Annual Report for Period: 06/2008 - 05/2009
Submitted on: 03/18/2009
Principal Investigator: Sinn, Robb .
Award ID: 0633264
Organization: North Georgia College
Submitted By:
Spence, Dianna - Co-Principal Investigator
Title:
Authentic, Career-Based, Discovery Learning Projects in Introductory Statistics

Project Participants

Senior Personnel

Name: Sinn, Robb
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Spence, Dianna
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Hendricks, Andrea
Worked for more than 160 Hours: No
Contribution to Project:
Andrea Hendricks was unable to serve as co-PI on this project after the award was granted. We changed our third co-PI from Andrea Hendricks to Todd Hendricks last year, and received confirmation of this change.

Name: Hendricks, Todd
Worked for more than 160 Hours: No
Contribution to Project:
As noted in the participant notes for our original co-PI Andrea Hendricks, we have been in the process of replacing Andrea Hendricks with Todd Hendricks as our co-PI.

Name: Hendricks, Todd
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

We have 3 collaborators in our department (Mathematics) to teach control and treatment sections of the statistics course. They have each taught one or more control sections (Spring 2008) and one or more treatment sections (Fall 2008). These Mathematics faculty are Brad Bailey, Karen Briggs, and John Holliday. To generate more data and to examine a possible learning curve effect among faculty, these instructors are teaching additional treatment sections of the course during the current (Spring 2009) semester (Bailey and Briggs) or next semester (Holliday). All 3 of these collaborators also assisted with the workshop held for statistics instructors.

We also worked with an interdisciplinary team of 8 faculty from other departments who assisted in developing authentic research constructs and project ideas from their fields that were used in the project guides that have been developed. The team members (and related disciplines) are: Stuart Batchelder (Criminal Justice), Nancy Dalman (Biology), Giovanna Follo (Sociology), Steven Lloyd (Psychology), James Martin (Psych./Counseling), Mohammad Nourbakhsh (Physical Therapy), Brent Paterline (Criminal Justice), and Marina Slemmons (Nursing).

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Project activities are described in the attached document.

Findings: (See PDF version submitted by PI at the end of the report)

Project findings are described in the attached document.

Training and Development:

Instructors participating in the control and treatment groups were trained to use the teaching methods and materials developed during this project. This includes 3 professors at NGCSU, 1 professor at GPC, and 1 high school teacher at FCHS. (See activities report document for full details.) These instructors developed professionally during their first semester of implementing these materials in their classes, and subsequently assisted in conducting training sessions during the workshop we hosted in January for other statistics instructors.

Outreach Activities:

Our primary outreach activity has been the 'Make It Real' Statistics Workshop that we hosted in January for teachers of statistics. This one day workshop was advertised in advance at local and regional conferences, as well as through our local RESAs (regional educational service agencies). Nineteen high school teachers of AP statistics attended. Full details of the workshop are given in the Project Activities document.

Journal Publications

Books or Other One-time Publications

Web/Internet Site

URL(s):

http://radar.ngcsu.edu/~djspence/nsf/

Description:

This site gives a high level overview of the project and provides links to reference materials and relevant documents. In particular, it has served as a resource for our interdisciplinary team members. Planned additions to the site include one or more pages with resources for instructors as they implement the treatment groups; and links to appropriate conference presentation and publication abstracts as they become available.

This site may also house information about the instructor workshops to be arranged in fall 2008; however, we may decide to place workshop information on a separate site altogether.

Other Specific Products

Product Type:

Instruments or equipment developed

Product Description:

Perceived Usefulness of Statistics scale:
This is the instrument we developed to measure perceived usefulness of statistics, as described in the section on project activities.

Sharing Information:

To date, the instrument has not been shared with anyone outside this project, nor has it been used outside the context of this project. The instrument will be shared closer to the end of the research phase of the project, both in conference presentations and in relevant articles that are submitted for publication.

Product Type:

Instruments or equipment developed

Product Description:

Statistics Self-Efficacy scale:
This is the instrument we developed to measure self-beliefs about statistical knowledge and skills, as described in the section on project activities.

Sharing Information:

To date, the instrument has not been shared with anyone outside this project, nor has it been used outside the context of this project. The instrument will be shared closer to the end of the research phase of the project, both in conference presentations and in relevant articles that are submitted for publication.

Product Type:

Instruments or equipment developed

Product Description:

Statistics Content Knowledge test:
This is the instrument we developed to measure content knowledge specifically in the areas of linear regression and t-tests, as described in the section on project activities.

