

**Action Research, Student Learning, and Change:  
Reform in Undergraduate Teaching**

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**Abstract:** This study describes a professional development project where undergraduate faculty in departmental teams used an action research model to hypothesize root causes of student achievement problems, select and implement course interventions, and collect data to assess intervention impacts. This study was conducted over the two years of the Faculty Improving Student Achievement Success (FISAS) project with follow-up data collected 18 months after project conclusion. Study results include faculty learning and course change, impacts on student learning, and institutional change. Overall, course interventions resulted in significant improvements in student learning and/or attitudes. The most important classroom interventions included finding mechanisms to increase student attendance and interaction with the content, and to implement early warning and intervention strategies that can assist students in recognizing unproductive patterns of academic behavior. Sustained changes and improved student achievement were found in those departments with low faculty turn over.

**Context and Purpose**

Few would argue about the importance of initial undergraduate college experiences in the STEM (science, technology, engineering, and mathematics) fields. Work by Tobias (1990) argued that the quality of introductory STEM courses is the single most influential deterrent of students remaining in the STEM field, with 40% abandoning their interest after their first undergraduate STEM course. Of those who persist past this initial course, fewer than 60% actually graduate in a STEM field. With a retention rate of less than 35%, STEM majors are an endangered group. Why do they leave? Students indicate that the features of the courses themselves discourage persistence, including a lack of relevance, passive student roles, emphasis on competition, and a focus on memorization and algorithmic problem solving.

While undergraduate STEM courses are recognized as a significant concern, instructional change in the United States has moved at glacial speed. Fortunately, a large majority of undergraduate faculty (63% in one report and 83% in the other) indicate a primary professional interest in teaching (Menges & Austin, 2001; NRC, 2003), and a rich set of resources exist to support change in undergraduate courses in general and STEM courses in particular, including a plethora of articles (Harwood, 2003), books (McNeal & D'Avanzno, 1996; NSTA, 2001; Siebert & McIntosh, 2001), journals (*Journal of College Science Teaching*), and professional conferences (Project Kaleidoscope). Unfortunately, the message is not being heard. As noted in one report, "many college faculty are not familiar with the literature [on student learning and teaching innovations] however, nor do they have the time, opportunity, or incentives to learn from it" (NRC, 2003, p. 15). Other studies note that, despite extensive professional development efforts, faculty classroom practices have retained a traditional lecture orientation (Walczyk & Ramsey, 2003).

So how can we improve faculty teaching and student learning in undergraduate courses, particularly in the STEM fields? Recent reviews of the literature indicate that while the research designed to help faculty improve their practice is extensive, "little is known to date about the motivations, perceptions, and processes of change that exist among university teaching faculty" (Wright, Sunal, & Day, 2004, p. 5). According to Menges and Austin (2001), research that documents and analyzes faculty professional development program effects on faculty teaching practices and the subsequent learning of students is even rarer. In addition, while much is known about professional development strategies and the general characteristics of successful professional development, few studies describe the proposed match of the institutional context to the professional development program (Guskey, 1995). This study is designed to help fill that gap.

### ***A Need for Change at Small Western University (SWU)***

A common indicator of student success in a course, or lack thereof, is the DFW rate. Courses with low levels of student success are characterized by high percentages of final grades of D and F and high levels of program withdrawal (defined as course withdrawal after the 21 day count). In an effort to analyze student success, institutions often study the DFW rates of its gateway courses, or those 100 and 200 level courses that act as the point of entry to the major. For this study and at SWU, gateway courses were defined as having 100 or more students in the course in each of four semesters and having 10% or greater D,F,Ws. If a student cannot succeed in a gateway course, they are left with three options: switch majors, change institutions, or withdraw from higher education.

Small Western University (SWU, a pseudonym) has long held a tradition of excellence in the education of undergraduate students. Based on institutional reports, however, many classes that act as a gateway to the quantitative fields of science, mathematics, and business were discouraging student access to these majors. Whether due to poor student preparation, dated teaching methods, inadequate student support, or a mismatch between course goals, delivery, and assessment tools, these courses often have high levels of students who receive a grade of D, F, or W. For instance, the DFW statistics at SWU in 1998 and 1999 identified approximately 23 courses each semester (out of approximately 140 gateway courses identified) with DFW rates of over 50%, and approximately 55 courses with DFW rates over 25% (SWU Planning and Institutional Research [PAIR] data). Over 95% of these courses were in the quantitative fields of science, mathematics, technology, and business. The result of low student success is often the selection of a major that does not include the quantitative fields or early attrition from programs at SWU. SWU retention rates for freshman from 1998-2003 was between 67-68% (SWU PAIR data). In fact, 12% of the SWU first-time freshmen earn a D, F, or W in half or more of their courses. Of this group, 41% did not return to SWU for the second semester and only 4% returned for their second year (SWU PAIR data). Obviously, success in entry-level courses had a significant impact on student access to a college degree.

To attend to this challenge, a pair of grants were obtained in order to offer science and mathematics faculty the opportunity to participate in departmental teams and use an action research model to hypothesize root causes of student achievement problems, select and implement course interventions, and collect data to assess the impact of the intervention. This project, named FISAS (Faculty Improving Student Achievement Success), was implemented in academic years 2001-2 and 2002-3. This paper reports on three important aspects of this project. First, the nature of the FISAS experience is described with specific attention to how the project design carefully considered the context of teaching and learning at SWU. In studies of other professional development programs, the powerful impact of context has been noted (Guskey, 1995). For instance, while successful professional development strategies and attributes of successful programs abound, the literature is filled with more examples of failure than success. Why? Many program designs disregarded the context of the professional development and assumed inappropriately that what would work in one context would work in another. In addition, the willingness of faculty to adopt new teaching practices is impacted by their disciplinary affiliation and departmental congruence of beliefs about the importance of teaching and value of

particular teaching practices (Braxton, Eimers, & Bayer, 1996; Braxton, Olsen, & Simmons, 1998; Wright, 2005). For these reasons, this paper will characterize the context at SWU and provide the rationale and underlying philosophy used to design the FISAS program. Second, this paper will report on the results concerning faculty learning, course change, and impacts on student learning. As noted by Guskey (2000, p. 33), "using measures of student learning as the principle criteria when determining the effectiveness of professional development is extremely rare." Finally, the professional development literature recognizes that the change process occurs at both the individual and organizational levels. Therefore, this paper will also report on institutional change that resulted from the FISAS project. The paper concludes with an analysis of the reform of undergraduate courses and derives implications for future projects.

