Roberta S. Matthews
and the Woodrow Wilson National Fellowship Foundation

The Power of Partnership:

How Early College Creates Rich Contexts for Engaging Faculties

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FOREWORD

Like each of the 13 intermediary organizations in the Bill & Melinda Gates Foundation's Early College High School Initiative, the Woodrow Wilson National Fellowship Foundation has brought its own particular approach to this nationwide effort.

Woodrow Wilson's six-plus decades of working with baccalaureate institutions nationwide positioned the Foundation not only to create Early Colleges—small schools that blend college and high school in ways that challenge traditional notions—but to do so in a way that engages college and university faculty intimately in the day-to-day work of the school, and that brings high school teachers into direct, ongoing conversation with their counterparts in higher education. The partnerships behind Woodrow Wilson Early Colleges bring these high schools together with community colleges, four-year liberal arts colleges, and major national research universities, with active participation from all partners in curriculum planning, instruction, and student support. The end goal, as with Early College High Schools throughout the national network, is to make college real for students who, because of the failures of traditional high schools in high-need areas, would otherwise face the longest of odds in getting to and through college.

Of the rich school-university partnerships that have become the hallmark of Woodrow Wilson Early Colleges, the Science, Technology, and Research (STAR) High School at Brooklyn College offers one of the best models. Created in 2003, STAR was one of the first Early College High Schools funded by the Bill & Melinda Gates Foundation. It graduated its first class in 2007 with an extraordinary 95% graduation rate.

Much of the secret to STAR's success lies in the model of collaboration described in the following report by Roberta Matthews, under whose leadership as Provost of Brooklyn College STAR was created. Her analysis of the experience of creating and supporting these partnerships offers a valuable template for other institutions. While preliminary results are encouraging, we will know a great deal more over time about Early College's ability to change the educational landscape for underserved students. Thanks to Dr. Matthews' work, we have an excellent guidepost for those who wish to follow this same path.

The Woodrow Wilson Foundation extends its thanks to the Bill & Melinda Gates Foundation, whose commitment to American education has made schools like STAR possible and has given Woodrow Wilson the special privilege of working with them. We also owe a debt of thanks to Dr. Matthews, recently retired from Brooklyn College, for the energy and dedication that have made possible the work she describes in these pages. We aspire to make the Foundation's efforts in educational practice useful to leaders and institutions nationwide, and trust that Dr. Matthews' insights will help make the Early College High School model more accessible to schools and colleges across the country.

Robert J. Baird
Vice President, School-University Partnerships
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This monograph could not have been written without the faculty at Brooklyn College and teachers at STAR ECHS who cheerfully agreed to be interviewed, some several times, and who often corresponded with me afterward to address specific issues. Their loyalty to their students, dedication to the teaching of science and mathematics, and their affection and respect for each other is a model of best practice and a credit to their commitment to their disciplines and their craft. The energy they give to the various aspects of their work, and the creativity with which they link research, teaching and outreach demonstrates the best work of scholars and teachers. It was a pleasure to work with them over the years, and it has been my pleasure to re-visit our shared work with them.

At Brooklyn College: Konstantinos Alexakos, Kathleen Axen, Arthur Bankoff, Jennifer Basil, Vincent Campese, Ray Gavin, Chaya Gurwitz, Louise Hainline, George Moriber, Sophia Perdikaris, Theodore Raphan, Dacota Stewart-Dick, David Stone, Rosamund Welchman, Vanessa Yingling. At STAR ECHS: Paul Anderson, Calvin Byers, David Connelly, Henrietta Coursey, Raisy Greenbaum, Daniel Holmes, Phil Jeffreys, Renee Kozlowski , Joan Moseley, Marcus Watson, Debbie Win. With special thanks to Susan Forman and Morton Slater (Gateway Institute) whose insights enrich this paper. Any errors or misstatements are mine alone.

Roberta S. Matthews

ABOUT THE AUTHOR

Roberta S. Matthews holds a doctoral degree in modern British and Irish Literature. She served as Provost and Vice President for Academic Affairs at Brooklyn College from 2001 though 2007. During her time there, she played a key role in devising a new strategic plan, envisioning the new core curriculum and creating new undergraduate and graduate programs. She launched the Center for the Study of Brooklyn and the Magner Center for Career Services. The Center for Teaching grew in prominence and effectiveness. As Provost, Matthews oversaw the hiring of over 150 new faculty and developed a rich orientation program for them. In 2003, in partnership with the NYC Department of Education and the Gateway Institute, and as part of the Bill & Melinda Gates Foundation initiative, she established the Science, Technology and Research (STAR) Early College High School. STAR graduated its first class in June 2007, with 72 of its original 76 students receiving their degrees.

Before coming to Brooklyn College, Dr. Matthews served as the founding Director of the CUNY Honors College: University Scholars Program. During 1999-2000 she served as Interim President at LaGuardia Community College / CUNY. Prior to that, she was Vice President for Academic Affairs and Dean of the Faculty at Marymount College in Tarrytown, New York. Matthews spent many years in high-level administrative positions and as a Professor of English at LaGuardia Community College. Her experience spans public and private, senior and community, small and large colleges.

Dr. Matthews has published widely and offered workshops on learning communities and active learning at colleges and universities across the country. Throughout her career, she focused on curriculum and program development, school-college collaboration, and international education, always dedicated to achieving educational excellence through intentional and proven reform efforts. She retired in June 2007 and continues to serve on education policy and advisory groups.

THE POWER OF PARTNERSHIP: HOW EARLY COLLEGE CREATES RICH CONTEXTS FOR ENGAGING FACULTIES

Roberta S. Matthews

INTRODUCTION

Today the United States faces complex education challenges: growing calls for a substantial increase in baccalaureate degree graduates in the next twenty years; a focus on the high cost and lengthy time-to-completion of a college education; and a well-documented, critical need for the production of more math and science majors.[1] Science educators such as Elaine Seymour (Seymour and Hewitt, 1997) and math educators (Schoenfeld, 2004; Greenberg and Walsh, 2008) involved in the Math Wars (second only to the Thirty Years War in length and intensity) suggest the scope of the problem.

As Michael Kirst points out, the disjuncture between K-12 and higher education is rooted "in history and encompasses governance, academic standards, notions of accountability, roles of teachers, finance, communications and organizational culture" (Kirst 2008). In this context, the Early College High School (ECHS) movement is, on one hand, the canary in the mine shaft, and, on the other, the light at the end of the tunnel.

ECHS is the canary in the mine because it challenges most of the assumptions that have driven secondary and postsecondary policies. Each of these sectors has gone its separate ways historically, with slight or no consideration of how its actions would affect the other sector, its potential partner. Little thought was given to the joint creation of mutually effective policies that would align teaching and learning in high school and college. The success of the Early College High School movement depends heavily on open cooperation and close coordination between the secondary and postsecondary sectors. Through this fundamental commitment to integrating the two sectors, ECHS identifies and challenges, by its very existence, those policies and practices that impede cooperation and preclude collaboration.

At the same time, ECHS is the light at the end of the tunnel because its promise of success depends on secondary and postsecondary faculty and administrators working together to achieve the common goal of educating the students they share. Creating and operating an Early College forces both sectors not only to work together on curriculum alignment but also to confront daily an array of challenges: deeply held beliefs on both sides about autonomy; rigid sector-bound financial policies that are anathema to blended and flexible approaches to learning; heroic attempts to work within a system that in reality must be fundamentally changed; and outworn assumptions so deep and so old that they routinely shape (and distort) actions and approaches that need to be questioned and revised.