Sharing Information:

To date, the instrument has not been shared with anyone outside this project, nor has it been used outside the context of this project. The instrument will be shared at instructor workshops, in conference presentations, and in relevant articles that are submitted for publication.

Product Type:

Teaching aids

Product Description:

Instructor Project Guide:
This resource provides guidelines and resources to help instructors to implement discovery projects in their statistics classes.

Sharing Information:

This guide is shared with instructors on the Internet at
http://radar.ngcsu.edu/~rsinn/nsf/IG.html

We are also discussing publishing this guide in conjunction with educational resources accompanying the statistics text "The Basic Practice of Statistics" (by David Moore). These discussions are taking place with Freeman, the publisher of the text.

Product Type:

Teaching aids

Product Description:

Student Project Guide:

This guide provides information and assistance to students implementing discovery projects in statistics.

Sharing Information:

This guide is currently available on the Internet at:

http://radar.ngcsu.edu/~rsinn/nsf/StudentGuide/StudentGuide.pdf

We are also discussing publishing this guide in conjunction with educational resources accompanying the statistics text "The Basic Practice of Statistics" (by David Moore). These discussions are taking place with Freeman, the publisher of the text.

Contributions

Contributions within Discipline:

Contributions within Discipline

The co-PI's on this project are mathematics educators who teach introductory statistics. The discipline for the project is therefore a confluence of statistics, a core course in many STEM and even non-STEM plans of study, and mathematics education. The curriculum developed and the dispersal of teaching methods will improve learning outcomes for many types of statistics courses. The instrumentation and educational research results will be of more interest to the mathematics education community at large, especially those who investigate secondary and post-secondary mathematics settings.

The best practice teaching modalities that inspired this project include discovery learning, apprentice learning, and attention to student motivation and attitudes. These practices have been widely studied by mathematics education researchers and implemented across many levels and types of courses. The co-PI's agreed to take these focal points of best practice mathematics education and apply them to introductory statistics courses. There would appear to be both need for these types of curricular advances together with means for measuring student progress broadly-defined.

Statistics educators have repeatedly suggested improvements ought to be made, especially focusing on implementation of the scientific method utilizing authentic statistical experiences (as is the case herein), but these calls for improvement have not been widely heeded (Bryce, 2005). Researchers have found statistics courses based on more constructivist models improved student attitudes toward statistics and that personal relevance is important for successful learning in statistics (Mvududu, 2003). A researcher used case-study methodology to evaluate a real-world, project-based approach to learning statistics and found that students learned more from the project than from any other instructional component of the course. The researcher further reported improvements in student motivation (Yesilcay, 2000).

The curriculum development portion of the project addresses the needs for more authentic statistics experiences while the scale development addresses two aspects of student motivation for statistics: students' perceived usefulness of statistics and students' self-efficacy for statistics tasks. The synergy of studying both achievement and attitudinal variables as the pilot phase moves forward is that three meaningful positive outcomes can result. First, performance indicators may increase. Second, performance may be equivalent to traditional methods, but the experience of authentic statistics practices may improve the attitudinal variables. According to the literature, improved attitudinal variables are linked to higher effort levels, better transference of knowledge to other domains, and higher likelihood to take future classes in the discipline. Third, the project may find that both performance and attitudinal variables are improved.

The contributions of the two attitudes and beliefs scales are new to the research literature and will interest mathematics educators who focus on secondary and post-secondary mathematics instruction and specifically those who study statistics education. Both have high reliability and validity. The Perceived Usefulness scale specifically measures students' beliefs about the usefulness of statistics in their careers and lives. The literature suggests high perceived utility for a subject is connected to higher effort levels and increased likelihood for further coursework in related areas. The Self-Efficacy for Statistical Tasks scale measures students' beliefs about their capabilities for mastering statistics concepts and processes. Self-efficacy is a task-specific construct which correlates highly with performance measures. Self-efficacy measures also correlate highly with many affective domain variables and attitudinal variables. However, self-efficacy has often been shown to mediate the affects of other affective domain and attitudinal variables upon performance. Determining the relationship between Statistics Self-Efficacy, Perceived Usefulness for Statistics and Performance will be a valuable contribution in the field of statistics education. The new scales will be of use to other researchers in this field interested in comparing and contrasting teaching methods and instructional approaches.

