

HOW DOES “JUST-IN-TIME” SCAFFOLDING OF DESCRIPTIVE AND
INFERENTIAL STATISTICS WITHIN AN EXISTING, QUARTER-LONG, GROUP
POSTER PRESENTATION OF SURVEY DATA IMPACT UNDERGRADUATE
STATISTICS STUDENTS’ ABILITY TO APPLY THEIR LEARNING?

by

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STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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ABSTRACT

The treatment of this project was based on the American Statistical Association's (ASA) *GAISE* project recommendations on how students best learn statistics. I implemented a student-designed survey and poster project to provide an opportunity for my students to learn by constructing their own knowledge through active involvement and having modeled content and technology concepts and practice. They were assessed on their statistical thinking while doing open-ended investigative project as groups instead of as individuals. They received consistent and helpful feedback on their performance from their peers and through interactions with and judges. And they learned statistics better through using technology to discover conceptual understanding as they analyzed their own data.

INTRODUCTION AND BACKGROUND

I have been teaching mathematics and science content at the secondary level since 1987 and at the undergraduate level since 1993. I have been teaching undergraduate statistics since 2007. This project was conducted at the Columbia, South Carolina campus of South University, which has an enrollment of nearly 1500 students. The campus is primarily non-traditional students enrolled in medically related majors. The Columbia campus has a nursing program and a pharmacy school.

Research was conducted in my introductory statistics courses starting with the 13 students in my fall 2010 quarter. My former students had already been doing survey projects for a couple of years, however, those projects had mostly been a *proof of content* instead of a discovery of content and process by inquiry. During the fall 2010 quarter, I reversed the order and presented content when it was needed. This *just-in-time* model allowed students to need statistics in order to interpret data they had collected.

This application of inquiry to statistics required significant use of scaffolding of the traditional descriptive and inferential statistics content. Scaffolding begins with students' pre-knowledge level and encourages them by providing the right amount of support to move them to a higher level of understanding. I helped the students with their spreadsheets, word processing, and presentation software to help them concentrate on collecting and coding data, making pivot tables and charts, and formatting a large format poster (36 x 56 inch). I provided this support term project to help students concentrate on the process of using a survey to collect and present data.

This lead to the focus question of the study: How does just-in-time scaffolding of descriptive and inferential statistics within an existing, quarter-long, group poster presentation of survey data impact undergraduate statistics students' ability to apply learning?

CONCEPTUAL FRAMEWORK

Science and mathematics educators have advocated forms of inductive pedagogy since the early 1900's (DeBoer, 1991). Inductive pedagogy proposes that knowledge was actively constructed by learners and was not transmitted by teachers. Constructivism, the notion that learners construct their own knowledge, followed the early developmental psychologist Piaget (1896-1980) who believed individuals constructed their own personal meaning and that knowledge survived when individuals saw it as viable and abandoned it when it was not. Therefore, a teacher's role in education is to induce dissonance in order to create conceptual conflict within their students and then help them to resolve their conflict (Lawson, Abraham & Renner, 1989). Presenting data that did not fit their learners' existing core beliefs made it more viable for learners to accommodate new data producing conceptual changes within their learners' core beliefs (Posner, Strike, Hewson, and Gerztog, 1982).

Recent proponents of constructivism have also been interested in understanding teachers' thought processes to discover what effective inquiry teaching is (Fang, 1996). Inquiry pedagogy requires both teachers and students to adopt different perception of their roles than those used in traditional didactic instruction. Crawford (2000) identified some roles that inquiry-based teachers might adopt including "mentor, motivator, guide,

and innovator” (p. 931). The roles of their students were understood to be that of active learners who constructs their own knowledge. Inquiry activity generates questions, courses of action, and data from observation in order to draw appropriate conclusions (D. Llewellyn, 2002).

Much of the philosophical and theoretical rationale that underlies the modern reform movement in education has been based on constructivism (von Glasersfeld, 1989). Reformers followed Piaget’s principle that, “To know an object is to act on it...to modify, to transform the object, and to understand the process of the transformation, and as a consequence to understand the way the object is constructed” (Piaget, 1964, p. 176). Thus, learners construct their own knowledge through interaction with their world, both people and things.