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[1] See, for instance, such widely publicized national reports as *Rising Above the Gathering Storm,* Committee on Prospering in the Global Economy of the 21st Century [Augustine *et al.*], (Washington, D.C.: National Academies Press, 2005 <at http://www.nap.edu/catalog.php?record_id=11463 >); *An American Imperative, The* Business-Higher Education Forum (Washington, D.C.: The Business-Higher Education Forum, 2007 <at http://www.bhef.com/solutions/anamericanimperative.asp>); and *Before It's Too Late,* The National Commission on Mathematics and Science Teaching for the 21st Century, (Washington, D.C.: U.S. Department of Education, 2000 <http://www.ed.gov/inits/Math/glenn/index.html>).

In this context, the experiences of high school teachers and college faculty at the Brooklyn College Science, Technology and Research (STAR) High School, a Woodrow Wilson Early College, are instructive. These teachers and faculty often teach together, literally, in working with STAR's students. The daily workings of the relationship between the school and the college, by their very nature, place challenges in the forefront and demand that they be addressed. For this reason, the Early College High School movement can lead—in fact, shape—the transformation of secondary/postsecondary relations in the United States.

While the Brooklyn College/STAR ECHS experience offers general insights for strengthening students' college readiness, there is particular value in STAR's lessons on delivery of introductory math/science courses, which one faculty member characterized as "the killing fields" . The school's definitive challenge, and the hallmark of its success, has been to ensure a seamless and engaging experience for students in math and science. This paper, based on conversations with Brooklyn College faculty and STAR teachers, will focus on their rich associations in science, and will touch on the issues surrounding the teaching and learning of mathematics, including shared efforts to develop curriculum, create productive relationships, define meaningful professional development, shape compatible assessment approaches, design effective student supports, and, overall, make college a daily and doable reality for students who might otherwise consider it out of their reach.

MAKING HIGH SCHOOL A COLLEGE PRIORITY

Any effort to create an Early College High School faces pervasive and varied obstacles. Because the ECHS/college partnership challenges accepted notions and works against custom and practice, overcoming these obstacles can be daunting.

The first administrative task for the postsecondary partner, then, is to clearly define its own strong rationale for becoming involved in an Early College High School—one closely related to the college's or university's mission, goals, and aspirations. At Brooklyn College, defining this rationale depended heavily on campuswide contacts and outreach. The first step: a meeting, convened by the Provost, with carefully chosen chairs and directors of math and science programs. All would have a stake in the success of an Early College High School; all would understand the significance of creating a possible conduit for bringing bright, motivated black and Latino potential STEM students to the College.

This group was a quick study—it took them no more than a few minutes to grasp why creating STAR was a good idea and to support its creation. Six years later, many of these same faculty are still involved with the students and teachers of STAR. Indeed, at both the high school and the college, it is primarily the science faculty who have the longest-standing and richest associations with their colleagues at the other end of the STAR pipeline. It seems fair to say that Early College was in the institution's DNA.

Once the Provost had secured the support of strategically placed chairs and administrators and had developed a list of likely leaders among them, the new Early College liaison made the first contacts to bring faculty and teachers together. This liaison position, essential to the success of an Early College High School,was filled, in STAR's case—and is ideally filled—by a person who has had experience at both secondary and postsecondary levels and is equally comfortable in

both venues. The STAR liaison was instrumental in a multipronged campus outreach effort from the Office for Academic Affairs, drawing on institutional priorities, relationships with individual faculty, appeals tailored to faculty and departmental interests and personal commitments, and serendipity. These combined approaches convinced key administrators and faculty to self-select into the program.

In having faculty and administrators who are willing to help create and sustain an Early College, Brooklyn College is not unique, nor are its faculty rare human beings with exceptional reasons for working with an ECHS. Rather, as the sampling in the sidebar (*below*) indicates, their motives were so varied and so common that they can be found on any campus. Hence, recruiting faculty into an Early College initiative depends on seeking out what inevitably exists, as opposed to wringing one's hands over its absence.

Some Brooklyn College Faculty Engaged With STAR: A Sampling

- A well-funded distinguished professor and highly respected research scientist, on the basis of a chance encounter with a former colleague involved in establishing STAR, became intrigued by the Early College concept and announced immediately "I'm in."
- A young, well-funded research scientist, motivated by her experience with an after-school enrichment program at the Museum of Natural History, wanted to give back to students in the community that surrounded the college.
- An untenured, funded scientist heard as a mandate a phone call from the STAR liaison beginning, "The Provost would like you to become involved." Her initial reluctance—based on a previous negative experience with high school students—was overshadowed by her subsequent, positive association with STAR.
- Two recently retired faculty, one from the Chemistry Department and one a math educator from the School of Education, spent endless hours at STAR when it first opened its doors. They are still involved in working one-on-one with new teachers on pedagogy and curriculum development.
- The chair of the Anthropology Department, always seeking volunteers for archeological digs, responded swiftly and enthusiastically to a request for a for-credit summer dig in Brooklyn for STAR students. The Brooklyn dig, which teams STAR ninth-graders with college students, has become an annual offering.
- A former chair of the Biology Department joined the project because of his conviction that interest in science begins well before the first year of college and needs early cultivation.
- More recently, faculty from various science departments have been brought on to implement the NSF CCLI Spark grant. Their intrinsic satisfaction in working with STAR students and teachers has resulted in quality experiences and long-term commitments.

If motivation matters, so too do incentives. In higher education, where reassigned time is a coin of the realm, college professors involving themselves in an Early College must be compensated in one way or another and their participation rewarded in tangible ways. They cannot be asked to teach ECHS students unless the time they spend doing so is formally acknowledged. Teaching ECHS students in a college class—whether placed in a class with college students or enrolled in

a section created particularly for them—is straightforward, since it fits into standard faculty workload calculations. But participation in other activities—for example, at Brooklyn College, the NSF-funded CCLI Spark workshops for first-year STAR students (*see sidebar, p. 5*)—means that the time faculty spend developing and offering such activities must be rewarded. Most faculty, especially young faculty under pressure to produce as working scientists and scholars, must be able to incorporate ECHS work into their standard workload. Reassigned time is the best way to ensure participation, unless non-teaching Early College work may be factored into or substituted for—and valued as much as—standard teaching obligations.

As important, given the rewards system and culture of institutions of higher education: Faculty who are not tenured full professors must have palpable proof that their ECHS participation, whether through curriculum development, teaching, or research, will be rewarded come tenure time. As one associate professor relatively recently involved in STAR noted, he had decided early on in his career to avoid school-college cooperation activities because of the travel time involved and its impact on the research by which he would be judged for tenure and promotion. He eventually became involved in STAR because it was an on-campus experience.

MAKING STEM AN EARLY COLLEGE FOCUS

If it is complicated to create an Early College that genuinely engages the higher education partner and its faculty, creating an Early College that focuses on science and math is even more challenging. At the same time, however, significant supports are available for leveraging, and the outcomes are rewarding.

At the college level alone, science is expensive; science outreach to secondary schools is all the more costly. Science functions on the apprentice model. Science faculty are pressured to bring in grants to fund their labs, and those labs must accommodate not only research but also instruction and mentoring for postgraduate students, graduate students, undergraduate students, and secondary students from various local high schools and various national science recruitment initiatives such as the Intel Student Research Contest, NIH's Minority Access to Research Careers (MARC) program, and NSF's Louis Stokes Alliances for Minority Participation (LSAMP) program. Given these existing pressures, the addition of yet more students from an Early College requires funding and logistical decisions that increase with the complexity and potential liability associated with the lab's activities.