The content test developed by the project team addresses very specific topics and will not be useful for widely testing content knowledge in statistics. However, the instrument has proved valuable in assessing content knowledge for two essential topics at the heart of the introductory statistics experience: regression and t-tests. These topics are central to basic statistics courses as well as more advanced statistics courses and to statistics courses in other disciplines. The instrumentation will prove valuable to explore the portability of these authentic discovery methods to other types of statistics classes on many types of secondary and collegiate campuses, one possible project target for a Phase II project proposal.

In sum, the curriculum development fills an observed need in statistical education circles, and the instrumentation provides valuable tools for researchers studying secondary and post-secondary mathematics education in general and statistics education in particular.

References
Bryce, G. R. (2005). Developing tomorrow's statistician. Journal of Statistics Education, 13(1).
URL: www.amstat.org/publications/jse/v13n1/bryce.html.

Mvududu, N. (2003). A cross-cultural study of the connection between students' attitudes toward statistics and the use of constructivist strategies in the course. Journal of Statistics Education, 11(3).
URL: www.amstat.org/publications/jse/v11n3/mvududu.html.

Yesilcay, Y. (2000). Research project in statistics: Implications of a case study for the undergraduate statistics curriculum. Journal of Statistics Education, 8(2).
URL: www.amstat.org/publications/jse/secure/v8n2/yesilcay.cfm.

Contributions to Other Disciplines:

Contributions to Other Disciplines

The Interdisciplinary Statistics Team (IST) formed an integral part of this project and provides strong evidence of the potential impact far beyond mathematics education or statistics. Statistics instruction forms an important part of the basic education in many STEM disciplines, especially the health sciences and engineering. One goal of future investigations if the current project bears significant fruit will be to ask about the portability of these instructional methods to other types of undergraduate statistics courses both in STEM disciplines and beyond.

The IST was formed from scholars in various disciplines who conduct quantitative, statistics-based research and/or teach statistics courses within their disciplines. From STEM disciplines, the IST included representatives from biology, nursing and physical therapy along with the co-PI's who all work in mathematics departments. Other (non-STEM) disciplines represented on the IST include business, sociology, psychology, criminal justice, political science and community counseling. It bears noting that the members of the IST have already expressed enthusiasm for involving their students in statistical research projects of the type they are helping to define and develop. They have noted that such projects will not only deepen their students understanding of statistics itself, but also bring more meaning to the constructs in their own disciplines. This observation highlights the interdisciplinary nature of this educational approach.

As the methods developed with the help of the IST prove effective, the results will be disseminated to instructors of basic statistics with potential for positive impact on all students who take statistics courses. The materials developed will also help statistics instructors to connect the content they teach more fully with other disciplines in a meaningful way. Thus, the positive impact is not merely one of understanding statistical tests and procedures better, but of understanding the importance, the role, and the relationship of statistics in other fields of study.

Mathematicians, as the co-PI's noted in the grant proposal for this project, are often ill-equipped to teach statistics courses having rarely conducted any survey-based studies or statistics-based research themselves. One key idea behind the Instructor's Guide (Fall 2008) and the workshop (January 2009) is to provide teachers of mathematics (both secondary and post-secondary) with all the support necessary to include these projects in their statistics courses. Inclusion of these projects by any individual instructor, however, will include training, tips and suggestions for engaging students in collaborative learning, utilizing relevant technology, writing across the curriculum, communicating mathematical ideas to others both orally and in written form, alternative assessment practices that enhance learning, and thoroughly testing a hypothesis using the Scientific Method. These best practice teaching methods will provide ideas and insights for mathematics instructors of a wide variety of courses in mathematics and other STEM disciplines.

If the current project proves to be successful, an obvious question arises. What other statistics courses might benefit from similar instructional methods? Dozens of different types of undergraduate statistics courses exist, and most have regression topics and t-tests as important topics. Research utilizing ANOVA is extremely similar to that for t-tests. A major benefit of the instrumentation progress made thus far by the current project is that it will allow further study of the impact of authentic discovery in other statistics courses in a wide variety of undergraduate STEM settings, for example, engineering, environmental studies and many health sciences.

Contributions to Human Resource Development:

Contributions to Human Resource Development

Professional development for mathematics instructors lies at the heart of this project. Mathematicians are often tasked with teaching statistics despite the relative rarity of mathematicians who have personal experience with survey-based studies or statistics-based research. The concept of this project was not only to develop and test an approach that improved statistics teaching and learning but also to develop and test concrete materials so comprehensive and of such high quality that instructors would be able to incorporate these methods easily, with reasonable effort and limited need for additional professional development.

The five pilot instructors attended half a day of training before implementing the materials in their own courses for the first time. This training, in conjunction with individual guidance offered to the instructors before and during their first implementation, was a significant source of professional development for them.

