology Institute researchers; and

A commitment by the Biotechnology Institute to assist in the development of a Grade 12 capstone experience for students aspiring to science careers.

DuPont uses the Delaware science program as a model and a resource for its science education outreach with school districts in other locations throughout the country where it has a significant community presence. DuPont has also provided laboratory safety training to Coalition Lead Teachers and Science Specialists and recently inaugurated an annual Community Science Day to celebrate the ongoing partnerships between K–12 teachers and research scientists in Delaware.