One faculty member, though committed to bringing students to visit his lab, was clear about not being able to accommodate large groups:

> We had [discussed] bringing [STAR Middle School] students to my lab for demonstrations of experimental techniques that they can only read about in their text. For example, when they learn about proteins and DNA it would be very interesting to have them see some of the techniques in action….But I think the major problem is the size of the class. We would have to conduct multiple demos for smaller groups.

Such on-the-ground realities led STAR's founders to scale back their original expectations for linking a large number of STAR students with Brooklyn College scientists in working labs, though both the school and the college continue their efforts to bring in as many students as possible.

While Early College students' access to some kinds of college science instruction has practical limits, college faculty still can offer other learning experiences that exceed what is possible in high

school. They tend to have more access than their secondary school colleagues to more varied resources and to have more experience and support for writing grants that will enrich ECHS students' experience with science. (The sidebar below offers examples of federal grant funds already in place at Brooklyn College—and many similar institutions—that can help to support Early College work.) Both in identifying new resources and husbanding available but sometimes shrinking resources, colleges must organize themselves to take advantage of what is already in place and what they may acquire to support college/ECHS work. As a variation on this theme, Brooklyn College established a "Braiding Resources Committee" that brought all players together to coordinate outreach to schools efficiently and rely on each other when the inevitable cuts came.

Start-up funding for STAR—awarded by the Woodrow Wilson National Fellowship Foundation, as one of the Bill & Melinda Gates Foundation's intermediaries for the national Early College High School initiative—allowed the school to develop in visionary ways, without cramped accommodations to existing funds. As these seed funds were expended, several NSF grants helped to create new learning resources, or expand already existing resources, for both STAR students and Brooklyn College students and faculty.

- An NSF CCLI grant supported and enriched high-quality hands-on science workshops on campus for first-year STAR students. These Spark Workshops—"designed to pique the students' curiosity and light a spark of interest"—had been a feature of the Brooklyn College/STAR partnership from the very beginning. The NSF grant facilitated fall introductory sessions that gave students a base of experience for their spring workshops; stabilized small class size; enabled high school teachers to co-teach the workshops with their college counterparts; provided reassigned time for faculty to develop and teach the first-year Spark Workshops and upper-level college courses; and funded supplementary, out-of-class tutors for STAR students attending college classes that were part of the CCLI grant.
- An NSF STEP grant funds a Shadow Day during which STAR sophomores attend college courses. STAR students discover, for example, that college students look just

Some NSF Programs at Brooklyn College Employed in STAR Collaborations

The Course, Curriculum, and Laboratory Improvement (CCLI) program seeks to improve the quality of STEM education for all undergraduate students. The program supports efforts to create, adapt, and disseminate new learning materials and teaching strategies, develop faculty expertise, implement educational innovations, assess learning and evaluate innovations, and conduct research on STEM teaching and learning.

The Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) seeks to increase the number of students (U.S. citizens or permanent residents) receiving associate or baccalaureate degrees in established or emerging STEM fields.

The **Graduate Teaching Fellows in K-12 Education (GK-12)** program provides funding for graduate students in NSF-supported science, technology, engineering, and mathematics (STEM) disciplines to acquire additional skills that will broadly prepare them for professional and scientific careers in the 21st century. Through interactions with teachers and students in K-12 schools and with other graduate fellows and faculty from STEM disciplines, graduate students can improve communication, teaching, collaboration, and team building skills while enriching STEM learning and instruction in K-12 schools.

like they do and that students are allowed, even encouraged, to ask questions in college courses. This early link between high school and college students delivers strong, early lessons about access and possibility.

- In addition, an NSF GK-12 grant brings doctoral students to STAR. The GK-12 Fellows' admiration of the STAR chemistry teacher's classroom skills were matched by his appreciation for their presence in his classroom: they supervised significant small-group lab work, enabling him to give his students more and better research projects.

Finally, there are potential (as yet untapped) resources available to STAR teachers and students: the association between Brooklyn College School of Education and the National Park Service educational facilities at Fort Wadsworth, the longstanding association between the School of Education and the Museum of Natural History. Always, there will be the systematic inclusion of Early College High Schools in science or math-education related grants that faculty bring to the college.

CREATING PROFESSIONAL DEVELOPMENT AND MENTORING RELATIONSHIPS

Planning Retreats and Ongoing Meetings

Avenues for sustained contact between faculty and teachers must be developed and modified according to circumstances. During STAR's first three years, annual retreats brought together groups of up to 30 faculty and teachers—some regular attendees, some one-time attendees—for a day-and-a-half-long meeting, including an overnight stay. These retreats were key to the development of STAR, as they not only introduced faculty and teachers to each other but also gave them sustained professional and personal time to work together and to get to know each other. The theme "Adapting to Brooklyn," hatched at the first retreat, has developed as a comprehensive cross-disciplinary theme at STAR over the years.

Retreat encounters ranged from small defining moments to deep revelations about the value of interaction between faculty and teachers. During one casual conversation between a seasoned faculty member from the Brooklyn College biology department and STAR's new biology teacher, the faculty member mentioned a textbook he liked. The teacher agreed enthusiastically, noting that he was using the text and liked it very much indeed, but could not find the accompanying CD. At that point, the faculty member reached into his shirt pocket and handed the elusive CD to his new colleague.

A new college faculty member in kinesiology, looking back on the retreats, felt she had learned more from the high school teachers than they from her. She personally learned how to make the material she was teaching more interesting, to define the threads of her presentations: "I came away from the sessions with high school teachers thinking that I had to improve how I was going to package what I thought was important. It was good for me to work with them… I thought they were doing a good job."

As programs and relationships became more established, the need and desire for such retreats diminished. Their magic had evolved into the everyday collaboration of faculty and teachers around shared workshops, classes, and students that has become part of the fabric of the Brooklyn College/STAR relationship. By the fourth or fifth year, annual retreats had been replaced

structurally by various interventions, such as a sustained series of curriculum development meetings, held over the course of a semester, where faculty and teachers in similar disciplines defined their curricular goals for students and addressed the potential of and obstacles to their shared endeavor. Over and over again, faculty and teachers cited these focused, sustained conversations as important encounters that yielded significant curricular and operational results, providing opportunities for professors and teachers who were teaching the same students to agree on necessary action steps, even within the confines of standardized curricula and potent custom.

One small example of how sustained conversations result in change: a joint approach to the question of students' handing in late assignments. High school teachers, who are rightfully encouraged to reach out and support students, pursue students who do not hand in assignments, and they grade the assignments, often without penalty, when they are finally submitted. Their (laudable) goal is to keep students on track to graduation. But, from the point of view of college faculty, such practices create bad habits that directly contribute to failure in college. A student in a college chemistry course with at least 100 students will not be allowed to submit late work, and is often shocked when late work is refused (despite statements in the syllabus to that effect). To change practice at STAR, the science teachers prevailed upon college faculty to write a letter to the principal asking that the practice of pursuing students for late work and then accepting and grading it without penalty be significantly modified. Teachers felt they needed the support of the college to change this high school practice that was resulting in short-term gains but long-term losses for students.

Students at STAR Early College High School learn about working independently with library resources. (Photo: R. Axinn, teacher at STAR)

This simple adjustment would never have surfaced if college faculty and high school teachers had not been talking to each other. Above and beyond assessing the relative merits and drawbacks of secondary as opposed to postsecondary approaches, the time has come for secondary and postsecondary educators to find common cause and work together to align curriculum while also preparing students for the challenges to come in each successive (ideally seamless) year studying science and mathematics.