Students have now utilized the Student Project Guide in several statistics classes, under the guidance of several different instructors. The instructors report overall success using the materials to guide their students. Many students have indicated that the Student Project Guide has enough information for them to brainstorm a research topic related to their career interests, develop a survey that includes demographics questions and questions targeting research variables, develop their sampling design.

The written materials themselves will provide an immense contribution to the professional development opportunities for teachers of statistics. A full-day workshop was recently conducted with 19 secondary mathematics instructors, and follow-up online sessions were held in the following weeks. The professional development offered in this workshop was informed by the successes and struggles of the five instructors during the pilot phase. Attendees of this workshop were teachers of AP Statistics. However, it was noted that some of the content of the workshop could be adapted easily to benefit teachers of non-AP mathematics courses in the high school curriculum, particularly for the linear regression projects. Another workshop, slightly smaller in scope, is planned for Fall 2009, in conjunction with the Georgia Mathematics Conference. This workshop will target high school teachers of non-AP courses, leveraging what we learned and accomplished by conducting the first workshop.

The project has provided professional development for the five pilot phase instructors, the workshop attendees (both current and future), and for anyone who accesses the online and/or print materials resulting from the project.

Contributions to Resources for Research and Education:

Contributions to Resources for Research and Education

Because the research and instrumentation in this project are based on mathematics education principles and apply to curriculum development in mathematics instruction generally and statistics instruction specifically, nearly all outcomes listed under 'Contributions within Disclipline' apply to this section as well. Briefly summarizing, that section detailed the value of the instrumentation work to mathematics educators who study secondary and post-secondary instruction and the value of the curriculum materials developed.

The project evolved slightly since the proposal and has thus provided another benefit to mathematics educators. The pilot phase included three mathematicians from NGCSU who have between one and seven semesters of experience teaching introductory statistics courses. Also, as originally proposed, a high school AP statistics teacher and mathematics professor from a two-year college participated in the pilot phase.

The pilot phase has utilized a treatment vs. control design. Each instructor provided his or her own control group by testing their Spring 2008 students on all instruments, teaching without the use of the authentic discovery materials. In Fall 2008, each instructor was supported by the co-PI's with training and professional development opportunities, and had access to all project-developed course materials. Then, each instructor's Fall 2008 classes were tested to determine the impact of the authentic discovery projects in their courses. This quasi-experimental design provides the best measure of the improvement gains that can be expected from utilizing these authentic discovery projects in statistics courses. The control group phase for all instructors is complete (including the high school section, which spanned the entired 2007-2008 school year). The treatment groups, started in Fall 2008, and will continue through the end of Fall 2009.

The addition of three more instructors to the pilot phase reduced the individual-specific professional development outcomes. Having five instructors instead of two has allowed the co-PI's to compare and contrast the professional development opportunities that were given to participants, and to identify those that afford the best chances of success in implementing these authentic discovery projects into a statistics course.

The co-PI's, informed by the experiences of these five instructors during the pilot phase, designed professional development experiences, both in the form of professional presentations at conferences and in the form of a teacher workshop. This project has been described in detail at two conference sessions-- one at MAA MathFest in July 2008, and the other at the 'Accepting the STEM Challenge' conference in September 2008. The first teacher workshop was held in January. Thus, in addition to the instrumentation and curriculum contributions, this project has added professional development opportunities to inform and enhance the skill sets of mathematics instructors.

As sufficient data are collected throughout the pilot phase to analyze and share, the co-PI's will present more details of this project at conferences related to mathematics and STEM education. The conference presentations will be assisted by at least two of the pilot phase instructors. The co-PI's have already included one pilot instructor in a conference presentation at 'Accepting the STEM Challenge' (September 2008). The presentation focused on the development and implementation of the teaching methods cultivated in this project, and offered insights from the co-PI's about the methods and materials that have been developed, as well as a first-hand account from an instructor learning to implement these methods for the first time. Because the treatment groups were still in progress at the time this conference took place, data were not collected for the treatment groups (content knowledge, perceived usefulness of statistics, etc.) However, the comparisons already conducted between control groups and 'preliminary treatment groups' (see Project Findings section) was shared.

The co-PI's have also drafted a proposal for submission to AMTE (Association of Mathematics Teacher Educators). The AMTE conference places a great deal of emphasis on presentations supported by specific research findings. Therefore, we did not have sufficient information of interest to share at the 2009 AMTE conference, but we expect to have sufficient findings to share at AMTE in 2010.