The National Research Council’s Inquiry and the National Science Education Standards (2000) summarized, “Understanding science is more than knowing facts. The emphasis of recent research has been on learning for understanding, which means gaining knowledge that can be used and applied to novel situations” (p. 116). Modern reformers have rejected traditional pedagogy’s emphasis on passive memorization of facts to active learning and constructing of conceptual knowledge through inductive pedagogy.

A recent reform study by the National Research Council, *How People Learn: Brain, Mind, Experience, and School*, was the product of the Committee on Developments in the Science of Learning (Bransford, Brown & Cocking, 2000). The report summarized the most important findings from neuroscience, cognitive psychology, and human development research and how it applied to the education. The findings present a more integrated view of memory, problem solving, reasoning, learning,

metacognition, and symbolic thinking. The research suggested that teachers who want to be "learner centered" should pay "careful attention to the knowledge, skills, attitudes, and beliefs that learners bring to the educational setting" (p. 133). Learner-centered academic environments include teachers who:

Are aware that learners construct their own meanings, beginning with the beliefs, understandings, and cultural practices they bring to the classroom.

If teaching is conceived as constructing a bridge between the subject matter and the student, learner-centered teachers keep a constant eye on both ends of the bridge. (p. 136)

Constructing that bridge included having teachers who not only have a good understanding of content knowledge but also strong pedagogical content knowledge (PCK). PCK uses effective strategies to help learners construct specific content knowledge by taking into account their learners' prior knowledge, beliefs, and cultural experience (Bransford, et al., 2000).

Constructivist pedagogical content knowledge filtered into the statistical educational community through its overlap with mathematics content. Guidelines for statistical education were published in the Mathematical Association of America (MAA) publication *Heeding the Call for Change: Suggestions for Curricular Action* (Cobb et al., 1992). Cobb emphasized statistical thinking, using student data, and fostering active learning and extended constructivist pedagogical content knowledge to undergraduate curriculum (Aliaga et al., 2005).

In 2003, the American Statistical Association (ASA) funded the *Guidelines for Assessment and Instruction in Statistics Education* or "GAISE" project that included a

focus group on introductory college courses (Aliaga et al., 2005). The collegiate focus group wrote that, “We endorse the ideas in the three original goals found in the Cobb report and have expanded them in light of today’s situation” (p. 7). This fixed Cobb’s (1992) work as the accepted recommendations for teaching introductory statistics courses (p. 1).

The *GAISE* project college focus group expanded upon Cobb and made six recommendations for the teaching of introductory undergraduate statistics:

- Emphasize statistical literacy and develop statistical thinking;
- Use real data;
- Stress conceptual understanding rather than mere knowledge of procedures;
- Foster active learning in the classroom;
- Use technology for developing conceptual understanding and analyzing data;
- Use assessments to improve and evaluate student learning (Aliaga et al., 2005. p. 1).

The co-founders of the American Statistical Association’s international research forums, Garfield and Ben-Zvi (2007), explored how to improve student learning of statistics by connecting and building on relevant research from psychology, learning and cognition, statistics, and mathematics education. In 2007, Garfield presented a paper to the ASA that provided an overview of current research on teaching and learning statistics that summarized many studies conducted by researchers from different disciplines focused on students at all levels. Her review stated the implications of the current research in terms of eight principles for learning statistics. These clearly continued the statistical constructivist tradition of Cobb (1992) and the *GAISE* project (2005).

Four of their eight principles on how students learn statistics are by constructing knowledge, by active involvement in learning activities, by practice, and when they receive consistent and helpful feedback on their performance (Garfield & Ben-Zvi, 2007).

As Garfield and Ben-Zvi (2007) wrote, “Teaching is not telling, learning is not remembering. Regardless of how clearly a teacher or book tells them something, students will understand the material only after they have constructed their own meaning for what they are learning” (p. 387). Donovan, Bransford and Pellegrino (1999) writing for the National Research Council agreed, “To develop competence in an area of learning, students must have both a deep foundation of factual knowledge and a strong conceptual framework” (p. 2). Obtaining factual information is not enough. Learners must master concepts to have deep understanding of information. They must transform and construct a random set of facts into usable knowledge. The teacher’s role is to coach students beyond their preexisting understanding (Bransford et al., 2000, p. 19).

