The North Carolina School of Science and Mathematics recently embarked on a curriculum review, one part of which was to update school-wide curriculum goals. A quick review of 12 websites from some of the most long-established Consortium schools, including NCSSM’s, revealed that very few of us list school-wide goals for our students on our sites. Moreover, we don’t say much about teaching our students to do research which, as measured by their success in science competitions and frequent entry into STEM fields as professionals, is one of the things we do best.

These observations and some preliminary work by former Executive Director Cheryl Lindeman on a STEM Roundtable Conference put us at the national headquarters of Sigma Xi, The Scientific Research Society in the Research Triangle on April 28-29, 2011, talking about our students’ scientific research and curriculum. We tackled questions such as:

- What should such a curriculum look like at a specialized secondary school like ours? At a regular public high school?
- What are the obstacles to establishing a scientific research program in high school?
- Whose is support is needed and what are the necessary components of the school culture to support such a program?

To begin the process of designing a research-based, laboratory-centered, STEM secondary curriculum, our working group asked the following question: What does a school need to have in place to make research viable for all students?

The answers boiled down to three broad criteria: school structure, curriculum, and school culture. Our group felt these characteristics were so inter-related as to be nearly impossible to discuss individually.

First, school structure refers not only to the physical components of the buildings and campus but also to time structures, administrative and faculty community, and parental engagement. Obviously, multiple laboratory and investigative spaces are important to a STEM curriculum, as is a good library and on-line availability for research purposes. Even more important than these, however, is the existence of an engaged faculty and administration. These groups hold much of the responsibility for a successful STEM school in that they must understand, participate in, and support the chaos often engendered by individual inquiry. Finally, but by no means insignificantly, parents must be willing to allow their students to engage in individual inquiry and must encourage independent thinking.
Administrative and faculty support of STEM research is essential. This mindset is evident in their willingness to collegially network with one another and with outside professionals for the benefit of students. Intellectual territoriality is to be avoided; indeed, administrators and teachers should instead demonstrate a belief that all knowledge is valuable and interrelated. These adults should model the collegial environment students will encounter in the world of academic research and professional work. An on-campus Internal Review Board (IRB) can teach students how to connect with potential mentors off campus to create an interdisciplinary network of support. This group will also critique all research proposals to encourage ethical and critical thought. Further, an informal network of interested adults on campus will furnish an easily accessible base of mentors who can directly support the efforts of students during the school day/term. Media specialists can create and maintain a data base of previous work for student reference, while older students can mentor younger in research projects. Original research should be supported, if not expected of all students.

During the school day and term, time must be made available for individual research. This time must be seen as integral to curriculum and supported as such, which means that “individual research time” cannot be the period used for assemblies, teacher planning, tutoring, or other purposes which detract from or even undermine the research process. Suggested uses for such a block of time include meetings between students and teachers mutually engaged in projects, meetings with off-campus mentors, laboratory experiment and data-gathering time, literature search, and data testing and evaluation. Mentored summer research may even be required as part of specific course work. It is critical that once this research time has been created it must be used wisely and well, with students and faculty alike being held responsible and accountable for progress. This accountability must be assessed on a regular basis.

Curriculum, the second element of a successful research-based STEM school, must provide students with exposure to a wide range of topics through a rich variety of courses across all disciplines. The interdisciplinary nature of learning should be stressed, with as much cross-curricular emphasis as is possible within each course. Writing modes necessary to each discipline must be taught and regularly assigned and assessed. Interdisciplinary testing and promotion of inquiry is highly desirable. Such exposure offers students a broad base from which to draw and shows them the reality of STEM research, in which investigators from different backgrounds collaborate to solve specific problems.

This curriculum should strive for both general and specific goals, including but not limited to the following:

- laboratory procedures and safety
- ethics of scientific research and experimentation
- how to contact and obtain mentors
- how to ask questions
- how to engage in library and data-base research
- how to write literature surveys
- how to write in subject-specific modes
- how to collaborate and communicate with classmates and interested adults
- how to design experiments
- how to gather, test, and interpret data
- how to draw reasonable and evidence-supported conclusions
- how to manage time
- how to keep clear, accurate records
- how to mentor younger students in their research projects

Finally, a school culture of continued and active learning/research in an ethical framework must be established. One critical component of that culture is the hiring of the right people in administration and faculty. The “right people” are those with a successful history of encouraging and mentoring student research. Administrators must trust that they have chosen well and allow teachers a fairly high level of creative independence. These professionals will already have bought into the ideas of interdisciplinary learning and individual student investigation, and they must be given the charge of defining the school’s culture so they have ownership of what goes on in the academic program. Culture cannot be imposed from above; it must be created by faculty members and students who will live it.

Ideally, the defined culture will include the notion of “failure” in research. Students often believe their project’s inability to support its experimental hypothesis means the research has failed;
therefore, the experiment, they think, must be
tweaked to produce a successful outcome. Adults,
however, know differently, and such knowledge
must be imparted to students. Without the
possibility of failure, there is little to gain in doing
research. Failure must be an option, for much can
be learned from “failed” experiments.

Further, the school culture will include the notions
of intellectual risk taking, thus encouraging
original research. This risk taking will be supported
in a dynamic learning environment that is collegial
and directed, as noted above in both school
structure and curriculum. High expectations of
students and faculty are essential to the culture
and curriculum; these expectations should be
supported by parents.

The school culture will also include the purposeful
management of chaos, as indicated in the
structural and curricular need for designated
research and collaboration times. In this purposeful
chaos, students will learn to share their developing
skills and research experiences; they will take
ownership of their work and communication about
it; they will observe models of the professionals
they aspire to become and serve as models to
younger students; and they will become
independent learners.

Clearly, the creation of an exciting research
program in a STEM school is dependent upon three
inter-related variables which cannot easily be
teased apart. Integral to any successful STEM
program is the considered creation of school
structure, integrated curriculum, and a dynamic
school culture.

Suggested References for Getting Started
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Websites
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