The co-PI's are also preparing presentation proposals to a number of other relevant conference organizations, including NCTM (National Council of Teachers of Mathematics), NCSM (National Council of Supervisors of Mathematics), SSMA (School Science and Mathematics Association), GAMTE (Georgia Association of Mathematics Teacher Educators), and GCTM (Georgia Council of Teachers of Mathematics). Similarly, as the data are fully collected and analyzed, the co-PI's will be in a position to submit manuscripts for publication in relevant journals. These journals include JRME (Journal for Research in Mathematics Education), SSM (School Science and Mathematics), and the Journal of Mathematics Education Leadership. As other opportunities arise to present project implementation details and findings, the co-PI's will leverage these opportunities as much as possible.

Contributions Beyond Science and Engineering:

Contributions Beyond Science and Engineering

This project focuses on a course typically taught by mathematics or statistics departments. Yet, many students taking an introductory statistics course are not STEM majors. The materials and approach that have been developed target the attitudes, beliefs and proficiency of students in STEM disciplines. Specifically, the courses of study for many engineering and health sciences curricula include statistics courses of this type. The benefits will cascade to other undergraduate programs like teacher education, business-related majors (accounting, marketing, finance, administration), psychology, communication, sociology, clinical counseling, political science, and criminal justice.

Inviting a high school to join the project will have even wider impact. Demonstrating the efficacy of these materials for high school AP Statistics courses will enable innovative and interesting STEM content to be absorbed into secondary schools, introducing high school students to a research-based, apprentice-learning approach appropriate for advanced undergraduates. A key feature of this project is infusing authentic statistics with an overt connection to the Scientific Method. Engaging high school students in the practice of developing and testing hypotheses will deepen their experience of science and mathematics and hopefully encourage more of them to pursue intriguing career opportunities in the many high-need STEM disciplines.

The interdisciplinary statistics team who contributed to this project was a group of professors and professional clinicians who teach statistics and/or research classes within their discipline. The design of the statistics projects for this study impressed many of them. For example, beginning with a regression project which requires larger sample sizes early in the semester produces estimates of population parameters that make one-sample t-test projects feasible later in the semester. Several commented that they intended to utilize some of these ideas to improve and add to the research and apprentice-learning in their own more advanced statistics courses. The interdisciplinary team also discussed the fact that these research experiences are more realistic and authentic than any others that many students receive prior to their graduate studies.

The inclusion of apprentice-learning and discovery-learning modalities in these survey-based research simulation projects has influenced how our colleagues think about their own courses, content and methods. If successful in securing Phase II funding for this project, the co-PI's plan to explore how well these materials can be exported to other undergraduate statistics courses as part of the evaluation design.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Organizational Partners
Any Journal
Any Book

Evaluation of Pilot Test Results

The available records and data allow for a partial quantitative analysis of the pilot test results and a qualitative analysis of the instructional materials. The pilot test results show a positive trend on all three variables, but only Statistics Content Knowledge gains were significant ($p = .09$). The attitudinal variables for the Treatment group showed improvement over the Control group, but were not significant.

A qualitative analysis showed some deficiencies in the teaching training modules, but revealed the instructional materials developed were of high quality. For the training modules, updates were added prior to the "Make It Real" workshop. The pilot test phase has been extended to test if better instructor understanding in two key areas would lead to more clear cut results.

Quantitative Analysis

Methods and Procedures

Our intention for statistical evaluation of the results is to perform a 2-way MANOVA with each of the instruments (see below) tested as dependent variables using the factors of pre/post, pilot site type and level of student. The sites chosen for the pilot test were a 4-year teaching university, a 2-year college and a high school. At this time, the high school site has not completed the final phase of the pilot test (anticipated May 2009). At this time, using three independent samples t-tests makes the most sense. A t-test was performed comparing the Treatment vs. Control groups on each of the instruments.

The instrumentation has been described elsewhere. In this statistical analysis, the following variable names were utilized:

> **CTotal** refers to the statistical concept test, an 18-item multiple choice test measuring a student's understanding of regression and t-test topics.
>
> **PUTotal** refers to the perceived utility of statistics scale, a 14-item instrument using 6-point Likert response choices.
>
> **SETotal** refers to the self-efficacy for statistics scale, a 12-item instrument using 6-point Likert response choices.

The descriptive statistics are as follows:

Instrument	Group	N	Mean	Std. Dev.
CTotal	Control	145	6.63	2.497
	Treatment	151	7.05	2.872
PUTotal	Control	145	50.86	10.234
	Treatment	151	52.38	10.594
SETotal	Control	145	56.53	22.736
	Treatment	151	59.02	14.208

Each hypothesis test was directional testing that the treatment group mean score exceeded the control group mean score. Positive scores on both scales meant improved attitudes towards statistics.