The conceptual framework allows experts to organize information into meaningful patterns and store it hierarchically in memory to facilitate retrieval for problem solving. And unlike pure acquisition of factual knowledge, the mastery of concepts facilitates transfer of learning to new problems. (Donovan et al., 1999, p. 2)

Another aspect to help statistical students to construct knowledge is to provide *scaffolding* to support and augment what learners can do to help them reason a path to understanding (Vygotsky, 1978). “Scaffolding allows learners to participate in complex cognitive performances, such as scientific visualization and model-based learning that is more difficult or impossible without technical support” (Bransford, et al., 2000, p. 243).

Kester, van Merriënboer, and Baumer (2001) argued that scaffolding could be presented *just-in-time* (JIT) as in on-the-job training. “The learner would be presented with the information needed to carry out a task precisely when it is used” (Kester, et al., 2001, p. 373). “Prerequisite information” (i.e., facts, concepts, etc.) should be presented “during the learning of how to do a task” (Kester, et al., 2001, p. 377). “Supportive information” (i.e., mental, causal, or conceptual models) should be presented while practicing the task “to promote the construction of new schemas through application” (Kester, et al., 2001, p. 377).

Learning is an active process and should not be evaluated by high stakes assessments only. Alternative assessment takes into consideration that learning may start out slowly but increase in speed as the learner starts to master the concepts of the new domain. As Bransford et al. (2000) have stated, “Often, evidence for positive transfer does not appear until people have had a chance to learn about the new domain—and then transfer occurs and is evident in the learner’s ability to grasp the new information more quickly” (p. 236).

There have been many constructivist studies on alternative assessment by researchers of college introductory statistics. All of these emphasize approaches that involve alternative assessments, as my survey project, that are more active. For example, Keeler & Steinhorst (1995) investigated cooperative learning and found that when students worked in pairs, their final grades were significantly higher and that fewer students dropped the course than in previous semesters.

Giraud (1997) found cooperative learning using random assignment of students in groups with a range of ability provided an opportunity for the more competent students to

scaffold tasks with less competent students. Magel (1998) also found that implementing cooperative groups in a large lecture class produced a significant increase on average exam scores compared to traditional pedagogy.

Meletiou & Lee (2002) used the Project-Activities-Cooperative Learning-Exercises or *PACE* model that emphasized statistical thinking, reasoning and discovery of results from data. Students were assessed on their understanding at the beginning and end of the course with an observed increase in understanding on tasks requiring statistical reasoning.

Bransford, et al. (2000) believe that learning a new content takes time and deliberate practice that enables students to monitor their learning so, “that they seek feedback and actively evaluate their strategies and current levels of understanding. Such activities are very different from simply reading and rereading a text” (pp. 235-236). Zieffler (2008) reported that “Research suggests that it takes time, a well thought out sequence of learning activities, appropriate tools, and discussion questions. Good reasoning about important statistical concepts can be developed very carefully using activities and tools given enough time and revisiting of these ideas” (p. 12).

Therefore, the conceptual framework used by this project was a constructivist understanding on how students learn statistics. This framework believes students construct knowledge best through active involvement in their learning, practice, and feedback from their mentors. This framework’s foundation was based upon early constructivism (Piaget and Vygotsky), the National Research Council, and modern statistical constructivism (Cobb and *GAISE*).

METHODOLOGY

The aim of this project was to improve my practice to help my students construct their content knowledge of statistics by implementing the GAISE project recommendations. I began by examining my existing practice in order to improve my pedagogical content knowledge of statistics. I also learned from experts (i.e., more knowledgeable others) and collaborated with my peers to move my practice forward. What I learned was that students learn statistics by constructing knowledge through active involvement in learning activities that provide modeled practice in statistics. I learned to assess statistical thinking by having students do open-ended investigative projects as groups instead of as individuals where they receive consistent and helpful feedback on their performance. They learn statistics better when technology helps them to discover conceptual understanding as they analyze data.

