Session Number

Strategic Alliance Between Higher Education, Secondary Schools, and Community Business and Industry to Improve Secondary Mathematics, Science, Technology, and English Education: A National Science Foundation Project

Jule Dee Scarborough, Ph.D. and Conard White, Ph.D.
Presented by Promod Vohra, Dean
College of Engineering and Engineering Education
Northern Illinois University

Northern Illinois University (NIU), Rock Valley College (RVC), and the Rockford [Illinois] Public Schools (RPS), as well as (a) Peer Master Teacher Leader(s) from Grayslake High School [IL] partnered to improve student achievement in secondary mathematics, sciences, technology, and English education. However, the models, strategies, and processes culminating in Rockford evolved over several major projects with other regional districts, or multiple districts, spanning approximately 12 years. The Rockford initiative involved past strategies, but also resulted in extended and expanded models and strategies. Districts that have participated in our programs have been urban, suburban, and rural, large and/or small. All models, strategies, program information, and pilot results will be available between March and June, 2004, in hardcopy from the American Association of Higher Education or at the website nsf.niu.edu. This site will also link to the Rockford site for more in depth information about the integrated curriculum modules. All goals, strategies, philosophies, models, processes, techniques, and procedures are fully documented with complete descriptions. All products and results are also fully described, with samples available. It is intended that this will encourage and aid others in replication or adaptation of aspects of this endeavor. This initiative was funded by the National Science Foundation, the Illinois State Board of Education, and the Illinois Board of Higher Education, with local RPS, RVC, and NIU matches. This collaborative venture is better described as a "center" in the complexity, number, and type of concurrent activities, products, and results.

The objectives to achieve the above stated goal included: (1) providing in-service education on up to 65 different topics each year; (2) providing in-service education to administrators about their leadership role and responsibilities in leading reform; (3) partnering with local business, industry, and community organizations to support secondary MSTE education and change; (4) producing a systemic model for improving MSTE; (5) developing teacher knowledge and skills in using computer technology and other discipline specific technologies; (6) developing teacher and counselor knowledge and strategies for infusing career and educational pathways into the curriculum and learning experiences, especially through partnerships; and (7) internally and externally evaluating all aspects of the initiative and developing a long term sustainable and continuous improvement plan. Specific outcomes and products can be reviewed on the above website or in the AAHE publication mentioned above.

Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition

Partnerships

An extended partnership model engaged a vast array of human resources to support the teachers in their development and pilot activities. As mentioned above, three institutions participated; however, within the higher education community support, there were many internal partnerships. The Department of Technology in the College of Engineering and Engineering Technology led the initiative; there were co-directors at Rock Valley College and for the Rockford District. The University of Illinois Medical School was also a partner. Within Rock Valley, professors from mathematics, the sciences, English, and a variety of engineering technology programs (e.g. electronics technology, manufacturing technology, nursing, aviation, and media technology) participated. Within the NIU community, the College of Liberal Arts and Sciences partnered with Engineering and Technology to include professors in mathematics, biology, chemistry, physics, geography, geology, and English, with some participation by science and mathematics education professors. All were practicing specialists, scientists, mathematicians, rhetoricians, etc., in their respective fields. Engineering technology professors in manufacturing and mechanical engineering were involved, and the College of Education also partnered, involving professors in pedagogy, counseling education, and instructional technology. It is important to note, however, that the College of Engineering and Engineering Technology provided lead professors in pedagogy, student assessment, curriculum development, and other educational expertise as well, typically perceived to be found in education colleges/departments. It is important also to note that many of the professors at NIU who were involved were NIU's Presidential Research or Presidential Teaching Professors, who are also well-known practicing scientists. Another spoke of the partnership wheel was, once again, a vast array of business, industry, and community partners: over 300 organizations, most major business and industry organizations, and agencies such as state infrastructural organizations (e.g.transportation, waste, and others such as the municipal police and local hospitals).