In his work, Guskey (2005) identified five levels of professional development evaluation: participants' reactions, participants' learning, organizational support and change, participants' use of new knowledge and skills, and student learning outcomes. The combined purpose of collecting and analyzing such information is to improve/inform program design, document program implementation and impact, and to inform future change efforts. The purpose of this study is to evaluate the impacts of an action research-based faculty professional development experience on faculty learning and teaching, student learning, and organizational change. While this study examines the change process in one institution, it offers a unique opportunity to evaluate a professional development program across Guskey's five levels while providing details on the nature of the professional development experience.

## **Methods**

### ***Data Collection and Analysis***

This study was conducted over the two years of the FISAS project with follow-up interviews collected 18 months after the project's conclusion. Institutional-level student data was collected three years prior to the project, during the project, and two years after project completion. In order to describe the project's structure and philosophy, artifacts were examined including grant applications, project flyers, steering committee minutes (coded as SCM and the date), and workshop planning notes (WN and date), handouts, and workshop minutes (WM and date).

To describe faculty learning and use of new knowledge and skills in classroom practice, annual work plans and final reports were examined, as well as minutes from the group synthesis sessions at the end of each year and an exit survey at the end of year 2. These data were triangulated with interview data collected 18 months after the completion of the project (conducted by a third party) to gain confirming evidence as to why the faculty joined the project, their current views of teaching, their ability or interest to sustain the work they started in the project, their perceptions of institutional support for teaching, and the perceived impact of the FISAS project.

To better understand the characteristics of the students who enroll in gateway courses, a 26 item survey was administered to 719 students. Results were disaggregated by final course grade (ABC vs DFW). To understand the differences between students' receiving ABC and DFW grades, student final course grades and demographics (N=23,255) from eight semesters (Spring 1999-Fall 2002) in 15 undergraduate courses in the areas of science, mathematics, and business was collected and analyzed. Specifically, a Chi-Square Test of Independence ( $\alpha = 0.05$ ) was used to compare ABC students to DFW students on the following variables: age, gender, ethnicity, college GPA, college class status, and number of college courses previously taken. The student surveys and focus group interviews helped to inform the quantitative analysis.

The principle means of assessing student learning was the pre and post data collected by team action research projects. For most projects, this data was quantitative in nature and compared students in experimental sections with those in control sections either during the same semester or with a previous semester. Overall results of the projects are reported though details of individual projects and impacts.

Finally, data on institutional change was obtained. Three indicators of institutional change were considered: sustained interventions by the FISAS participants, sustained and expanded FISAS course interventions to other sections of the course, and sustained and institutionalized leadership of the FISAS project. To determine participant intervention sustainability, an analysis of faculty retention was conducted to determine issues related to ultimate impact versus investment. For faculty who remained at SWU 18 months after the FISAS project, interviews were conducted about project impact and sustainability. To provide insight into the expansion and sustainability of FISAS interventions to other course sections, rates of A and DFW grades at the end of the course were compared pre and post-FISAS. Since all of the courses in the FISAS project were taught in multiple sections and no project team consisted of all faculty who taught a given course, institutional impact could be noted in an overall change in final course grades. Starting with course grade data from Spring 1998 (three years before the project start), the rates of students earning the grade of A and DFW were calculated for all sections of each course impacted by FISAS. Percentages of A and DFW grades (pre-FISAS) were then compared to percentages from the time of the first FISAS intervention (typically two years - 2001-2 and 2002-3) and through Fall 2004, two years after the conclusion of the FISAS project (post-FISAS). Percentages were compared using a Chi-Square Test for Independence to determine significant change ( $\alpha = 0.05$ ) in final grades and to act as an indicator of the long term impact of the FISAS project intervention for each course. Finally, institutionalization of the FISAS project was based on efforts to expand SWU leadership of the project.

### ***Participants***

The two year FISAS project began in Fall 2001 when a recruitment campaign was launched through the project staff and steering committee (made up of key faculty and administrators at SWU). Participation was elicited through letters of invitation from the Provost, deans, and department chairs, and through individual solicitations and general announcements. In year 1, participation was limited to faculty in the departments of science and mathematics due to grant funding agreements. During the early stages of the FISAS project, the Provost was contacted by the Dean of the College of Business, requesting assistance for his faculty in improving their DFW rates. The Provost agreed to pay for six business and technology faculty to participate in FISAS. Final participation included faculty and instructors from the departments of chemistry, environmental sciences, geology, physics and astronomy, mathematics and statistics, accounting, economics, and computer information systems. It is interesting to note that these departments are often described as having high levels of paradigmatic development that results in strong consensus on course content and teaching strategies. Unfortunately, this consensus is often with teaching practices that are in opposition to those recommended for improvements in undergraduate education, such as teacher/text-centered instruction and low levels of colleague interaction about teaching (Braxton et al., 1998; Wright, 2005). In contrast, low paradigmatic fields such as psychology and history, tend to value advocated teaching practices such as student-centered teaching approaches and team teaching (Braxton et al., 1998; Wright, 2005).

In year 2, participation was open to all academic departments. Despite this increase in project scope, no new department teams joined the project and all of the original department teams continued with only minor changes in team composition. Over the two years of the project, 14 tenured or tenure-track faculty and 13 instructors participated in the project.

### **Results**

The results of this study are organized into five sections. The first is a description of the FISAS project. This description not only provides a context from which the rest of the data can be viewed, but also provides the philosophy and rationale for the project structure. The next four sections describe the results concerning the characteristics of students in science, mathematics, and business gateway courses; faculty learning and change; student learning; and institutional change.

### ***FISAS Project Philosophy and Structure***

Professional development efforts in higher education are not new and, while the literature provides a wealth of suggestions for strategies that can be used, more research is needed to determine the best match of professional development models to contextual needs (Weimer & Lenze, 1994). In order to ensure the highest possibility of success, the design of the FISAS project was based on both the research on effective elements of professional development and a careful consideration of the context at SWU. Specifically, the FISAS project was designed around the value of honoring faculty members' dedication to high quality teaching, acknowledged the importance of overcoming barriers, provided for collaboration, and ensured ownership of teaching and learning. (See Table 1 for a comparison of context to project components). Finally, the change theory used in this project closely followed the elements of the conceptual change model, using action research strategies as the professional development vehicle. Each of these elements is described below in terms of how they were incorporated in to the FISAS project design.