My project was conducted during the fall 2010 quarter. During the quarter, students in my undergraduate introductory statistics course worked in self-selected groups of three to four students to analyze posters from prior quarters' students. Each group then produced their own project survey, spreadsheet, summary, and poster using the former student projects as models. The objectives for the project are listed in Table 1. The group artifacts were rich in complexity and provided evidence for several of the research components of my capstone (Table 2).

Additionally, whole group discussions about statistical content always followed small group activities. I modeled computer applications only when the students needed the technology. I encouraged the students to interpret the statistical results only after they were able to see charts generated from their pivot table data.

Table 1
Objectives of the Project

The objectives of the project were to enable students to:
• Use research principles to design, create, and implement a survey instrument. • Use statistical principles to analyze, and interpret data obtained from a survey. • Use technology to communicate findings from survey data.

Feedback and assessment were provided by peers and by myself during the project and after milestones were accomplished. I constructed at least nine instruments designed to collect evidence for specific research components. At least three instruments were used to collect evidence for each particular component.

Table 2
Triangulation Matrix of Research Component

Research Component	Evidenced from		
Active-learning Student-produced Data	Project Surveys	Project Spreadsheets	Project Executive Summaries
Group Projects	Project Posters	Post- and Post- Surveys	Project Executive Summaries
Peer Review Assessment	Group Peer Ratings	Post- and Post- Surveys	Project Posters Ratings by Peers
Scaffolding Modeling	Project Posters (from prior quarters)	Post- and Post- Surveys	Project Posters Ratings by Judges
Technology	Project Posters (PowerPoint)	Project Spreadsheets (Excel)	Project Executive Summaries (Word)

The Learning Through our Statistics Project survey was administered both pre and post-treatment (Appendix A). The survey contained 10 questions in a Likert-scale format. The data was coded 0 for *strongly disagree*, 1 for *disagree*, 2 for *neutral*, 3 for

agree and 4 for *strongly agree*. The data was analyzed for comparison between the surveys for reporting in the analysis section.

The Peer Group Evaluation instrument (Appendix B) was administered at least twice each quarter to provide peer review assessment of each group member's contribution to the project. The form provided the directions to evaluate yourself and every member of your group by circling the overall contribution to the Group Project choices. The five choices to circle were Awesome, Reliable, Good, Ok, Poor. Results for each student were scored, compared, and analyzed for gains or losses and used for a participation assessment.

Peer Poster Ratings were administered as a group-to-group peer assessment. A poster session provided an opportunity to communicate the findings of their projects before external judges and their peers. "Statistical Poster Judging" was rubrics designed for external assessments by content knowledge experts (Appendix C). Analysis of all Lickert qualitative data used modes, modal classes, counts, and percent of totals.

Findings were discussed with my instructors and my peers from the Montana State University EDCI 509 and 575 courses and peers from my university. Each quarter provided an opportunity to do more data collection, analysis, iterative integrations and revisions of my implementation based on my findings. Final findings from all three iterations were collected into an online collection including a virtual poster and presented at the Capstone Conference.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board (Appendix D) and compliance for working with human subjects was maintained. Specifically, my question, "How does my "just-in-

time” scaffolding of descriptive and inferential statistics within an existing, quarter-long, group poster presentation of survey data impact my undergraduate statistics students’ ability to apply their learning?” was approved for research.

DATA AND ANALYSIS

The results of the pre-Learning our Statistics Project Survey (Appendix A) indicated that 78% of the students had strong agreement with the statements ($N=13$). They indicated that they valued group work, gained from modeling by the instructor and could learn through doing work themselves (Figure 1). They were neutral when asked whether a complex project could assist their learning of statistics and the value of peer review of their work.

