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# Impact of Course Reform on College Students

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# Impact of Undergraduate Science Course Reform on Student Outcomes

We summarize here initial findings of the five-year National Study of Education in Undergraduate Science (NSEUS) addressing, "What is the impact of undergraduate course reform as measured by the beliefs and actions of higher education faculty on short- and long-term student outcomes?" At 103 institutions, undergraduate reform courses were taught as a result of participation in the 12-year NASA/NOVA professional development program from which a stratified random sample of 30 institutions was selected. Institutions were stratified by Carnegie type and sustained offering of the reform courses. At these institutions one reform was matched with one comparison non-reform undergraduate science course, totaling 60 courses serving about 4000 students. We focus here on the pilot study conducted to determine the efficacy of the procedures and instruments planned for gathering data in the large scale national study of 30 institutions.

A detailed synthesis of the research literature indicated that reform efforts are needed in undergraduate science courses serving pre-service elementary teacher candidates, that undergraduate science faculty have benefited from professional development on teaching, and that support exists for specific types of reform.

Next, NSEUS conducted a survey of the population finding it represented diverse institutions. The reform courses at these institutions were developed and offered at various times beginning in 1996. After eleven years, 70% of the institutions continue to offer 146 reform courses, with 118 additional courses created as a direct result of the impact made by the original reform process on campus. These value-added reform courses represent an impact 64% greater than the original 185 courses developed in the professional development program. Once developed, reforms created in the faculty

professional development program have continued in the large majority of cases. The single most important factor in the sustained offering of reform courses was identified as the continuous functioning of a collaborative faculty team with its' original team members or with replacement members. Reform courses in the population: (1) involve all students in an inquiry/investigative approach to learning science, (2) include fully integrated inquiry/investigative activities that involved the majority of class time, (3) use collaborative and cooperative learning groups, and (4) use continuous alternative assessment.

In the third step, an NSEUS pilot study determined the feasibility of the planned procedure and instruments for gathering data in a large scale national study. Four courses, with about 300 students, were studied in the pilot. In addition, three graduates from each course were selected for long term follow-up. This included visiting a total of 12 in-service K-6 teachers teaching science lessons in their elementary schools. The pilot study examined factors in the learning environment and content structure and organization in reform and comparison courses at two institutions. It compared these factors to the learning outcomes of students in the courses. Also considered was how differences within and between courses affected current students' short-term outcomes. The pilot further considered long-term outcomes found among in-service K-6 teachers who were graduates of the pre-service program and had participated in either the reform or the non-reform course.

Instrumentation used by NSEUS includes the following. The *Constructivist Learning Environment Survey* (CLES) monitors the development of constructivist approaches in the classroom measuring the role of students in helping to construct their

own learning as perceived from the teacher's and/or students' points of view. The *Thinking about Science Survey Instrument* (TSSI) assesses students' understandings of nature of science and the socio-cultural resistance to, and support for, science in areas of significant cultural concern. The *Draw-A-Scientist Test* (DAST) examines people's beliefs about what a scientist is. *The Science Teaching Efficacy and Beliefs Instrument* (STEBI), is a survey measuring two components of teacher efficacy beliefs. The STEBI-A is a version specifically relating to teaching science in an elementary classroom. The STEBI-B measures the self-efficacy of pre-service elementary teacher candidates in regard to science The *Reformed Teaching Observation Protocol* (RTOP), a classroom observation protocol measuring quantitative characterization of the degree to which a science classroom is "reformed" (Sawada & Pilburn, 2000) based on national standards for science education. Observation, interview, and analysis protocols for Pedagogical Content Knowledge found in in the Content Representation (CoRe) and Pedagogical and Professional Experience Repertoires (PaP-er) instruments are used together to capture and portray pedagogical content knowledge of undergraduate science course instructors and K-6 in-service teachers. An achievement assessment also was developed in conjunction with each of the course instructors to assess meaningful understanding the *Nieswandt Model Standardized Test* (NMST). The items assessed a few key related concepts developed in the course that related strongly to one of the course's main content objectives. The questions included three levels of related concepts: descriptive, hypothetical, and theoretical which students were asked to combine, link and apply in a complex system in scenarios or contexts different that studied in the course.

A site visit occurred to the reform and comparison courses at the pilot undergraduate institutions and to the elementary schools in which a sample of graduates of the reform course and of those who had taken the comparison course were teaching. Observations were made during instruction at the higher education institution and at the elementary schools. Course and/or lesson artifacts were collected and content analyzed. Interviews occurred with reform and comparison course instructors, focus groups of course participants, and with graduated in-service teachers. Profile matrices of instructor/teacher pedagogical content knowledge were developed along with descriptions of the learning climate affecting each classroom.

The quantitative results indicate: (1) students in reform-based science courses perceived a more positive classroom learning climate than did those in comparison courses with significant differences found. Reform course students perceived a learning environment more compatible with the reform goals of the national science standards, than did comparison course students. (2) Little or no growth in science content achievement or understanding, in perceptions of science, or of the impact of science on society was found over a one semester period in the undergraduate courses.

Qualitative data sources demonstrated reform course had positive short-term impacts on students and long-term effects on graduated in-service teachers in their own classroom science teaching. The more positive reform course classroom learning environment related to positive long term learning outcomes. Reform course undergraduate students were much more positive toward science than comparison students and had a better understanding of the relevance of the course’s material to their own lives. Not all reform elementary science lessons, however, by in-service teachers

who were reform course graduates were rated higher than those science lessons of the comparison course graduates.