### **Insert Table 1 About Here**

SWU was an institution in need. According to the second grant application to support the FISAS project:

From those [Steering Committee] meetings came the recognition for the need for a faculty development project aimed at student achievement that was respectful of the knowledge, expertise, and motivation of the faculty, that helped support faculty efforts to improve their courses, and that began the process of building a campus community dedicated to discussing and implementing classroom-based changes that might better support students and faculty in their efforts to enhance academic excellence. (Grant application, 1/02, p. 2).

The SWU faculty were discouraged by the DFW and retention statistics that were released to the campus community and were fearful of how the data would be used. Two possibilities existed - to use the data as a weapon or a tool. When data is used to point blame and find fault, it is being used as a weapon. When data is used as a weapon, faculty commonly respond by withdrawing from the problem and resisting potential solutions (Middendorf, 1998). When data is used as a tool, it honors individuals' commitments to the profession and puts them in control of change. Data used as a tool points not to individuals but to an existing set of circumstances that are causing the concern. In order to activate change, participants must see the data as a challenge, be provided with the resources to examine the data, identify the problem, and find and evaluate a solution. In this way, the data in this study was used as a tool and faculty were recognized as knowledgeable professionals who had the potential to improve student learning. Recognizing the powerful impact of fueling dissatisfaction as a precursor to change (Gess-Newsome et al., 2003; Posner et al., 1982; Sunal et al., 2001), the FISAS steering committee took the purposeful stance to use the DFW and retention data as a tool to motivate faculty to change while honoring their commitments to teaching (SCM, 8/23/01). Creating dissatisfaction was the first step in the conceptual change model. The FISAS project was therefore seen as a professional development project that was designed to "help teachers maintain, or in some cases, rediscover the enthusiasm, hopefulness, and commitment that they have for teaching" (Guskey, 1995, p. 116).

The FISAS project had two goals: 1) to improve student success and retention in gateway courses, and 2) to increase faculty commitments to learner-centered techniques (grant proposal, 1/02, p. 5). In order to achieve these goals, FISAS was designed to engage faculty teams in identifying and solving a specific student learning concern in a specific course. The team approach was selected to provide support and encouragement, broaden responsibility for teaching and learning (an especially important strategy with working with multi-section courses), foster ownership, and provide motivation and sometime peer pressure to implement the selected innovation. Creating support networks and opportunities for collaboration among faculty members has been found to be one of the most important conditions when instituting change

(Harwood, 2004; Sunal et al., 2001; Wright, 2005), especially when disseminating course innovations to colleagues (Krockover et al., 2001)

The FISAS project provided participants with facilitated discussions concerning issues surrounding gateway courses and strategies that might increase student learning and success. Each semester the FISAS group met for a 3 hour evening session where the purpose of the project was explained; preconceptions about teaching, learning, and change were explored; and strategies to improve student success were examined. For instance, during the first group meeting, there were a series of facilitated activities around the question, "What potential reasons exist for poor student achievement?" (WN, 11/19/01). Two key points were developed from this exercise: 1) We need to shift our thinking from a responsibility for teaching to a responsibility for student learning, and 2) Barriers to change exist, but they can be overcome if we choose to focus our attention at course level change (SCM, 11/27/01). A specific focus on student learning provided a reason to examine data, allowed faculty the opportunity to examine their own goals for instruction, and to select the form of instructional intervention that felt the most appropriate to their context. Using departmental teams allowed for university-level change around the central theme of improving DFW rates while allowing teams to identify their own learning challenges and interventions. This integrative design for the level of professional development implementation has been advocated by Guskey (2000). The personalization of the professional development experience by using departmental teams has been used successfully in other settings, shifting the focus from external professional development to a more internal professional involvement and control (Olsen, Maple, & Stage, 1995; Schibeci & Hickey, 2004). The desired outcome from this stance was ownership of both the process and the products of change.

The second stance of the FISAS project, ignoring barriers that could not be changed and focusing on that which was within the control of the faculty, was both critical and liberating (Olsen et al., 1995). Early discussions during the first meeting allowed faculty to expound upon the barriers and problems that prevent student success and, as anticipated, many of these barriers were beyond their control and were typical of the barriers listed in other studies of undergraduate reform (Gess-Newsome et al., 2003; Harris, 2001; Sunal et al., 2001). Acknowledging these barriers, and purposefully choosing to relegate them to the background in an effort to focus on what could be changed (classroom instructional interventions) allowed the faculty to take personal control of the change process. The importance of the decision to focus on course level change has been found effective in other higher education settings as well (Wright & Sunal, 2004).

In addition to the evening meetings each semester, the teams met in at least one large group work session each year. These work sessions, lasting one and a half days, provided a retreat-like setting where teams could work with support staff to identify a student learning concern, identify indicators of success in attending to this concern (for instance, if the goal was to increase student understanding of the content, data could include improved quiz and test scores), hypothesize a course-based intervention that was likely to influence the learning concern, and determine pre and post measures that would provide evidence of the impact of the intervention (WN, 1/10/03; WN, 11/13/03). This structure provided the teams with self-selected interventions for which they felt a degree of comfort, making the change process manageable and incremental (Guskey, 1995). Based on team planning, work plans were filed for the spring semester of each year. After a semester of intervention and data collection, teams submitted a written report of their activities including the data they collected and the impact of their intervention. These reports were presented orally to the FISAS group following year 1, and presented as a poster at a university-wide Assessment Fair in year 2. Following each of the closing sessions, the group met to process the overall institutional learning from the team projects by identifying commonalities in the interventions and results.

The above project plan follows a conceptual change framework in that it worked from a sense of *dissatisfaction* in the participant (the DFW and retention data), allowed the faculty members to seek *plausible* alternatives to their teaching (classroom-based intervention), and test the intervention for *fruitfulness* (examine pre and post data for evidence of success) (Posner et al.,

1982). This action research model was a strong match to our theory of change and the needs within the institution. The action research process was based on the belief that faculty can form valid student learning questions and provided a mechanism to teams to engage in group problem solving and the search for viable solutions. While action research has not been used extensively as a professional development tool in the United States, it has been described as especially relevant for faculty because it promotes professionalism and focuses on improving teaching and bringing about curriculum change (Kember & McKay, 1996; Krockover, et al., 2001; Raubenheimer, 2004), while attending to the recommendation that “teaching effectiveness should be judged by the quality and extent of student learning” (NRC, 2003, p. 4). In addition, new instructional practices are more likely to be retained when there is evidence of their effectiveness, and student learning is one of the most powerful forms of evidence for teachers (Guskey, 1995; Krockover et al., 2001).