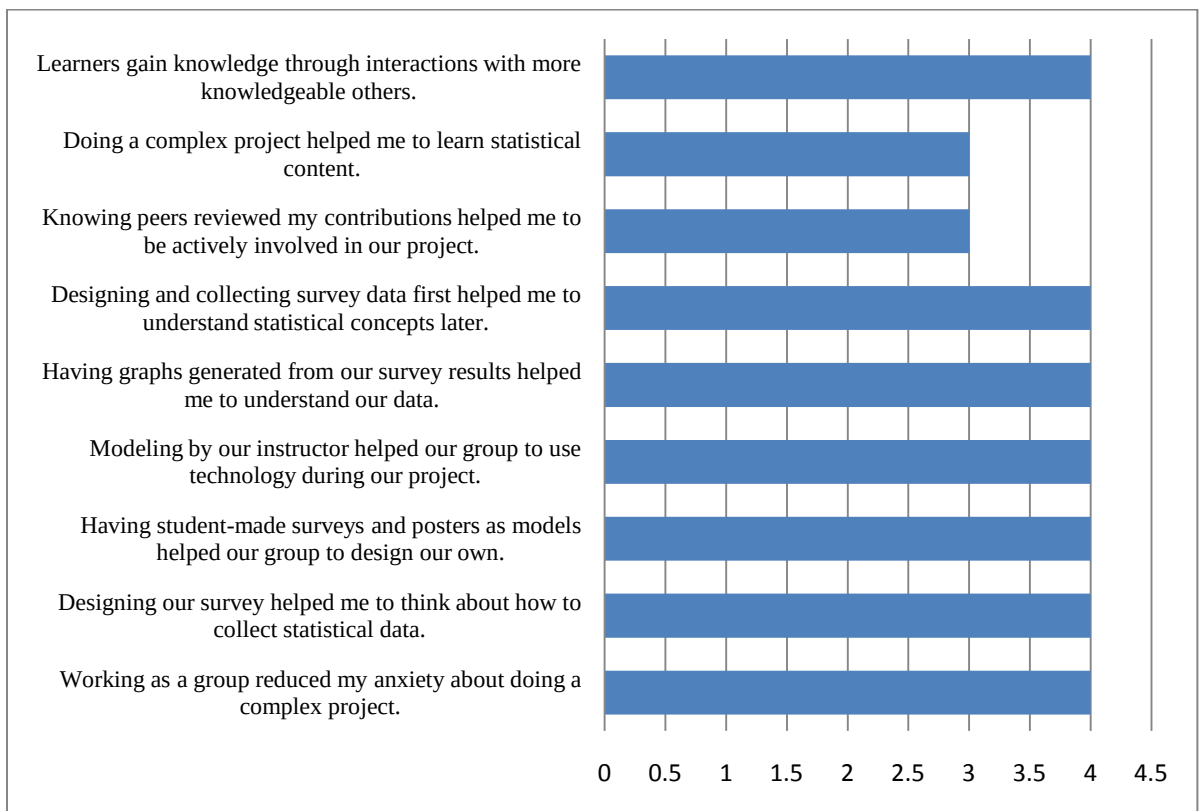


Figure 1. Pre-Survey Question Modes from Learning from Our Statistics Project, ($N = 13$)
 0 = Strongly Disagree, 1 = Disagree, 2 = Neutral, 3 = Agree, 4 = Strongly Agree.

The post-survey results ($N=10$) indicated strong agreement in all areas (Figure 2). The most significant areas of growth (22%) occurred in the two previously neutral survey responses. The students, by the end of the term, believed that doing a project helped them to learn a complex concept, statistics; and that peer review helped them to stay actively committed to their project.