Joint Projects and the Bigger Picture

If ongoing meetings between college faculty and high school teachers—clearly a necessity in planning school curriculum and practice—are also key in professional development, so too are shared projects. Work done under the CCLI Spark grant awarded to Brooklyn College by NSF required close connections between high school teachers and college professors, leading to still larger effects of cooperation and collaboration. Professional partnerships have developed based on clear understandings of how to engage students more fully in science and prepare them better to complete high school graduation requirements.

A biology professor honored for her excellent teaching by Brooklyn College now works closely with the STAR's ninth-grade Living Environment teacher, one of the school's original teachers, in a CCLI Spark seminar. The biology professor considers her partner a wonderful teacher, and says she has learned a great deal from him about how (and how much) to present new materials. She

works closely with her partner teacher so that STAR students' experiences in her Spark lab map onto the Living Environment curriculum. For her, co-teaching is a value-added experience that enriches both the Spark seminar and the Living Environment class by giving students long-lasting creative and intellectual tools.

This professor, who sees her role as one of enrichment and development, believes that one long-term goal of such school-college collaborations should be the creation of a comprehensive science enrichment timeline, with college experiences mapped onto the required high school curriculum and Regents preparation experiences. Such an approach, she argues, enable STAR students to learn scientific concepts as tools to apply in any course (since, as she points out, the scientific method is universally useful and applicable). Characterizing her STAR students as "bright and engaged… and rising to whatever level is set," she nevertheless notes a major problem with how high school science is taught: When asked to respond to the simple question, "What is your hypothesis?" students learn that there is a right answer to present when they hand in their work—indeed, if they are "wrong," they conscientiously white out their original hypothesis and put in the "right" one. But trying to provide the "right" hypothesis as an answer does not prepare these students for real science, the professor argues, since in actual scientific research, so many hypotheses are "wrong."

As a woman scientist, the same biology professor understands the feeling of being an outsider and has identified standard practices in science classes and labs that reinforce that feeling. She goes out of her way to relate science to the lives of STAR students and to make them feel that they belong in science. Since STAR students constantly ask her what it is like to be a woman in science, she is aware that her presence in her lab makes a huge difference in how these students perceive themselves and their futures. This perception suggests both a model and a possibility for other institutions that seek to attract and hold women and minority science students (Seymour and Hewitt, 1997).

During an interview, this professor also noted the importance of the Brooklyn College STEP program and Brooklyn College student tutors who work in the Spark program, and suggested that a school-college science club be created. She exemplifies the thoughtful faculty member who understands that reaching out to young non-traditional students and encouraging them to enter the sciences requires multiple strategies. Indeed, a common refrain among STAR middle school and high school teachers and Brooklyn College professors was the necessity of facilitating visits to the science labs in various venues, as well as the need to exploit what a middle school teacher characterized as the "wow factor" of science in younger students to develop and hold their interest as they move along.

The STAR Living Environment co-teacher believes that, when a small group of students focuses on one small piece of the universe—in this case, crayfish—and on the opportunity to design experiments and think about possible results, students get a much more intense experience of science than is possible with the breadth of coverage dictated by the Living Environment course. Although the "elegance of experimental design" is theoretically part of the Living Environment curriculum, the opportunity for students to develop their own questions and to do hands-on work related to their own ideas is not. In his Living Environment class, he has to be so directive for students to get it "right," according to the curriculum standards, that experiments are reduced to a cookbook experience. In the Spark collaboration with Brooklyn College, these same students

can "muck around" and talk about what they are doing. From his point of view, the Spark seminar is more authentic and, because it is laid out so clearly, leaves room for real experimentation. It is therefore a professional development opportunity both for him and for the STAR students, since neither teacher nor students have time in their high school science class "to go out and play" (literally and intellectually) with science.

For professors with limited experience of first-year high school students, the Spark seminars can constitute a kind of culture shock. For instance, not realizing that young students love "take-aways," a professor of nutrition was surprised when her seminar students insisted on taking home the 99-cent plastic measuring cups she had purchased for an experiment in order to measure quantities of food in their own kitchens. On another occasion, to explain how fat is digested through its emulsification in water by bile, she had the students prepare vials of vegetable oil to which they added water with blue food coloring in it. The vials—which enabled students to see the liquids separate, combine after shaking, and then re-separate—looked like little lava lamps. The students insisted on bringing their vials back to STAR to show their friends. Having discovered that these young students need and want "goody bags," this professor underwrote the cost of these items herself in the hope that, when students took the measuring cups home or the vials back to STAR, they would talk about what they had learned and engage their families and fellow students.

From this professor's point of view, the developmental differences between first-year high school students and first-year college students made it all the more critical to involve STAR teachers closely. During the fall semester, she had offered two large introductory workshops for STAR students—part of the Spark program which helps students choose the spring seminar that most interest them—and believed that the STAR teachers' participation was key. When the teacher was engaged, had prepared the class, and had promised follow-up assignments after the large seminar, the students were engaged; when the teachers treated the session as time off, so did their students. Indeed, it was an English teacher who incorporated the large seminar into his own classwork and kept pointing out to the students how this experience was giving them a taste of college. He subsequently became the co-teacher of the smaller spring seminar, helped create interactive activities, and completed all the lab work with the students. His involvement and commitment were much appreciated and contributed directly to the success of the class.

There and Back Again: A Mentor on Both Sides of the Fence

One unique and important asset to the Brooklyn College-STAR collaboration has been a retired chemistry professor who began as a high school teacher. This scientist's career as a college professor was marked by a commitment to working with secondary school colleagues and students, and his work is legendary throughout the borough.

At STAR, the retired professor has worked tirelessly with science teachers since the school's inception, making a tremendous difference in the success of new science teachers. In addition to keeping everything in perspective, the older professor provided materials, advice about good classroom management, and general encouragement. One of the STAR teachers who benefited from this senior mentor's guidance—and who had himself characterized the first year of teaching in a New York City school as "one of the worst experiences you can go through"—has subsequently advised every new colleague to establish a relationship and pay attention to the retired professor, who continues to visit STAR once or twice a week. Since the professor knows

that it takes years to become a good teacher, he helps new teachers survive and learn over an extended period.

Respectful of his colleagues and recognizing their strengths, this retired chemistry professor has taken pride in working not only with new STAR teachers, but also with the school's experienced science teachers. He points to the creation of "a wonderful set of review questions" for the chemistry Regents as one product of such collaboration. He lists, as proof of the power of sustained relationships between Brooklyn College and STAR, a series of other special initiatives, many facilitated by the Early College liaison/coordinator: developing yearly outlines with topic sheets and curriculum review for high school science courses; showing new teachers how to structure tests; offering workshops at the college for STAR teachers; setting up an early-alert anecdotal system to refer underperforming students to the guidance counselors; helping to develop a summer chemistry prep course for STAR students before they enter college chemistry; working to establish ways to reward STAR teachers at the college by offering them college courses to teach during the summer or special research grants. Noting also that the College recruits minority Honors students to tutor STAR students and that six of its science departments are involved with STAR, he characterizes the Brooklyn College/STAR partnership as a "pretty complete integration of curriculum, workshops, meetings, research, and job opportunities."

TEACHING AND LEARNING: THE VALUE OF SCHOOL/COLLEGE PARTNERSHIPS

Collaborating Around Obstacles to Teaching and Learning

As fruitful as college/high school partnerships can be for professional development, the faculty and teachers at STAR found, at least initially, that structural challenges and systemic differences between college and high school can also confound efforts at collaboration. At the same time, the strength of their shared commitments and joint efforts often led to innovations in teaching and learning that helped to offset or overcome some of these obstacles.