Professional Development Program

The program involved teachers and counselors in workshops designed to achieve the initiative goal and objectives. Teachers participated in upto, and sometimes over, 150 hours per year, enough to completely recertify. Although there was a specifically designed program for the counselors, counselors joined teachers in some of workshops, and both teachers and counselors learned of the benefits of working together on student learning activities to enhance and accomplish both of their individual interests for students. Some of the primary topics and learning experiences were on educational paths to careers, secondary to postsecondary articulation, interdisciplinary teaming, industrial visitation and partnering, state student learning and teaching standards, Bloom's Taxonomy and state analysis, state learning standard performance indicators, student performance assessment and improving traditional assessment procedures, electronic student portfolios, Dale's Cone of Learning, integrated curriculum models, interdisciplinary team instructional delivery, block scheduling, MSTE discipline updates, brain research, multiple intelligences, learning styles, teaching models and teaching styles, cooperative learning, instructional technology learning activities on the development of Webquests, web pages, the development of virtual tours and animation to enhance teaching and learning, action research, planing and execution, Marco Polo, graphic organizers, layered curriculum, PDAs for teaching and learning, reading and writing across the curriculum, as well as special

interdisciplinary (MSTE) workshops based upon themes, (,e.g. agriculture innovations, green chemistry, navigation, GIS/GPS, CAD, CADCAM, lasers), and a variety of workshops on the use of computer technology, software, including collaborative software and more. Specific counselor related topics, in addition to some of the above, were on infusing career and educational pathways into their work with teachers and students, incorporating the counseling standards into their planning and actions, learning about national models, initiating teacher/counselor partnerships, creating a district leadership model counseling staff for to lead counselor planning and activities, and developing an action plan to guide future requests and actions.

Educational Products

Educational products can be described in many ways: products, processes, procedures, outcomes, results, etc. Each has a different meaning. For example, the interdisciplinary and integrated MSTE curricula modules were each a new product. But incorporated within the modules are also new educational models, processes, and procedures that the teachers learned about and then incorporated to use, and then piloted (e.g. new teaching models, performance assessment procedures, as well as traditional pre/posttests, new uses of technology, identification of Bloom's Taxonomy levels for new delivery models, interdisciplinary team delivery, partnership activities, and more). Therefore, the "module" represents not just a single new educational product, rather a new set of nested products, processes, procedures and strategies.

In addition, there are other outcomes. Most teachers gained new knowledge and skills in the use of technology for teaching and learning and demonstrated their new knowledge and skills throughout their professional development program, as they performed and learned simultaneously, and then throughout their pilot activities. There were outcomes that related to attitudes towards teaching and learning, more qualitative in nature, and there were research results from the piloting of the culminating modules with students in the classrooms. Thus, it is important to understand that much more than a single educational product, the module, resulted from this endeavor. See the publication and website mentioned above for more detail.

The program design was comprehensive in nature, transcending well beyond a typical "string" of workshops and leaving it to the teachers to incorporate what was learned into their teaching. This endeavor began with needs assessments, and national and state goals; provided a more holistic multi-leveled professional development program. Each level followed teachers into the classrooms to pilot their new products, processes, strategies, and procedures with feedback and support throughout the entire endeavor. The overall philosophy of the program leaders was also to model what was expected of the teachers: teaching through example modeled the best practices. For example, when teachers were expected to use new teaching models, performance assessment, or interweave learning with performance, many program leaders modeled those new strategies. Teachers were expected to develop and use rubrics to score performance tasks; particular program leaders did the same. Performance tasks and rubrics, another product example, are embedded or nested within the overall module. Thus, even though the modules were products themselves, there were many other products, new strategies, processes, and procedures nested or incorporated into the culminating product: the interdisciplinary and integrated MSTE curriculum module.