The statistical assumptions for t-tests are independence, normality and homogeneity of the variances. The variance assumption highlights an intriguing feature of the data and will be discussed at length below. The independence assumption is tricky, with the control groups individualized based upon the instructor. The trends specific to instructor can be better analyzed and controlled in the MANOVA setting. Violations of the independence assumption can decrease p-values, making them appear significant while they may, in fact, be further from zero. Given the sample size, the t-tests are robust so that any violations of the normality assumption will not impact the results.

Violations of the homogeneity of the variances assumptions is not typically a critical matter, especially not with virtually identical group sizes (Treatment vs. Control). Some problems exist with procedures that check this assumption, specifically Levene's test, the SPSS default procedure. Of interest is the striking difference in the standard deviations between the Treatment and Control groups on the SETotal variable.

Previous work related to these instruments have led the PI's to consider an interesting hypothesis: student groups exposed to the authentic discovery have at times demonstrated a decrease in their self-reported self-efficacy for statistical tasks relating to real-world statistics-based research. The PI's have conjectured that exposure to the messiness and tedium of some aspects of real-world statistics-based research has increased the accuracy of their self-efficacy judgments which, prior to these authentic experiences, were possibly quite naive. The hypothesis poses an interesting investigation path for future research studies to consider. With data collected during the instrumentation and pilot phases, the PI's hope to delve more deeply into this question.

As it stands, there is an interesting anomaly with the self-efficacy variances which, given the dissimilarity to the other two instruments, may be an indication of some higher order effect on student attitudes and self-beliefs. The PI's will continue to brainstorm what additional variables may be added to future investigations.

Results

A summary of the statistical tests is as follows:

Instrument	t	df	p	Mean Diff.
CTotal	1.339	291.1	.091*	0.42
PUTotal	1.257	239.9	.105	1.52
SETotal	1.124	239.9	.131	2.49

Using a liberal level of significance of 0.1, appropriate in this case due to the exploratory nature of the investigation and the small hypothesized effect sizes, only the CTotal test was significant ($p = .09$). Of interest to the research team was how the other variables hover just outside the significant region.

One of the pilot test groups, due to several instructor absences caused by severe health problems of a family member, did not complete the second authentic discovery project. When the classes affected were withdrawn from the comparison, the significance level of the Ctotal variable was unchanged, while the SETotal variable was significant at the .05 level ($p = .047$). In the second instance, the startling difference in the standard deviations for the Treatment vs. Control group remained.

The two projects take a total of about five hours of classroom time, or about 10% of total instructional time per college semester. The impact is less in the high school setting, though students may need more guidance. The effect size, while significant, is likely to be small. Given the data, we predict that extending the pilot test through another semester may allow the instructors to better integrate the authentic discovery projects into their courses and improve the student outcomes.

Qualitative Analysis

Two separate qualitative analyses were undertaken to review the instructional materials, one to rate the usefulness of the Student Guide, the other to rate the usefulness of the Instructor's Guide and the Teacher Training module.

The Instructor's Guide was provided to the pilot test instructors approximately three weeks prior to the start of the "Treatment" semester, together with a 3-hour seminar discussing the implementation. The primary weakness of the training related to the difficulty in helping students brainstorm solid ideas and turn those ideas into a high quality survey. The largest successes discovered relating to the training module and the Instructor's Guide were the rubrics and grading aides and the assignment sheets. We provided all rubrics, aides and assignment sheets in Word document form to the instructors so that they could alter them as needed for use in their classrooms. Overall, the PI's were satisfied with the training materials and modules.

To test the Student Guide publication, PI Sinn offered no direct instruction about the requirements of the projects. Instead, he created reading assignments covering approximately 25 pages of the Student Guide, Variables Guide and Vignette. Each of three reading assignments was assessed with a "team quiz." The results are both subjective (since only PI Sinn was involved in the investigation) and anecdotal, yet PI Sinn was amazed at the difference in quality of the ideas presented between the groups. Reading the Student Guide and pouring over examples of other students' work turned out to produce a much higher quality of submission during the early stages of the first team project. PI Spence had similar observations about the quality of her students' research ideas when the students were directed to rely on the Student Guide. Although PI Spence did not replace direct instruction with the Student Guide, the guidance her students received was integrated with the content in the Student Guide, and their research questions and variables were more robust than those suggested by students in previous classes who had not had the benefit of the Student Guide as a resource.