School-college collaborations face two main structural challenges to teaching and learning: the impact of standardized testing on the quality of curriculum and instruction in high school and the lack of alignment between high school and college preparation and expectations. Ultimately, the two inform each other.

In New York State, all students must pass the standardized state Regents examinations in the sciences in order to graduate from high school. While neither teachers nor professors dismissed the Regents exams outright—some, in fact, expressed admiration for their development and goals—it is clear that the exams' unintended consequences warp students' learning experience and have important implications for the study of science.

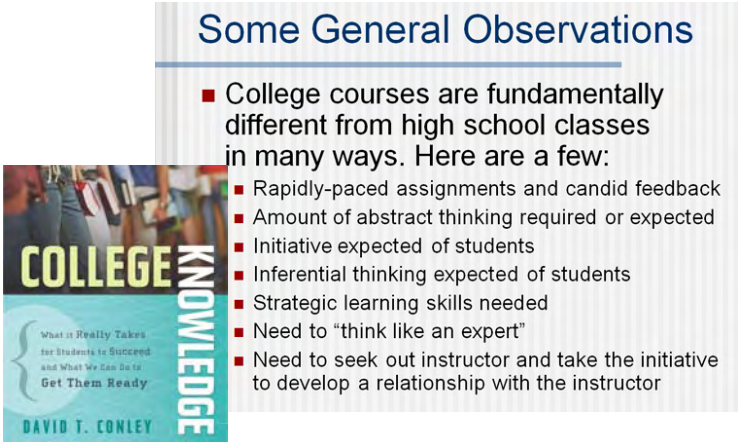
By their very existence the Regents exams, looming at the end of a semester's or a year's study, shape the curriculum and allocation of time in a class. Science teachers begrudged time spent getting through the broad, shallow curriculum mandated by the tests. They believe that students need more time and experience in science labs, learning to apply lab skills and mathematical functions in a variety of situations. Especially as they developed relationships with college professors and saw for themselves how poorly matched high school practice was with the

performance expectations of college professors, teachers expressed frustration with a tight curriculum that precluded attention to developing essential college science survival skills.

From the college side, one science professor was especially clear about the negative impact of the Regents exams on student preparation for college-level science courses. Although he considered the Regents exam in his field to cover the right topics, he thought the process of exam preparation was debilitating for students learning to do science. Like his high school colleagues, he found that "formulaic learning" was one consequence of having to "cover" so much material, and did not permit exposure to the "grammar and syntax" of science—how to break problems down. Students with a science background in high school should arrive at college able to apply learned tools to unfamiliar problems; the majority cannot.

The work of David Conley clearly underscores the universality of this predicament nationwide, across all disciplines. The lack of alignment between secondary and postsecondary education—between expectations, standards, skills valued, and body of knowledge emphasized—is one of the major issues undermining the quality of education in the United States. In *Towards a More Comprehensive Conception of College Readiness* (2007), Conley outlines the skills, abilities and habits of mind necessary, by discipline, for success in college. He suggests how much work still needs to be done to assure that these skills and abilities are intentionally developed during the high school years, then appropriately assessed by the exit exams (local, regional, state) used to certify successful completion of high school.

The University of Oregon's David Conley, in Towards a More Comprehensive Conception of College Readiness *for the Bill & Melinda Gates Foundation and in his own* College Knowledge, *has outlined key competencies for college success that go beyond academic excellence.*



Alignment issues between high school and college are further complicated by the fact that professors and teachers face different pressures and are driven by different value systems. Where high school teachers are limited by an imposed curriculum preparing students to perform on standardized city and/or state tests, college professors have a degree of autonomy that may result in the delivery of idiosyncratic, dead-end or obsolete courses that would be impossible in secondary schools.

Both STAR teachers and Brooklyn College faculty noted these differences and their day-to-day cultural ramifications, and each group was taken aback at the resulting excesses in both systems. Neither is a good situation, as both can deny students science experiences that address their fascination with real-world connections and applications. Arguably, the alignment of secondary and postsecondary curricula would help alleviate such excesses and is an ending devoutly to be wished. Interestingly enough, one theme emerged consistently from conversations with Brooklyn College faculty and with the STAR high school and middle school teachers: they welcomed contact with each other and thought that their students should be encouraged as well to work with each other and cross boundaries to learn from each other.

Beyond the impact of standardized examinations and lack of alignment, both high school science teachers and college professors noted a range of additional challenges to teaching and learning across the high school/college divide, some gleaned from direct contact with STAR students in college classes and some from extended conversations among themselves:

- In urban high schools, students are not given responsible choices about class attendance and related behavior; rather, they are required to attend class and do not have the option to withdraw. By mid-semester, some students are hopelessly lost and bored. Discipline problems and unproductive student-teacher interactions are a natural consequence. In college, by contrast, students need to manage themselves. Either they learn how to do this quickly or they are gone by the end of the first semester.
- There is a general absence of literacy skills. High school students lack essential vocabulary and the knowledge background often assumed in college classes.
- Students have poor math skills. They have difficulty reading word problems either because they read them as one discrete sentence at a time without making logical connections between the sentences, or they see the entire problem as an undifferentiated lump they cannot break apart. In both math and science, students cannot apply what they have learned in one context to another, or to other examples, in order to solve a problem.
- Because high school students do so much rote learning, they neither understand the scientific method nor have any real opportunity to use it. The broad, shallow knowledge demanded by standardized tests does not map onto the basic, essential skills needed to work in a laboratory.

For students, their teachers, and college faculty alike, the Early College model brings all of these issues to the fore early enough so that they can be addressed systematically. As a result, ECHS graduates save money because they acquire a substantial number of college credits; moreover, because they are savvy about the college experience when they graduate from high school and formally enter college, they are less likely to incur the costs of repeating college classes, and much more likely to feel the sense of readiness and mastery that allows them to do well in college classes. Instead of providing these students with an early opportunity to do poorly in college, the ECHS model prepares them to succeed.

One observation in particular stands out—that ECHS students lacked both confidence and preparation for science and math. Professors committed to working with STAR students said they hoped to convince the students that they were "good enough" for science. An anthropology professor who had taught one of the workshops for first-year STAR students from the very beginning (she is now part of the CCLI Spark program) believed that fear of science was not the obstacle students needed to overcome, but rather a negative perception of self. Unlike her students in the elite after-school museum program, STAR students, she found, challenged her to persuade them that they were smart enough to participate in science-based experiences.

A science educator teaching Physics I hoped his class would demonstrate how good pedagogy would engage students, pique their interest and curiosity, and help them stay on a science track. He documented the impact of the "how" of learning on two groups of students with similar social and ethnic characteristics and identical academic preparation for this particular course; all STAR

students passed the course handily, while none of the other group did. He attributed the strikingly different results to STAR students' familiarity with collaboration and group work—which at STAR is an important value developed from the very beginning, and an important antidote to negative behaviors and negative academic results in college science courses. (Alexakos and Jones, 2008).

Additional common insights emerged among the college faculty who taught STAR students either in workshops or in college classes. They noted the importance of hands-on and take-away science, especially for the youngest STAR students, but also for the juniors and seniors. They felt that high school students need more supervision and help to do college-level scientific work and reading and writing. Indeed, much more support and guidance generally is necessary for younger students. Faculty cannot assume that young students will read an assigned chapter or an article. Most professors developed homework questions based on the reading that had to be submitted before class, collected and "graded" homework, and made clear in class how the reading was explicitly related to the class topic of discussion or lecture that day. In short, they took nothing for granted, as they do with their college students. Rather, they learned that high school students need constant feedback and interaction to ensure they are working both in and out of class. In addition, many brought college student tutors to class to work with students, interspersed small-group activities among their standard lectures, and tested or quizzed students more often than the standard college midterm and final.