Modules. Each teacher, or usually teacher team, designed and developed a 3-6 week, some 8 week, and a few, semester or year long, interdisciplinary and MSTE integrated module. These were not just lessons; in fact, they were complex modules with many lessons. Even more importantly, the modules incorporated new models, strategies, procedures, and learning processes, so they were far more a culminating product than merely a curriculum document. Teachers worked on these modules from the very beginning of the first workshop, and as they learned more, they built the modules accordingly, using the gained information, knowledge, or new skills. For example, each module documents the following:

Module Introduction-Title; timeline; description, purpose and rationale; learning standards; interdisciplinary content areas; MSTE; industrial partners and partnership activities; specialized vendors and equipment or material sources and contact information; teaching models; models of integration; technology utilization; software, including Webquests, web sites, PowerPoint presentations, spreadsheets, images, videos, and discipline specific technology requirements (e.g. CAD, heart monitors, etc.); Bloom's Taxonomy levels by lesson; opportunities for further fields of study or further curricular integration; performance task descriptions; rubrics; and pre/posttests and procedures; lesson titles; and ranking.

Lesson Activities and Procedures- Lesson titles and numbers; lesson topics; lesson benchmarks (by standard); needed materials, equipment, and supplies; student assessments; and lesson activities and procedures, including all handouts, worksheets, visuals, post-lab worksheets, problems analysis forms, and technology descriptions.

Student Activities- Lesson titles and numbers, lesson topic descriptions (ones that will entice and motivate students), "What is the lesson about?", "What are we going to do today, and why?", and "Where does it lead?" It also includes student artifacts, assessment procedures, rubrics, and/or criteria. This section is designed to be of intrigued to students, to motivate and interest them, developed and written accordingly.

Evaluation Form Checkoff- Module conference, completion status checkoff list, copies of modules for teachers and district, industry partner list, electronic copy of module, workshop questionnaire, and completion certificate.

All products and the module quality standard were equal to graduate level development, so the standards were very high. Teachers were provided with a framework, required elements, criteria for development, and a rubric with which the module would be scored upon completion. They were supported through the professional development and product development processes; this enhanced the potential for high quality and well designed and developed modules. However, it is important to note that most of the teachers have been highly motivated. Their response to being provided with (a) good individual technology (laptops, software, color printers, scanners, and digital cameras, as well as module specific peripheral devices and software); (b) higher education partners; (c) local business, industry, and community learning experiences and partners relating to the standards and context chosen to frame their modules, and (d) ongoing feedback and support was enthusiasm, motivation, high productivity, and commitment; and a special note, they commented repeatedly about how great it made them feel to be treated as

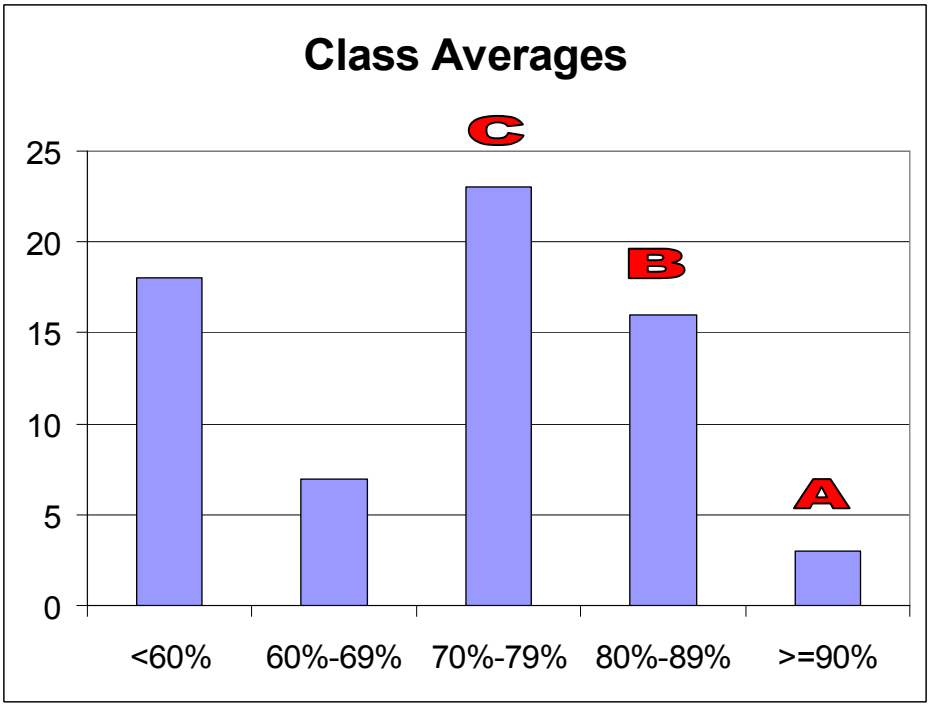
professionals and to have workshops in a professional, conference-like setting, with appropriate tools, materials, and supplies. They often showed up early, stayed late, and worked in-between workshops to finish projects before the next one or to incorporate new ideas or other work.