Support for faculty teams was provided through the project PI (a science educator), the staff members in a science and mathematics teaching center, and by a graduate student who was familiar with reform-based teaching in undergraduate classes and with classroom assessment techniques. These individuals provided the teams with technical assistance such as access to research on teaching techniques, curricular resources, and data collection and evaluation instruments. Participants were awarded a \$2000 stipend each year upon the completion of project requirements. In addition, faculty teams were encouraged to apply for mini-grants (\$500-\$3000) to support aspects of their work, such as for a teaching assistant, web developer, or additional course materials. As noted in the research, providing support in the form of money (the stipend), time (teaching assistants to help grade papers or collect data), and technical assistance can help remove perceived barriers, act as a catalyst for change, and promote positive attitudes in participants (Harwood, 2004; Sunal et al., 2001). Additionally, while faculty often comment that they are willing to make instructional changes on their own, the presence of an external facilitator can act as a critical friend or “catalyze” more reluctant participants (Kember & McKay, 1996).

### ***Characteristics of Students in Gateway Courses***

While course-based data was important for the validation of teaching interventions, institutional data was needed to uncover more broad-based patterns as they related to student retention and success. In order to understand the characteristics of students in gateway business, mathematics, and science courses at SWU, a 26 item survey was administered to 719 students in seven gateway courses during 2002-2003 (year 2 of FISAS). Survey results addressed student demographics, perceptions of the course, academic habits, impact of the course, and perceptions of college life and SWU. Results suggest that the population sampled was typically younger than 22 years with a class standing of Junior or lower and academically competent with some deficiencies in study habits. Most students described their classes as challenging and dependent upon the memorization of facts and equations - a finding startlingly similar to that of Tobias (1990) when seeking reasons for students dropping out of the STEM fields. Students attended class at a moderate rate (75% of the time), but rarely participated in class-related discussions outside of class (1 to 3 times a semester). Most students said that their goals would be affected by their level of course success. Implications for concerns about course grades are discussed by Menges and Austin (2001), where grade-oriented students were on-task during classroom instruction only 48% of the time compared to learning-oriented students at 69% of the time, suggesting that students who focus more on accomplishing a goal (earning a passing grade) than learning may be less likely to be successful. Finally, a majority of students reported attending SWU for aesthetic reasons or because of financial incentives as opposed to SWU's academic programs or reputation.

To understand the differences between ABC and DFW students, student data (n=23,255) from seven semesters (Spring 1999-Fall 2002) were collected and analyzed. Results suggest that DFW students are more often of ethnic heritage, male, and anticipate that course success will have a strong impact on their academic goals and interests. DFW students are more likely to see courses as challenging, describe themselves as academically less prepared, and are less likely to attend class regularly. Most surprising, 99% of ABC students predict they will earn an ABC as a

final course grade, while 83% of DFW students also predict that they will receive an ABC, indicating an inaccurate awareness of grade status and the impact of study habits on course success. DFW students more often depend on doing homework and studying notes as their primary study strategies, while ABC student are more likely to depend on doing homework and reading the text. This last finding is indicative of a potential problem: students who review the instructor's notes generally perform better than those who only review their own notes (Menges & Austin, 2001). While these findings have strong explanatory power for the results of the action research projects, this level of data analysis was not completed until after the conclusion of the FISAS project, so faculty participants were unable to benefit from this information.

***Faculty Learning and Change: Ownership of Student Learning***

During the two years of the FISAS project, 27 faculty across 8 departments worked to incorporate classroom based interventions in 21 courses, impacting approximately 7000 students each year. While Menges and Austin (2001) note that most research reveals what faculty members do following professional development, research provides little insight into why they do it. When asking FISAS faculty and instructors why they elected to participate, two types of answers were found. For many tenure and tenure-track faculty, participation was based on the dissatisfaction that arose from the DFW reports disseminated by the campus administration, or because there was a sense of need to change instruction due to low levels of past success. These reasons to participate reinforce the use of dissatisfaction as a precursor to change and validate one of the premises upon which the FISAS project was designed. While the instructors expressed dissatisfaction with student learning success, their involvement in the project was also often linked to the need to earn additional money or based on the perceived pressure from the participation of another faculty member in their department. Others noted the importance of peer support and collaboration and their sense of responsibility to improve the learning experience of their students. In the majority of cases, faculty and instructors believed that they would have made the changes identified in their selected intervention without the project, but noted that it was less likely that they would have completed the change or collected data to substantiate the effectiveness of the change without the project. This set of findings is supported by the research of others (Daas, 1997; Harwood, 2004; Kember & McKay, 1996; Schibeci & Hickey, 2004; Sunal et al., 2001).

Beyond obvious pride in improving teaching and learning, there were a number of ancillary benefits for involvement in the project. In the 4 years since the FISAS project inception, four of the participants have been awarded national, state, or university level teaching awards. One department was awarded a grant from another agency to continue the work started with FISAS. Two teams presented papers at national conferences about their FISAS work and one team submitted a paper on their work to a national professional journal. Obviously, the personal gains from participating in the FISAS project have been significant, with satisfaction expressed in both taking control of a learning challenge and producing publications and presentations that are recognized as the cultural currency of research while support the enhancement of teaching (Kember & McKay, 1996; Olsen et al., 1995).

***Student Learning: Reinventing the Wheel***

Each team in the FISAS project was given the task to identify a student learning concern, select an intervention that had the potential to address the problem, and collect pre and post data to determine the effectiveness of their selected intervention. While there is not sufficient room to provide the details of each action research project report, Table 2 provides information about the nature of the course, the intervention, the ultimate impact on student learning, and the statistically significant long term impacts of course changes on rates of A and DFW final grades. (The long term impacts on A and DFW rates will be discussed in a later section.) Action research data related to student learning was derived either from comparisons between experimental and control sections, or sections from non-intervention semesters with intervention semesters. While it is recognized that the individual studies may not have the rigor of a publishable research study, the quality was sufficient to provide the faculty involved with data to help determine the usefulness of the intervention they selected.

Project types were examined for common themes and categorized. Some projects had components in more than one category. Overall, 1 project focused on course readiness (a mathematics pre-test), 10 on increasing the conceptual engagement of students (e.g., quizzes, problem solving, interactive note-taking), 5 involved the retooling of content or pedagogical frameworks (e.g., theme-based, increased real-life applications), and 5 included increased opportunities for group work (e.g., cooperative learning, problem-based learning groups). These findings are similar to those of Raubenheimer (2004), who noted that action research projects often result in attempts to change teaching methods from more traditional to more learner-centered forms of instruction.