Partnerships for Adapting Teaching and Learning

As for their own understanding of teaching and learning, both the college faculty and the high school teachers felt that their interactions had changed their approaches—indeed, their lives, and often in profound ways.

STAR teachers said that, at the very least, they had a much better sense of how to prepare their students for college by making them more articulate in new ways through such approaches as peer teaching. They also tried, in their high school classrooms, to better prepare students for the college learning style by modeling college policies on such issues as late work, students' accountability for their own learning, and plagiarism and proper citation, as noting primary and secondary sources is so essential in college courses. Generally, they indicated that they now focus much more on helping students develop the skills they will need in college: reading and writing, critical and quantitative thinking.

The college professors also said that their association with high school teachers has had a significant impact on how they teach. They reported a new appreciation for the importance of sharing one's enthusiasm for one's discipline (often assumed as a given if students have elected to take the class), making their courses more user-friendly in any number of ways, intentionally engaging students in required reading, breaking up lectures into ten-minute intervals interspersed with some related hands-on activity for the class, and other simple but key differences that can matter as much in the early years of college as in high school.

College faculty who worked closely with high school teachers particularly expressed gratitude for the pedagogical expertise they shared. They said their teaching in general had been transformed through sustained encounters with teachers who cannot assume students' intrinsic interest and motivation and who are always looking for ways to engage students who have not chosen to take a course (as is so often the case in college), but instead may have been placed into a requirement for graduation. Many noted that they were now setting up more active classes, working on "delivery systems," thinking about *how* to present materials in addition to *what* to present. (For detailed information about some additions and accommodations made to college classes and workshops see Gurwitz and Raphan [2008] and Lowe [2008.])

In a Living Environment lab, Marcus Watson carefully goes over lab instructions with his class. (Photo: Joan Moseley, STAR Early College High School.)

In sum, college faculty universally said that they appreciated the insights their high school colleagues brought with them to the college classroom, especially since most college faculty have not traditionally been taught pedagogy or exposed to pedagogical approaches during their graduate education. Several national initiatives (such as Preparing Future Faculty) have sought in recent years to address this lack of preparation; while this work is all to the good, hands-on experiences like those of Brooklyn College faculty at STAR may be the most effective way to demonstrate and drive home the importance of pedagogy.

The association of college professors and high school teachers offers myriad opportunities for professional development, and ultimately highlights the need for more structured institutional approaches. The time high school teachers spend on campus working with college professors and STAR students in various capacities (ranging from co-teaching to student counseling) has evolved for both groups into valuable opportunities to increase their pedagogical skills and disciplinary knowledge. Each group brings different and useful knowledge and skills to the table, and their interactions are acknowledged by both as enriching all. Over and over, Brooklyn College faculty and STAR teachers alike cited and celebrated the value of these associations. The encounters around teaching and learning have changed how college professors and high school teachers approach their teaching and student learning. Clearly, devising systemic ways to facilitate such encounters on a larger scale would enrich both secondary and postsecondary learning across the board.

The Role of Faculty and Teachers in Placing Students in College Classes

Once the formidable technical obstacles of course identification, scheduling, calendar issues and the registration of Early College High School students in college courses are resolved—and these are not routine or easy—some key academic issues remain, and have the capacity to either sink or float the entire endeavor. Since STAR is not located on the Brooklyn College campus, leaders in the school's creation made immediate decisions to get the STAR students on campus as soon as possible, and also to offer all college classes on campus. As a result of this early

determination, STAR students begin going to Brooklyn College during their first high school semester for a library research project and an introduction to laboratories, and continue visiting campus for their second semester workshops.

An early, unhappy experience with an introductory college chemistry course taught by an eminently qualified STAR teacher revealed a number of issues to be addressed: the placement and assessment of students; the establishment of clear and consistent guidelines for interaction and of access to information; and the development of common standards and open lines of communication. Indeed, after this initial experience, the college liaison/coordinator took specific steps to address all of the misunderstandings and missteps that had dogged this first college science course experience for STAR students, teachers and college professors.

Academic standards for college courses, of course, are the province of the higher education partner in any Early College High School. In addition, college departments set standards for placement into their courses for all students. Experience at Brooklyn College, however, has led to the development of additional guidelines for the successful placement of Early College students in college courses. BC faculty and STAR teachers agreed unanimously that, after students' academic eligibility for college enrollment was determined, the college faculty and high school teachers needed to work together, based on their knowledge of their students, to place ECHS students in—or out—of college courses.

The quality of the Early College experience depends on developing and sustaining good relationships between high school and college faculty. High school teachers welcome the opportunity to recruit for college courses those students they think would be interested or challenged by such courses; it is in their interest to help ensure that college faculty have satisfying experiences with STAR students. As important, a good experience at the college helps ECHS students appreciate themselves and their abilities. The more alignment, the better has been the experience of faculty who have worked closely with high school counterparts. A Brooklyn College anthropologist whose department has developed a close, sustained relationship with a STAR biology teacher pointed out that the involvement of a dedicated classroom teacher makes a huge difference in the preparation and attitude of students. This professor reported that students trained and recommended by the STAR teacher in question, who works closely with the anthropology department, "shine" in her anthropology classes; she is amazed at their preparation, their abilities, and their love of challenge. College faculty members' positive experience with carefully placed STAR students also underscores the importance of motivation and choice for the students themselves, who feel guided, prepared, and committed, rather than feeling randomly or belatedly placed in an unwanted or unexpected experience.

Joint faculty/teacher decisionmaking about placements can—and should—also affect choices not only about *which* students to place in college courses, but *how* to place them. The configuration of a class makes a huge difference in the behaviors and learning of students, given students' different levels of commitment to college classes: Attending high school is a requirement and, for some students, an imposition they resent, while attending college is a choice and a goal. College professors are considerably less likely to encounter resistant students in their classes, and virtually never have to deal with inappropriate behavior, so may be less accustomed to students with potential behavioral problems.

Joint decisions about overall placement strategies for Early College students may identify the most productive approach. There are two popular configurations for college placement of these students: placement by cohort and placement in mixed classes of college and high school students. Each involves a series of tradeoffs. Placing Early College students in college classes by cohort allows for more support than they are able to receive in than mixed classes; on the other hand, cohort classes lend themselves to negative acting out by insecure students who may not believe that they will successfully complete a college class. Behavioral problems often abound.

By far, faculty prefer mixed classes of college and Early College students. In such classes, there are no disciplinary issues; faculty often cannot distinguish between college and high school students because Early College students rise to the occasion, instead of being distracted by their lowest common denominator. This configuration also addresses the desire on the part of some teachers for blind grading so that high school students are not identified and possibly singled out or ostracized because of their status. Optimally, small groups of six to ten Early College students will be placed together in one college class so that the Early College High School can provide tutoring and support to these small groups, while giving them a true college experience.

In some Early College partnerships, false budgetary issues driving each of these models get in the way of good practice based on experience; these should be modified to support the best approaches for each Early College and its students. Here again, shared decisionmaking by college faculty and high school teachers can help determine the approaches that are preferable for their particular students.