Student Achievement Results Summary

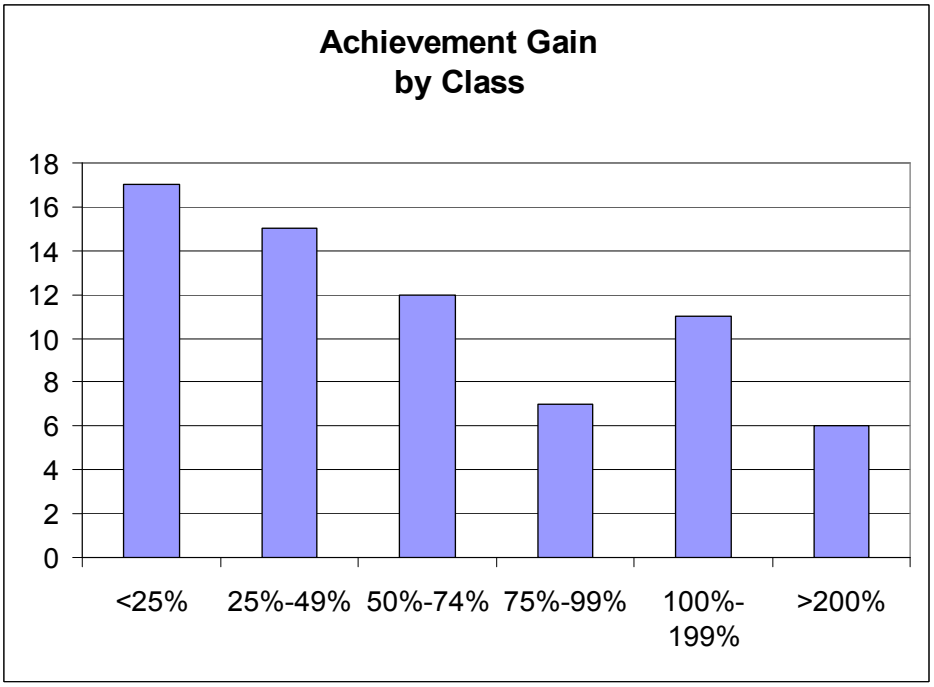
During the seven years the project has been conducted, data has been collected from 59 teacher teams, have developed instructional modules, and have utilized them in their classrooms. These teams were made up of over 300 teachers from five Rockford high schools, six Rockford middle schools, and four high schools within the northern Illinois region. Data was collected from 2794 students.

In order to test for student gain in achievement, each team, as a part of its design of instructional module, developed a traditional test instrument. This instrument had to be designed to measure the Illinois Learning Standards incorporated into the instructional module objectives. These tests were designed by the team instructors and administered at the beginning of module instruction to assess students' prior knowledge of the subject matter. At the end of the module, the test was again used to measure student accomplishment.