### **Insert Table 2 About Here**

A synthesis of the action research projects by the faculty at the end of each year revealed the following key findings:

- *Attendance is critical to student success.* Random quizzes, taking attendance, and cooperative learning techniques all help encourage attendance.
- *Increased interaction with the content* (through quizzes, cooperative learning, problem solving, class time to start homework and interact with faculty, study groups, etc.) assists students with content comprehension and achievement.
- *Early intervention strategies*, such as quiz or readiness test scores that help students identify poor study habits or conceptual understanding, encourage students to take responsibility for their own learning while there is still time for remediation. (WM, 5/13/03).

For the participants in the FISAS project and for their colleagues, these findings were important because they were based on lessons learned with students and courses at SWU. These findings, however, are not new. For instance, in a review of teaching in higher education, Menges and Austin (2001) list a plethora of findings related to teaching techniques that result in increased student learning. Among those listed are the following:

- Student-faculty contact outside the classroom has a positive influence on students.
- Faculty knowledge of student learning difficulties is rare - but when it exists, it is used to design instruction (as opposed to teacher personal preference or trial and error).
- Students who expected to be questioned orally at random reported better preparation and scored better on quizzes than students without that expectation.
- For meaningful learning to occur, students must be attentive to the learning task, such as through "active learning" techniques.
- Techniques that increase student engagement are effective in enhancing learning and satisfaction.
- Research on peer teaching and tutoring is sufficiently strong to recommend wider adoption of those approaches.
- Cooperative and active learning approaches were associated with the greatest gains in self-learning (compared to other learning experiences).
- Achievement, persistence, and attitude were higher for students in cooperative or collaborative learning environments as compared to others.

The statements above are also consistent with the seven principles of good practice in undergraduate teaching (Chickering & Gamson, 1991) which includes student contact, student feedback, student cooperation, active learning, high expectations, time on task, and respect for diversity; as well as reflected in the six recommendations to improve undergraduate teaching and learning synthesized from the research and policy literature, including faculty and student contact, systematic program advisement, feedback on student performance, learn about students, foster egalitarianism and tolerance, and demonstrate a concern for improved college teaching (Braxton et al., 1996).

In many ways, the data gleaned from the action research projects and from the analysis of the students at SWU are striking in their similarity to the findings reported above. Such similarity prompts the question about the efficiency of action research based strategies. Through the FISAS project, have we only managed to reinvent the wheel?

The FISAS participants, like most faculty in higher education, rarely have the time to read the research literature on teaching and learning. Therefore, the FISAS project provided the faculty with an opportunity to learn similar lessons to the findings in the literature, with an important difference: these are conclusions that they own, allowing them to personalize the findings in a context of high relevance - their own classrooms. We hypothesize that the impact of the FISAS project would have been diminished if these faculty were simply presented with the findings on effective teaching at the undergraduate level. The power of the FISAS project then was the self-discovery of these principles in their own classroom settings at SWU.

***Institutional Change: Gaining Skill, Loosing Capacity***

The goals of the FISAS project were to improve undergraduate student retention and success and to increase faculty commitments to learner-centered techniques. The results of team action research projects certainly provides evidence that the goal of improving student learning was at least partially accomplished as part of this project. Learning gains were seen in all of the project classrooms.

While individual faculty and classroom gains were made, how did FISAS impact SWU? For evidence of institutional change, evidence for one or more of the following conditions would need to be met: 1) course interventions were transferred to other courses taught by the FISAS faculty, 2) course interventions were sustained and/or expanded to other sections of the same course (in the case of multi-sections courses), including sections not taught by FISAS faculty, and/or 3) FISAS project leadership was sustained and institutionalized. Did these forms of institutional sustainability occur?

In order to investigate the first condition, changes in additional courses by FISAS faculty, two data sources were explored: university retention of faculty and instructors in the FISAS project, and faculty interview data collected 18 months after project completion. In designing the FISAS project, tenured and tenure-track faculty were initially targeted for participation. Based on interest and the large number of undergraduate courses assigned to temporary instructors and graduate students, these individuals were also invited to participate. In the end, the number of faculty and temporary instructors was almost equal (6 tenured faculty, 8 tenure-track faculty, and 13 instructors). The negative consequences of this decision are found in an analysis of the recurring role of project participants in gateway courses at SWU. Of the 6 tenured faculty, one left the institution and a second moved into an administrative role, decreasing his teaching responsibilities. Of the 8 tenure-track faculty, 3 left the institution, often for reasons related to their potential success for tenure, and 5 achieved tenure. Of the 13 instructors, only 4 have taught continuously at SWU since the FISAS project was completed. Two of the instructors left SWU for a year in order to further their education and are now once again teaching at SWU. These numbers represent a 54-66% loss of capacity, with the highest levels of loss at the instructor level. Of note, 75% of the mathematics faculty (two tenure-track and four instructors) and 75% of the physics and astronomy faculty (one tenure-track and two instructors) who participated in FISAS are no longer employed at SWU. Such issues of faculty retention may simply be a fact of academic settings, but it raises questions about the nature of investments in professional development. When faculty development dollars are limited, in what kind of instructional staff are the dollars best invested? Additional implications for faculty retention are discussed with the next data set.

In order to answer the question related to the transfer of FISAS interventions to other course sections, an analysis of DFW trends from 1998 through 2004 was conducted, where percentages of grades of A and DWF were compared for FISAS project courses seven semesters before and five semesters after the interventions. This analysis included all sections of the course taught,

including those taught by FISAS faculty and others. We propose that increases in percentages of A and decreases in percentages of DFW would act as an indicator of sustainability of the teaching interventions and the potential transfer of these interventions to other course sections and/or instructors.

Based on a statistical analysis of final course grades pre and post-FISAS, significant increases in grades of A exist for 5 of the 12 courses for which there is data, and significant decreases in DFW rates were found for 7 of the 12 classes. Findings for which there was statistical significance are listed in Table 2. In one instance, there was an increase in DFW rates following FISAS. In interviews with the impacted department, the change was due to a change in course staffing where the FISAS participant was no longer teaching the course.