MATHEMATICS: A PARTICULAR CHALLENGE FOR SCHOOL/COLLEGE PARTNERSHIPS

The Mathematics Disconnect

By comparison with the science partnerships between Brooklyn College and STAR that have been described thus far, this Early College's mathematics partnerships have proven challenging. While these challenges are particular to local circumstances, anecdotal information suggests that, unfortunately, similar issues arise nationwide—with some notable exceptions.

Nationally, according to Conley (1997, 9-10, 28), there is little alignment between the math taught in high school and the math needed to survive in college math and science courses. This lack of alignment may be traced both to the isolation of many college math departments from mainstream activities and concerns at their own colleges and universities, and to their limited outreach to local school systems. There are, across the country, heartening exceptions to this pattern—such as the Transition Mathematics project in Washington State and Agile Mind, a rigorous standards-based college prep math program working in collaboration with the Charles A. Dana Center at the University of Texas at Austin—whose work is helping align middle- and high school math more consistently to college readiness standards. But the attenuated Math Wars (Schoenfeld, 2004; Greenberg and Walsh, 2008) have left the discipline in some disarray.

Although the School of Education at Brooklyn College has a strong math education program, relations with the Department of Mathematics are less robust than they should be. With the exception of the retired math education professor who has been working at STAR over the past

six years and the involvement of one full-time professor in the Mathematics Department who taught one pre-calculus course to STAR students, contact between mathematicians at the college and math teachers at STAR has been minimal.

This is a shame given, for example, the dedication of the math educator and the appreciation of a new middle school math teacher who has been working with her. Their relationship is a model of what should be happening. Since STAR's January 2008 curriculum retreat, the retired School of Education professor (whose activities at STAR had not been as sustained nor as encouraged as those of the retired science professor) spent the spring semester visiting STAR twice a month to sit in on the classes of the 6th grade math teacher. This teacher, certified to teach 7-12 math, arrived at STAR with good experience teaching secondary school students. Her assignment at STAR was her first contact with 6th graders, and her contact with younger students uncannily mirrors the experience of college professors teaching first-year STAR students in the Spark workshops. As first-year STAR students were challenging and engaging for college faculty, so too 6th graders were a challenge for this high school math teacher, who realized how much knowledge she had been able to take for granted with her high school students and, for example, how important and essential manipulatives—hands-on objects used to demonstrate mathematical principles and operations—were for 6th-graders, as opposed to her students in high school.

Harold Alexandre works with a student in an Integrated Algebra class at STAR. (Photo: Joan Moseley, STAR Early College High School.)

From an institutional perspective, and according to STAR's founding principal, the Early College needs focused and coherent leadership in math education. In New York City, math sequences change with regularity. While the STAR ECHS has hosted a variety of math specialists over the years—indeed, at moments one needed a score card to sort out representatives from various approaches, sponsored by various interested parties, from both internal and external entities—there has not been ongoing, dedicated leadership in this area. The undivided attention of a dedicated math coach, a fearless leader promoting best practice and developing a coherent and sustained program with clear goals, would ensure a coherent math program in the STAR middle and high school, facilitate the development of essential skills and abilities, complement the already-rich associations existing in science, and focus on the development of these associations in mathematics with the college. The work of a math coach alongside college faculty could parallel the work of the dedicated high school literacy coach who, with her college counterpart, has been able to accomplish a great deal in the humanities at STAR.

At STAR in particular—and, one would suspect, in other Early Colleges, secondary schools, and colleges and universities throughout the country—attention to mathematics as it is taught and learned is a critical issue crying out for attention. The small number of U.S. students in the doctoral sciences and the miniscule number of mathematics majors in our colleges and

universities will not be resolved until the teaching of math in our elementary and middle schools is tied more effectively to the development of essential math skills in secondary school and college, and until mathematicians reach out to math teachers and work together towards common goals.

Math as the Basis for Science

Math and science faculty consistently insisted that, in everyday life, all of us employ both the scientific method and mathematical thinking all the time. Indeed, Shirley Malcom's observations (1997) about mathematics apply as well to science: "… [M]athematics is everywhere: we should offer students the opportunity to study what they know, what they love, what they care about, what interests them, and then find the mathematics in it" (p 31). She points out:

> This idea of turning content on its head to fit the subject to the audience is the real uncharted territory of mathematical education…It will take people with deep understanding of content and a willingness to perceive the possible advantages of breaking out of the box of content and the linear approach. Until this happens, our own academic community will be our own worst enemy in this discussion. (p. 35)

Whatever red flags arise from the lack of school-college collaboration around math are exacerbated by unanimity among Brooklyn College scientists about the critical importance of mastering fundamental math skills for the understanding of science. These scientists were talking not about calculus, but about more basic mathematical skills: problem-solving, critical thinking, fractions, calculating percentages, the simple manipulation of variables, and algebra. It is clear that the solution at STAR (and throughout the country) will be to align intentionally what students need to know in college science courses with the math they are learning from the 6th grade on. Alignment must happen early, foundations need to be fortified, and secondary and postsecondary educators must focus on teaching and reinforcing necessary transition skills and essential abilities.

One science professor asserted that as anatomy is the ABCs for the study of the human body, so too some very basic math skills, some of which depend on rote memory, are necessary for the study of science. She faulted early education and the tendency to segregate students into "math-talented" vs. "creative" groups; she said she believes that schools and colleges give too many students at all levels a pass for being "math-phobic." She also observed that, as a scientist, she depends equally on her math and her writing skills and considers them inseparable.

Forman and Steen, the authors of *Beyond Eighth Grade: Functional Mathematics for Life and Work* (1999), echo these sentiments and those of Malcom as well:

> Most of the elements of functional math are unsurprising…. By highlighting the rich mathematics embedded in everyday tasks, this approach… can dispel both minimalist views about the mathematics required for work and the elitist views of academic mathematicians as an area with little to learn from work-based problems. (v-vi)

During a conversation, Forman, noting the cumulative nature of math, pointed to skills that are fatally detached from each other and from the study of math as well. For example, math has a special vocabulary in which common words (for instance, *irrational* and *volume*) have uncommon meanings. To avoid confusing students, teachers need to specifically point out and discuss these

differences in meaning. Students also need to be taught how to read a math problem; in particular, they need help translating between the prose and the math embedded in word problems. As Zull points out (2002), science and math are too often approached as if experts are talking to experts when, in the vast majority of classes, experts are talking to novices. Shared assumptions and common understandings do not exist between the former and latter groups; indeed, uncommon interpretations and bizarre misunderstandings are more common than not, and need to be acknowledged and addressed.

The math professor who taught pre-calculus to STAR students made similar observations as his science colleagues about the "psychological baggage" students brought with them to his class, and about the need to address attitudinal and behavioral problems based on insecurities and lack of confidence. He was critical of the inadequacy of math training in secondary school—not only for STAR students but also for his own daughter in a suburban school. He expressed his sense that secondary schools train students for recognition and performance as opposed to engagement and thought, and that, as a result, high school math does not prepare students for college math. For example, secondary school textbooks signal the existence of a problem instead of developing the ability to identify a problem embedded in text; because of such strategies, students cannot identify or solve a smaller, embedded math problem along the way as part of getting to the basis for solving a larger problem. This approach fails to prepare students either for the use of math in science courses like chemistry, or for math as it is taught in college. His observations strike a familiar chord: the lack of substantive preparation for using mathematics or science in new, unfamiliar circumstances, as opposed to absorbing enormous amounts of superficial information recalled for standardized examinations.