One particular finding shared by PI’s Sinn and Spence was that when using the Student Guide, their students more frequently created variable constructs that were computed from a collection of questions, rather than relying on a single survey question variable. Not only did this tendency result in more interesting and original research ideas, but these students often had better project results (e.g., higher R^2 values, stronger levels of significance).

Discussion

The significant increase in content knowledge ($p = .09$) coupled with positive appearing gains in attitudes provide hopeful initial findings for this study.

The dual concerns of small effect size and inadequate training in survey design prompted several of the pilot test instructors to offer to repeat the use of the Authentic Discovery projects in a subsequent semester. The PI’s were able to find some small stipends to support their endeavors at the 4-year university. Thus, the pilot phase has been extended for three of the instructors including one whose course and participation in the study were both curtailed due to severe illnesses within his family. The extension will allow us to establish the effectiveness of more detailed and extensive survey design training and reduce the negative impact of instructors using methods with which they are unfamiliar, a process that can be uncomfortable for some students in certain circumstances.

Further research is needed to establish with certainty exactly what variables are influencing students’ self-efficacy for statistical tasks. The variance question in this pilot data is suggestive, as are some findings during the instrumentation phase. The PI’s will develop more questions and perform further analyses, together with possibly including a related research question in future studies. Additional instrumentation may be necessary to determine the precise interactions at work.

Based upon the qualitative analyses, a minor update of the Student Guide materials and an overhauling of the Instructor’s Guide will be undertaken in 2009. The proposed improvements in survey design training were implemented during the “Make It Real” workshop, a program attended by all but one of the pilot test instructors. The feedback from first time participants and the critique from the pilot test instructors indicate that the proposed remedies did, in fact, successfully address the deficiencies. The next challenge will be to develop written materials that mirror the hands-on training provided at the workshop so that those who use the Instructor’s Guide will be able to develop the needed skill set.

In sum, both the quantitative and qualitative investigations provide reason to be guardedly optimistic about the final results of the study. At this time, the PI’s feel as though the Authentic Discovery method has helped both students and instructors while remaining only a small part of the total classroom experience.

Project Activities

The scope of the project did not change, but the schedule of implementation changed due to a number of factors, many of which were noted in detail in the 2008 annual report. All revisions to the project timeline are evident in the summary of project activities below.

1) ***Instrument development***: In summer and fall 2007, we researched existing instruments in the areas of statistics attitudes, confidence, self-beliefs, and content knowledge. We used these to inform our own development of 3 instruments appropriate for use in our data collection phase. The first instrument targets perceived usefulness of statistics; the second instrument targets student self-beliefs about statistics skills (statistics self-efficacy); and the third instrument targets statistical content knowledge. Because the target statistics topics in this project are linear regression and t-tests, the self-belief and content knowledge instruments focus specifically on these concepts.

2) ***Instrument validation***: Near the end of fall semester 2007, we administered these instruments to 328 students in sections of elementary statistics at NGCSU, for the purpose of validating the instruments. With the data collected, we ran analyses for reliability and conducted KR-20 and exploratory factor analyses (EFA) on the instruments, with assistance from Frank Pajares (our instrument validation expert). Based on the findings from these analyses (see Project Findings section), minimal revision was called for; however, we did revise all three instruments as the analyses seemed to indicate appropriate.

3) ***Development of constructs and projects***: During fall 2007, the interdisciplinary team was formed (see Participants section). We met with the team late in fall 2007 to communicate the nature and goals of the project, to convey their roles, and to define their deliverables. The team members worked first individually to identify authentic research constructs in their respective fields. Then the team met during spring 2008 with the construct ideas that they had documented and exchanged ideas, both about constructs and about reasonable project ideas that incorporate these constructs. These constructs and research project ideas formed a component of the teaching materials that were developed (see next item).

4) ***Development of teaching materials and resources***: An *Instructor Project Guide* and *Student Project Guide* were developed to facilitate the discovery learning projects in statistics classes. These materials include a catalog of constructs and project ideas proposed by the interdisciplinary team. The *Instructor Project Guide* includes sections on project overview, literature review, course design considerations, guidelines for assessment, guidelines for assigning and directing collaborative teams, research techniques for projects, data analysis and reporting considerations, and an extensive technology guide. Several instructor resources are included, such as sample assignment pages, sample hypothesis and proposal documents, project instructions for students, and sample scoring rubrics. The Student Project Guide includes an explanation of both projects (scope and sequence), and detailed guidelines for selecting a research topic, crafting a research question, defining appropriate variables, composing a suitable survey or instrument, using sound sampling techniques, and avoiding pitfalls that introduce bias or bad data. Also

included are specific assignments to guide students through the process, a technology guide, and guidelines for presentation of research results.