So what explanations exist for these long term learning gains in over half the FISAS courses? Sustained and expanded course changes, the introduction of effective course interventions, and stability of faculty appear to offer partial explanations. As mentioned earlier, all the gateway courses in this project are offered in multiple sections by multiple faculty. Despite emphasizing the importance of participating in faculty teams, no departmental team included all members of the faculty who taught the course. Therefore, over all changes in the percentages of A and DFW grades can either be attributed to department-wide adoption of the course interventions introduced by the FISAS project, or substantial learning gains by students in courses taught by FISAS participants - so much so that gains in these courses were sufficient to make significant changes in the overall final grades of the course. In talking to participating faculty, both explanations existed. For a number of the courses, the interventions introduced by the FISAS participants acted as a pilot for the department. Based on evidence of student learning success and the enthusiasm of the instructor, many departments were willing to adopt changed practices across all course sections. In other courses, department-wide adoption of learner centered strategies did not occur, but FISAS participants assumed increased ownership (and teaching loads) in the courses they modified, therefore having an increased impact on student success.

The nature of the course interventions also made a significant impact on student success. In examining the courses for which there were significant learning gains, the courses often implemented frequent quizzes, either as a way to increase student attendance and/or as a mechanism to give students increased contact with and information about their level of success in learning the material, or the courses adopted cooperative learning strategies. Of these two techniques, increasing quizzes is a simple, time efficient method of facilitating learning and providing feedback. In interviews with faculty, this technique has been one of the easiest to maintain. Cooperative learning, while potentially more difficult to adopt, encompasses many of the recommended features of effective undergraduate teaching including active learning, increased contact with the content, peer interaction, and student feedback about their thinking.

Finally, faculty stability played a large role in the sustainability of course interventions. In examining those courses with no significant changes or decreases in student success, all the courses were in areas where faculty retention was low. This finding both supports the importance of professional development in facilitating change while highlighting again the issue of faculty retention. Overall, these statistics show a positive institutional impact of the FISAS project on many of the classes involved in the reform effort. Therefore, the goal of changing the nature of a subset of the gateway courses at SWU was achieved through the FISAS project with the impact sustained beyond the project period.

As the project moved through year 2, the expectations for project faculty to gather and share ideas and resources became more and more difficult, with faculty having multiple and conflicting time constraints. Several planned meetings were cancelled due to limited participation. Time was blamed for this level of attrition, the same reason given for additional teams not joining the FISAS project in year 2. As the FISAS project concluded in year 2, the Principal Investigator received a different grant and could no longer sustain leadership of FISAS. Based on these situations, an exit survey was distributed to determine the merits of the project, collect indications of continuing

interest in the project, and to identify a new project PI. While the exit surveys indicated that all faculty enjoyed their involvement in the FISAS project, less than half of the participants expressed interest in continuing for another year, with many of the participants indicating that they were leaving the institution for higher paying positions. Others felt that they had accomplished their project goals. Those who indicated an interest in continuing stated that they would work on course improvements with or without the grant, though they would prefer to receive the stipend in recognition of their work. In fact, faculty interviews revealed that for many of the participants, the FISAS project acted as an important turning point in their teaching career and launched a renewed emphasis on teaching and the determination to seek additional professional development opportunities that would result in more student-centered instruction. In the end, however, project leadership could not be found. Based on these factors, the FISAS project was disbanded in 2003 even though a third year of funding was available.

### **Conclusions and Implications**

This study examined a professional development project for undergraduate faculty members to determine its' impact on faculty learning and change in teaching practice, student learning in impacted courses, and institutional change and sustainability. In using the data from faculty learning, course implementation, and student learning, it appears that the FISAS project was a success. Faculty teams made course changes in 21 different courses impacting over 7000 students. In the vast majority of cases, the course interventions made significant improvements in student learning and/or attitudes and many of these improvements have been sustained well after the project period. Perhaps more importantly, the FISAS faculty felt respected for their willingness to attempt to improve student learning, supported in their efforts, proud of their accomplishments, and in many cases were willing to both sustain and expand the efforts initiated in the FISAS project. Many of the features of the FISAS project that were purposefully included in its design were noted as responsible for this success: honoring faculty desires to be good instructors who care about students learning, using data as a tool as opposed to a weapon, building collaborative relationships, ensuring ownership of the change process, and using action research from a conceptual change perspective as the vehicle for professional development.

When examining the results of this project, there are a great number of things that SWU as an institution was able to learn. Many of these lessons had to do with the analysis of the sum total of results from the action research projects and the analysis of institutional data. As a group, the faculty and instructors in the FISAS project learned that the most important classroom interventions included finding mechanisms to increase student attendance and interaction with the content, and to implement early warning and intervention strategies that can assist students in recognizing unproductive patterns of academic behavior. These findings are not new and in many ways represent a great deal of faculty effort to "reinvent the wheel," however, this inquiry process was essential to the ultimate ownership of the knowledge gained and served to reinforce future efforts at reform. As noted by Guskey (1995, p. 126), "the key to greater success in professional development rests not so much in the discovery of new knowledge, but in our capacity to use deliberately and wisely the knowledge we have."

While exit surveys and interviews indicated that the faculty and instructors enjoyed their involvement in the project, less than half of the participants expressed interest in continuing for a third year. Time was the primary reason given for discontinued participation, even though the demands for group gatherings decreased over the length of the project. Beyond the obvious impact of attrition from SWU, many participants felt that they had accomplished their project goals. These losses were most severe for faculty who had not yet earned tenure, and for temporary course instructors who make up a significant portion of the instructional staff. For those who wanted to continue the project, many stated that they would continue to make course improvements with or without the grant, but preferred to be paid for their work.

Several implications exist for this work. First, when faculty are given ownership of teaching and the resulting student learning, and they are provided with support systems that allow them to experiment and examine student learning, improved teaching practices are possible.

Second, faculty who are interested in improving courses often indicate a sense of moral imperative to provide high quality education at the undergraduate level. Unfortunately, many of these individuals are also untenured faculty or instructors. As the reality of tenure reviews and the requirements for strong research portfolios increases, willingness to “sacrifice” time to teaching decreases. For those faculty who are in temporary appointments, the chance for sustainability often leaves with their selection of a more permanent and higher paying job. While young untenured faculty are particularly vulnerable, senior faculty can also be negatively impacted by efforts to improve their teaching by earning reduced merit pay (based on decreased research productivity) and being given increased teaching and advising loads (Wright & Sunal, 2004).

As noted by Harris (2001, p. 50), universities and its faculty face “strong disincentives to implement new techniques in their courses.” Without exception and across institutional types, Menges and Austin (2001) note the positive correlations between salary and scholarly productivity and the null or negative correlations between salary and teaching productivity. Reinforcing this finding, Walczyk & Ramsey (2003) note that “faculty view undergraduate teaching as an encumbrance on their research time” (p. 579). While 63% of the faculty agreed that their primary interests were in teaching, 75% of these same faculty agreed that it would be difficult to get tenure without publishing, and only 12.5% said that they were rewarded for good teaching (Menges & Austin, 2001).