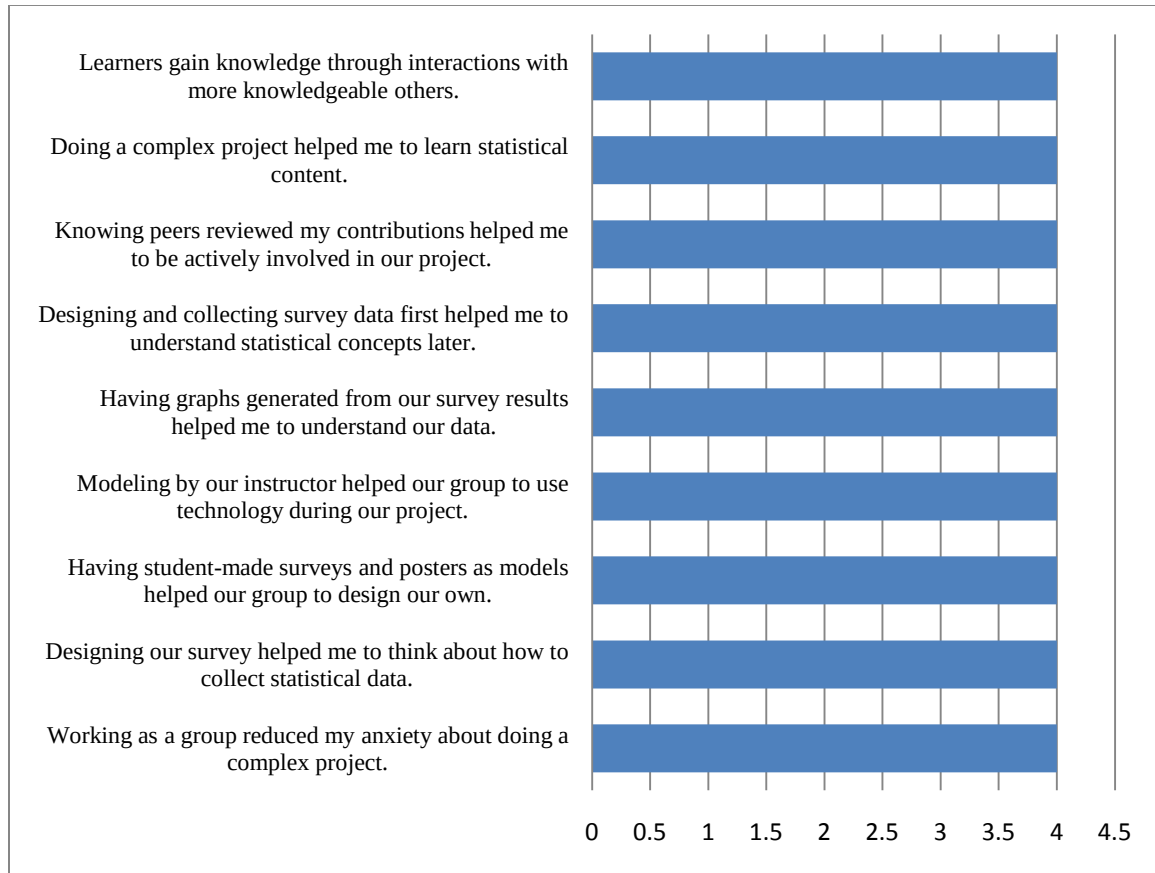


Figure 2. Post-Survey Question Modes from Learning from Our Statistics Project, ($N = 10$).
0 = Strongly Disagree, 1 = Disagree, 2 = Neutral, 3 Agree, 4 =Strongly Agree.

The students demonstrated actively learning statistics through student-produced projects. First, groups designed their own surveys after group discussions to collect data (Figure 3). They used dichotomous, Likert-type and ranking style questions in the surveys. They also collected gender and age data.

S e x E d u c a t i o n

Do you believe Sex Education should be a part of the school curriculum?	Yes	No
Do you believe parents should depend on school-based Sex Education?	Yes	No
Do you agree schools should have condoms available in public schools?	Yes	No

Sex Education should be abstinence-only-until-marriage.

1	2	3	4	5
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Sex Education should be taught to include pregnancy prevention and STD awareness.

1	2	3	4	5
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Rank at what grade level should Sex Education begin to be taught 1-4; 4 being the most preferred and 1 being least preferred.

4th – 5th	6th - 7th	8th – 9th	10th -12th
Grade	Grade	Grade	Grade

Female	Male	Age Group:	18-25	26-39	40+

Figure 3. Example of a Student-produced Survey from SexEd Group.