Topics covered in both the student guide and the instructor guide are often related and interdependent. Therefore, both guides are written with extensive hyperlinks and have been made available to teachers and students online.

5) ***Control group implementation***: The control and treatment group design was improved to help control for variability between instructors. Participating instructors taught their sections of statistics the way they would ordinarily teach any mathematics course assigned to them (before later teaching the course with the materials developed in the project.) The design was structured this way so that the control and treatment groups would not inadvertently compare instructors rather than teaching methods. Three statistics instructors (other than co-PIs Sinn and Spence) participated at NGCSU; co-PI Todd Hendricks participated at Georgia Perimeter College (GPC); and Debbie Barrineau participated at Forsyth Central High School (FCHS). Control sections were taught in spring semester 2008 for all college instructors; because the high school course is a 1-year course, the FCHS control sections spanned the full 2007-2008 school year.

6) ***Training of participating instructors***: The 5 participating instructors (3 at NGCSU, 1 at GPC, and 1 at FCHS) attended a training session with Robb Sinn and Dianna Spence in August 2008. Because each of these instructors had already met with us individually several times to learn about the project, only about half a day's formal training was needed. During training, participating instructors became acquainted with the teaching materials, practiced working through various phases of the projects (such as instrument design and data analysis), and covered logistical and administrative details of implementation and data collection.

7) ***Treatment group implementation***: Each of the instructors noted above used the materials we developed to teach one or more treatment sections. Because Robb Sinn and Dianna Spence had previously used these teaching techniques and supplied the content for the instructor and student guides, they assisted all of the participating instructors and were available as resources to them throughout this phase. The first treatment sections were taught during fall semester 2008 at NGCSU and GPC. Again, because the high school course is a 1-year course, the treatment sections at FCHS span the full 2008-2009 school year, and will not end until May 2009.

8) ***Ongoing treatment groups***: The learning curve for instructors to implement these materials and teaching techniques successfully varies by instructor. One participating instructor at NGCSU was also only able to implement one of the two projects included in our teaching materials. Therefore, the three college instructors at NGCSU agreed to conduct treatment sections of their statistics courses for a second semester. Some of these treatment sections are being taught currently (spring 2009) and some will also be taught next semester. Because the FCHS treatment groups do not end until May 2009, the addition of additional semesters for college instructors does not delay the project, but rather, adds additional data for us to analyze. These data may also help us identify trends over time as instructors become more acclimated to using these materials.

9) ***Workshop for statistics instructors***: We hosted a one-day workshop for statistics instructors on January 30, 2009. Nineteen participants attended the workshop, which was entitled the "Make It Real" Statistics Instruction Workshop. Although the workshop was open to both high school and college instructors, all participants were high school teachers of Advanced Placement (AP) Statistics. Sessions conducted during the workshop included:

   I – Designing Quality Variables and Constructs
   II – Hands-on Survey Design Session
   III – Project Organization, Phases, Assessment, and Rubrics
   IV – Best Practices and Avoiding Pitfalls (Panel Discussion)
   V – Technology Tools and Hands-On Data Analysis
   VI – Team Presentations (Participants share their work product)
   VII – Instructor Observations from First Implementations

   In early February, we conducted a series of follow-up sessions online to allow participants to discuss the material further, including details of their own plans for implementation. Instructors who so desired were eligible to earn 1 PLU (Professional Learning Unit) credit by participating in the workshop.

10) ***Preliminary data analysis of treatment and control sections***: Although treatment groups are still being implemented and data collection is ongoing, some preliminary data analyses have been conducted. The findings of these analyses are detailed in the project findings section.

11) ***Dissemination of information about project***: Although statistical results of our work are not yet available, we have shared information about the scope, organization, and progress of this project in two conference presentations to date:
    a) Dianna Spence, "*Authentic Discovery Learning Projects in Statistics.*" MathFest 2008 (a conference of MAA, the Mathematical Association of America). Madison, Wisconsin, July 2008.
    b) Dianna Spence, Robb Sinn, & Karen Briggs, "*Discovering How to Discover.*" Accepting the STEM Challenge Conference (hosted by PRISM – Partnership for Reform in Science and Mathematics). Atlanta, Georgia, September, 2008.