Clearly, the teaching of mathematics and the alignment of the secondary and postsecondary teaching and learning of mathematics must be high national priorities. Moreover, the dialogue between content and pedagogy must be transformed into one embracing both the essential contents and successful pedagogies that prepare students to use mathematics effectively in all contexts.

CLOSING THE LOOP: BROADENING THE IMPACT AND REACH OF ECHS/COLLEGE COLLABORATION

The interactions of STAR teachers and Brooklyn College professors contain key lessons for teacher preparation—whether through schools of education or through alternative pathways to teaching—as well as for the design of future high school/college partnerships and for the alignment of standards and curricula.

At Brooklyn College, the faculty involved with STAR have come primarily from the School of Liberal Arts and Science (LAS), with the School of Education contributing two fine additions—a retired math professor and a science educator. This particular local circumstance has given rise to the following observations about ideal relationships among arts and sciences professors, education faculty, and ECHS teachers. At some other Early Colleges, however, the partnership between the school and a college or university is located primarily in the School of Education; in others, a four-year college or university partners with a community college to help deliver the first two years of college or its equivalent. While each circumstance carries within it a special set of opportunities and challenges that are outside the scope of this monograph, the message is the same: If real change in our educational system is to occur, and particularly if the United States is

to reach its goals in math and science education, lessons learned through the systematic interactions of educators across too-rarely-flexible institutional boundaries must be shared and applied widely.

The absence of boundary crossing between K-12 and higher education—indeed, the existence of barriers that have a direct impact on the teaching and learning of science at all levels—is illustrated by the following anecdote from Elaine Seymour's 2006 testimony to the Research Subcommittee of the Committee on Science of the U.S. House of Representatives Hearing, *Undergraduate Science, Math and Engineering Education: What's Working?* :

> In our study of why undergraduates leave the sciences (Seymour & Hewitt, 1997), we noted that, although almost 20% of our student sample had seriously considered science or mathematics teaching, this dropped to under 7% in senior year among those who persisted in their STEM majors. A major factor in this decline was students' awareness that their professors—whose approval and support they sought in developing a career path—defined teaching ambitions as "deviant." Faculty were commonly believed to withdraw from students who openly expressed an interest in K-12 teaching and those who still intended to teach become covert about their intentions:....
>
> > I've never discussed it with any of my chemistry professors. For the most part, I've got a feeling of disdain for teaching from them. This is something that they have to do, but they don't really support anyone who wants to do it. Fortunately, I had an incredible chemistry teacher in high school, and I go back and chat with him still. He tells me, "You're going to be a good teacher." I get more encouragement from him than from anyone on campus. (Male white science persister)
>
> Students who wanted to teach also described discouragement from family members and peers who perceived teaching as a career with low status, pay, and prospects. Students of color were the only STEM seniors who reported encouragement from faculty and advisors to become K-12 teachers. (1,2)

This commentary painfully illustrates the cultural and values gap between current and future secondary school science teachers and postsecondary faculty, and underscores the traditionally unhappy relationship between colleges of liberal arts and science and their schools/colleges of education. It has been a decade since the American Council on Education published *To Touch the Future: Transforming the Way Teachers Are Taught*, which included a high-profile call for liberal arts and science and education faculty to find common cause and to work together. Certainly the joint experiences of STAR teachers and Brooklyn College faculty in the liberal arts, sciences, and education suggest that if a college has a school of education, especially one that offers programs in math and science education (or whatever the disciplinary theme of the ECHS), there should be a strong relationship among teachers, arts and science faculty, and education faculty, working in concert to achieve shared goals.

Yet, just as campus culture affects the engagement of arts and sciences faculty in an ECHS initiative, negative attitudes and limited points of view among college and university faculty also shape attitudes and relationships with colleagues, teachers and students across the board and hamper faculty involvement in any aspect of an Early College partnership. Interdisciplinary and cross-sector faculty/teacher partnerships too often go against the established culture of higher education, including its reward system, and the gains to be reaped from such associations remain theoretical at best. Untenured faculty in an education school, like those in other disciplines/areas, must be able to base their association with an ECHS on substantive research projects that will emerge from such interactions and support the faculty member's attainment of tenure and promotion.

One example of a *good* fit is the work of the aforementioned Brooklyn College science educator. Because he had appropriate credentials, the Physics Department was happy to give him a section of Physics I to teach to STAR students. His experiences the first year yielded a conference presentation and published article (co-written with a STAR graduate who had been in the class) on the value of kinship networks to support success in science classes, long his research interest and focus. Videotapes of his class provide ample proof of the value of group work among students who have shared positive educational experiences, know each other's strengths and weaknesses, and are willing to work together to pool their talents to learn new material.

The author congratulates a graduate of the STAR Early College High School, Class of 2007. (Photo: Brooklyn College.)

Based on faculty's own experiences with STAR students and a renewed focus on the performance of first-year students in introductory chemistry classes at the college, the Brooklyn College Chemistry Department hopes to intervene directly in the preparation and professional development of chemistry teachers, some of whom, in any case, are teaching out of their licensed field. Having identified one problem—the absence of engaging high school lab experiences that develop scientific skills and habits of thought—the department hopes to reach out to new teachers with a course designed specifically to help them become comfortable trying more creative approaches. Department leaders envision a how-to course addressing such practical issues as how to procure chemicals and how to use them safely; the primary focus would be on helping teachers design their own lab experiences for students and identify available materials and kits that will allow them to offer such creative labs, even in the absence of facilities.

Clearly, dedicated educators at all levels and in all settings are willing to act upon what they have learned about the respective strengths and weaknesses of secondary and postsecondary curriculum, teaching and policies. To ensure that the future of science/math education is brighter than its past, it is essential to keep open the existing lines of communication, to open new ones, and, most of all, to close the loop so that lessons learned have an impact on teaching and learning and on how future teachers and professors approach teaching and learning.

Finally, the importance of mentoring and induction cannot be emphasized too strongly. STAR science teachers have been fortunate to avail themselves of the services of the retired chemistry professor described earlier. One teacher, grateful for the faculty mentoring partnership to which he attributes his survival as a high school science teacher, could not fathom how teachers survive the first few years of teaching without such assistance.

And national statistics suggest that they do not. Although STAR has been blessed with a relatively stable group of science teachers, the turnover of new teachers is a national phenomenon, with up to one-half of all new teachers in urban districts leaving the classroom in

their first three years. This situation poses a challenge to any initiative or partnership that seeks to develop incremental approaches based on shared experiences; the constant arrival and departure of new teachers creates the additional and exhausting task, for ongoing partners, of perpetually going over the same ground with new arrivals. Indeed, the retired professor/mentor himself expressed concern about where new, good teachers were going to come from as the STAR Early College program ages and natural attrition from retirement and transfer, much less the dizzying departure of new teachers, takes place. For any number of depressing reasons—from the attitudes described by Seymour at that 2006 Congressional hearing to the behavior of young students in so many secondary schools—the pool of declared future science teachers is much too small. For example, when one professor teaching a Spark seminar encouraged one of her math-talented first year STAR students to think about becoming a teacher, he refused outright because he was did not want to spend his time "dealing with rude kids."

There is one grand lesson to be learned from the study of the various levels and kinds of collaboration among Brooklyn College faculty and STAR teachers and students: despite great challenges, the potential for transformation is realized in the daily interactions of professors and teachers who find common cause through working together in an Early College. The degree to which such boundary-crossing can be replicated throughout the nation and translated into the policies and procedures of ordinary school systems and colleges and universities, and the degree to which such boundary-crossing forces attention to and focuses energies on easily ignored issues, is the degree to which substantive and necessary change will occur throughout the educational continuum.

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