Obviously, institutions need to redesign reward structures and give more weight to instructional innovation in tenure and promotion decisions and in salary merit structures. Why don't these changes occur? Menges and Austin (2001) blame it on the myth that teaching effectiveness and research productivity are positively associated, a correlation that has experienced a consistent lack of support when examined in various research studies. What are the implications of this myth?

So long as the myth persists, it forces many academics to work against the teaching mission of their institutions. If given limited discretionary time, faculty members, even at liberal arts colleges, prefer to direct time toward research and writing. ... Is that because of perceived rewards, or is it because faculty members find research and writing to be more controllable and intrinsically satisfying activities? (Menges & Austin, 2001, p. 1129).

Sustaining efforts to change undergraduate college courses appears possible at the individual faculty and instructor level, but less likely to be sustained institutionally. As long as teaching (as determined by the quality of student learning) is placed in low esteem for tenure and promotion decisions, few faculty will afford the time needed to improve classroom practice. As long as teaching gateway courses is seen as an undesirable assignment and therefore relegated to temporary instructors, few changes in college undergraduate courses will be realized or sustained.

This research fills an important gap by providing insight into the process and products of the professional development of undergraduate faculty and the impacts on faculty learning and teaching, student learning, and institutional change. Additional research is needed on other factors, similar to student learning data, which can act as tools for change and facilitators of teaching dissatisfaction. Additional examples are needed where there is a strong match between need and the selection of an appropriate professional development strategy. Finally, future research is needed to help identify the characteristics of those faculty who are willing to participate in reform and to determine the reward structures that enhance their ability to remain in the teaching profession, thus providing a return on professional development investments.

## References

- Braxton, J.M., Eimers, M.T., & Bayer, A.E. (1996). The implications of teaching norms for the improvement of undergraduate education. *The Journal of Higher Education*, 67, 603-626.
- Braxton, J.M., Olsen, D., & Simmons, A. (1998). Affinity disciplines and the use of principles of good practice for undergraduate education. *Research in Higher Education*, 39, 299-318.
- Chickering, A.W., & Gamson, Z.F. (Eds.). (1991). Applying the seven principles of good practice in undergraduate education. San Francisco, CA: Jossey-Bass.
- Dass, P.M. (1997, March). District-wide professional development of science teachers: Factors influencing the implementation of the Iowa Chautauqua model. Paper presented at the National Association for Research in Science Teaching annual meeting, Oakbrook, IL. Retrieved 3/24/05 from <http://www.educ.sfu.ca/narstsite/conference/97conference/dass2.pdf>.
- Gess-Newsome, J., Southerland, S.A., Johnston, A., & Woodbury, S. (2003). Educational reform, personal practical theories, and dissatisfaction: The anatomy of change in college science teaching. *American Educational Research Journal*, 40, 731-767.
- Guskey, T.R. (2005). Taking a second look at accountability. *Journal of Staff Development*, 26 (1), 10-18.
- Guskey, T.R. (2000). *Evaluating professional development*. Thousand Oaks, CA: Corwin Press.
- Guskey, T.R. (1995). Professional development in education: In search of the optimal mix. In T.R. Guskey & M. Huberman (Eds.), *Professional development in education* (pp. 114-131). New York: Teachers College Press.
- Harris, M.T. (2001). Strategies for implementing pedagogical changes by faculty at a research university. *Journal of Geoscience Education*, 49 (1), 50-55.
- Harwood, W.S. (2003). Course enhancement: A road map for devising active-learning and inquiry-based science courses. *International Journal of Developmental Biology*, 47, 213-221.
- Harwood, W.S. (2004). Factors affecting science and science education faculty collaborations. In D.W. Sunal, E.L. Wright, & J. Bland (Eds.), *Reform in undergraduate science teaching for the 21<sup>st</sup> century* (pp. 53-68). Greenwich, CT: Information Age Publishing Inc.
- Kember, D., & McKay, J. (1996). Action research into the quality of student learning: A paradigm for faculty development. *The Journal of Higher Education*, 67, 528-555.
- Krockover, G., Adams, P., Eichinger, D., Nakhleh, M., & Shepardsen, D. (2001). Action-based research teams: Collaborating to improve science education. *Journal of College Science Teaching*, 30, 313-317.
- McNeal, A.P., & D'Avanzo, C. (Eds.). (1996). *Student-active science: Models of innovation in college science teaching*. Orlando, FL: Harcourt-Brace & Company.
- Menges, R.J., & Austin, A.E. (2001). Teaching in higher education. In V. Richardson (Ed.), *Handbook of Research on Teaching* (4<sup>th</sup> ed., pp 1122-1155). Washington, DC: AERA Press.
- Middendorf, J.K. (1998). A case study in getting faculty to change. In M. Kaplan (Ed.), *To improve the academy*, Vol. 17 (pp. 203-224). Stillwater, OK: New Forums Press and the Professional and Organizational Development Network In Higher Education.
- National Research Council. (2003). *Evaluating and improving undergraduate teaching in science, technology, engineering, and mathematics*. Washington, DC: National Academy Press.
- National Science Teachers Association. (2001). *Practicing science: The investigative approach in college science teaching*. Arlington, VA: NSTA Press.
- National Science Teachers Association. *Journal of College Science Teaching*. [www.nsta.org](http://www.nsta.org)
- Olsen, D., Maple, S.A., & Stage, F.K. (1995). Women and minority faculty job satisfaction: Professional role interests, professional satisfactions, and institutional fit. *The Journal of Higher Education*, 66, 267-294.
- Posner, J., Strike, K., Hweson, P., & Gertzog, W. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66, 211-227.
- Project Kaleidoscope. [www.pkal.org](http://www.pkal.org)

Raubenheimer, C.D. (2004). Professional development of university science faculty through action research. In D.W. Sunal, E.L. Wright, & J. Bland (Eds.), *Reform in undergraduate science teaching for the 21<sup>st</sup> century* (pp. 199-223). Greenwich, CT: Information Age Publishing Inc.

Schibeci, R.A., & Hickey, R.L. (2003). Dimensions of autonomy: Primary teachers' decisions about involvement in science professional development. *Science Education, 88*, 119-145.