The following chart displays the results of the posttest administered at the close of the instructional module. The chart indicates the frequency of mean class scores in categories roughly associated with ABCDF grade ranges. That is, 3 of the participating classes had a class average in the "A" range, and another 16 classes had an average in the "B" range. The fact that 28% of the participating classes (16 out of 67) had averages of "A" or "B" is outstanding. The largest number of classes (23 or 34%) had an average in the "C" range. Sixty-two percent of the classes represented in the study had "final exam" class averages in the "C" or above range. The data clearly indicate that high levels of learning are taking place within the participating classrooms. It is important to note that there is a higher than average math and science failure rate in this district, so even those within the "C" range were considered success stories.



Gain in achievement of each of the participating classes can be shown by comparing the posttest with the corresponding pretest class averages. In 58 of the 59 classes represented in the study, a significant gain in achievement was demonstrated. One class showed a slight but insignificant gain. Those data are displayed in the following chart.



As can be seen from the chart above, six classes experienced a gain in achievement of over 200% during the course of the instruction. In addition, 25% of the classes at least doubled their achievement, while over half experienced a gain that exceeded 50%.

In order to summarize the findings of the project, one must examine the 1997 – 1998 year separately from the others. A fundamental change in research design took place after that year. The major thrust of year one was to attempt to determine if the use of teacher teams in conjunction with an integrated curriculum could demonstrate an increase in student achievement when compared with a traditional, separate curriculum approach. Treatment groups composed of students enrolled in classes incorporating an integrated curriculum approach were compared with control groups of students enrolled in regular separate subject areas. The success of this year would form the basis for further study in subsequent years.

Data collected during the first project year indicate that the integrated curricular/teacher team approach is a viable method. Data from four of the nine first-year teams exhibited a significantly higher gain in achievement in the classes utilizing the integrated curricular approach compared to the classes utilizing the traditional separate approach. The data from the remaining five teams showed no significant differences between the treatment and control groups. None of the teams experienced outcomes where the integrated curricular approach was less effective than the separate approach. Remember again, that the failure rate in mathematics and science is typically higher than average. The conclusion drawn from this initial study is that the use of teacher teams

in conjunction with integrated curriculum can demonstrate an increase in student achievement over a traditional separate curriculum approach.

Subsequent project years focused not only on student achievement gain over the course of instruction but also on the effectiveness of the integrated curricular/teacher team approach with regard to gender and racial/ethnicity. In virtually every case, data collected during those years indicated that a significant gain in achievement took place over the course of instruction.

Of the 50 teams reporting during these years, only seven showed a significant difference in achievement scores between male and female students. Of those seven teams, five teams showed that females scored higher than males, while the reverse was true in the remaining two teams. No interviews were conducted with teams to try to determine reasons for these differences. However, it is interesting to note that the only module subject areas where males out-scored females were architecture and physical education. All of the modules where females topped males in achievement featured English as the subject area.

Ten teams reported data that displayed a significant difference in achievement among the categories of racial/ethnicity. In six of those teams, Caucasian students displayed higher achievement scores than students in other R/E categories. In three teams, Asian students out-scored students in the other categories. No additional information was available that might explain the observed differences in these teams.

In summary, it seems that interdisciplinary teacher teams and integrated MSTE curricula [expanded definition above] have the potential to improve student achievement. The PI and Research Associate recommend that these studies be replicated and continued in a more controlled environment.

Biographical Information

JULE DEE SCARBOROUGH, Ph.D. Principal Investigator. Full professor in the College of Engineering and Engineering Technology, Department of Technology at NIU in Industrial Management with 15 years in automated manufacturing. An NIU Presidential Distinguished Teaching Professor and W.K. Kellogg National Leadership Fellow. She has been awarded approximately $8.5 million in external funding, is well published and traveled widely internationally.

CONARD WHITE, Ph.D. Research Associate. Full professor, emeritus, in the College of Engineering and Engineering Technology, Department of Technology at NIU. His area of expertise is Electrical Engineering Technology, Physics, and educational research.

PROMOD VOHRA, Dean, College of Engineering and Engineering Technology. Full Professor in the Department of Technology. Holds a bachelor's degree in electrical engineering, a master's degree in Industrial Management, and an Ed.D. in Instructional Technology.