Siebert, E.D., & McIntosh, W.J. (Eds.). (2001). *College Pathways to the Science Education Standards*. Arlington, VA: NSTA Press.

Sunal, D., Bland, J., Sunal, C., Whitaker, K., Freeman, M., Edwards, L., et al. (2001). Teaching science in higher education: Faculty professional development and barriers to change. *School Science and Mathematics, 101*, 246-257.

Sunal, D. W., Wright, E.L., & Bland, J. (Eds.). (2004). *Reform in undergraduate science teaching for the 21<sup>st</sup> century*. Greenwich, CT: Information Age Publishing Inc.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier*. Tucson: Research Corporation.

Walczyk, J.J., & Ramsey, L.L. (2003). Use of learner-centered instruction in college science and mathematics classrooms. *Journal of Research in Science Teaching, 40*, 566-584.

Weimer, M., & Lenze, L. F. (1994). Instructional interventions: A review of the literature on efforts to improve instruction. In K. Feldman & M.B. Paulsen (Eds.), *Teaching and learning in the college classroom* (pp. 653-682). Needham Heights, MA: Ginn Press.

Wright, E.L., & Sunal, D.W. (2004). Reform in undergraduate science classrooms. In D.W. Sunal, E.L. Wright, & J. Bland (Eds.), *Reform in undergraduate science teaching for the 21<sup>st</sup> century* (pp. 33-51). Greenwich, CT: Information Age Publishing Inc.

Wright, E.L., Sunal, D.W., & Day, J.B. (2004). Improving undergraduate science teaching through educational research. In D.W. Sunal, E.L. Wright, & J. Bland (Eds.), *Reform in undergraduate science teaching for the 21<sup>st</sup> century* (pp. 1-11). Greenwich, CT: Information Age Publishing Inc.

Wright, M. (2005). Always at odds?: Congruence in faculty beliefs about teaching at a research university. *The Journal of Higher Education, 76*, 331-353.

Table 1

*FISAS Program Components as Compared to SWU Context*

<b>SWU Context</b>	<b>FISAS Program</b>
Faculty discouraged by DFW and retention statistics	<ul style="list-style-type: none"> <li>• Recognize and honor commitment to student learning</li> <li>• Treat faculty as knowledgeable professionals</li> <li>• Use data as a tool as opposed to a weapon</li> </ul>
Many barriers to the change process	<ul style="list-style-type: none"> <li>• Focus on classroom level change</li> <li>• Encourage incremental change</li> </ul>
Feeling of isolation and overwhelmed at scope of the problem	<ul style="list-style-type: none"> <li>• Departmental teams</li> <li>• Cross-campus collaboration</li> </ul>
Need for ownership	<ul style="list-style-type: none"> <li>• Self-selected learning challenge and intervention</li> <li>• Data collection on resulting student learning</li> </ul>
Need for recognition and support	<ul style="list-style-type: none"> <li>• \$2000 stipend</li> <li>• Mini-grants for TAs, etc.</li> <li>• Technical assistance</li> </ul>

Table 2

*FISAS Action Research Projects, Student Learning Results, and Long Term Impact on Percentages of A and DFW grades*

Course	Learning Concern	Intervention	Student Learning Results During the Semester of Intervention	Changes in % of A and DFW Grades*
Intro to Accounting for majors	Low levels of student engagement	Cooperative learning through an interactive software program	Decreased DFW rates and positive feedback from students	N = 1809
Chemistry for majors I & II	Conceptual understanding	Weekly just-in-time web-based quizzes	Positive correlation between quiz taking and final grade, differences noted in top 85% of class	A = 22%→30% DFW = 29%→18% N = 5810
Organic Chemistry I & II	Poor grades and content comprehension	Interactive note taking, weekly quizzes providing for multiple attempts and immediate feedback	Increased quiz scores (71.3 to 78.2) and decreased standard deviation (12.0 to 6.3), increase in A and B grades, 10% increased pass rate on national exam	N = 1355
Principles of Accounting I & II	Increase student interaction and interest	Problems before content presentation, cooperative learning, review sessions	Significant improvement in test scores, increased student interest in the course and content	A = 14%→17% DFW = 34%→30% N = 5248
Computer Information Systems	Increase student attendance and grades	Randomly administered quizzes in 77% of the class sessions covering previous work (prior day or current day)	Attendance improved from 46% to 73%, increased in average course grade from 2.58 to 3.13 (on a scale of 4.0)	DFW = 19%→17%  N = 9180
Computer Information Systems Lab	Understand requirements, attendance, increase comprehension	Syllabus quiz early in semester, quiz or exam in each course session, mix of objective and performance-based assessments	Grades of A increased from 36% to 58%. No change in DFW rates. Increased course attendance. Strong correlation between syllabus quiz and final grade	A = 43%→57% DFW = 16%→14%  N = 8555
Economics: Quantitative Methods	Concrete understanding of concepts	Data interpretation versus calculation, cooperative learning, team projects, self-scoring web practice quizzes	DFW rates dropped from 29.5% to 14.75%, web quizzes a performance predictor for final exam. Improved performance on mid-term exam	A = 22%→30% DFW = 29%→18%  N = 2762
Intro to Environmental Sciences Lecture	Big picture, ability to ask and answer scientific questions	Course reorganization from weekly topics to four themes, group research projects	Need to decrease to three themes, increased student comprehension, need to move students from policy to scientific perspective	A = 18%→23% DFW = 22%→16%  N = 2403
Intro to Environmental Sciences Lab	Improved skill in designing science experiments	Theme-based lecture course, field-based laboratory experiences	Increased attendance and engagement with course material. Improved lab performance	No data available
Geology	Low student engagement	Increased discussion, web-based tutorial prior to three field trips	Strong correlation between involvement in class discussion and final grade. Reduction in DFW rate from 19% to 13%	**DFW = 6%→10% N = 533
Calculus: Pre, I, II, & III	Student comprehension	Interactive note taking, cooperative learning, homework assistance in class	Decreased DFW rates between 3% and 19% depending on course section	DFW = 27%→21%  N = 1315
Math for Elementary Ed majors I & II	Attendance, attitudes toward math	Taking attendance, physical and technology-based manipulatives, videotapes of K-6 classroom instruction	Increased attendance, improved attitudes, 10% reduction in DFW rates	N = 4435
Intro to Physics for majors I & II	Math readiness, attendance	Web-based readiness test, minute papers	High correlation between attendance and final grade	N = 1678

\* Only statistically significant changes are listed.

\*\* Increase in DFW rates after the intervention.