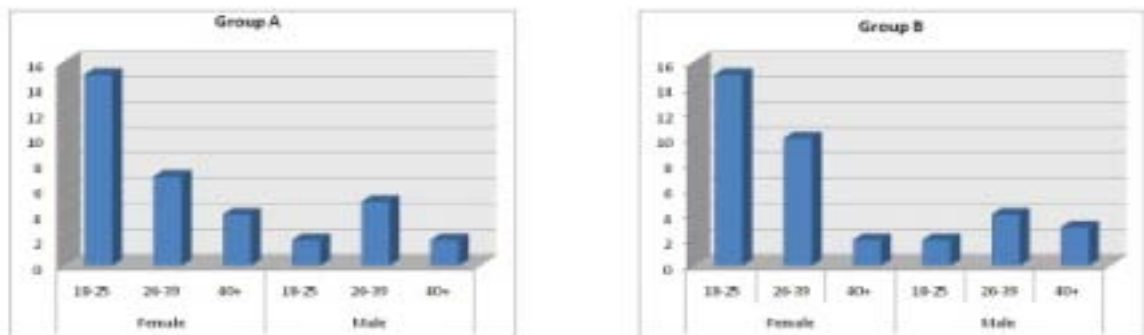
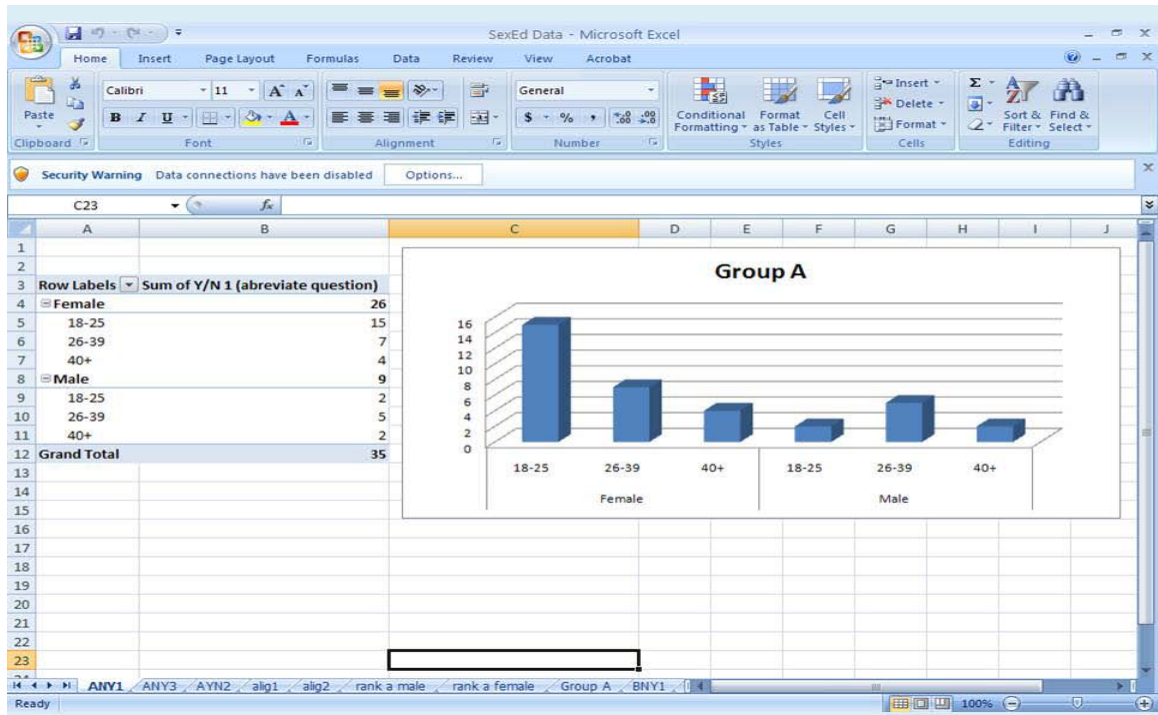
By way of example, the sex education research group collected 100 surveys from their target population and conducted two simple random samples of 36 surveys using a random number table. They coded the data from the simple random samples and created spreadsheets (with Microsoft Excel) using their own numeric codes to interpret the qualitative raw data produced from their surveys (Figure 4).

SexEd Data

B	Survey #	M/F	Age Band	Y/N 1 (in school)	Y/N2 (parents depnd)	Y/N3(condoms)	L1 (abstinence)	L2(preg/std)	4th-5th	6th-7th	8th-9th	10th-12th
1	43	0	1	1	0	0	1	1	1	4	2	3
2	51	0	2	1	0	1	5	1	4	3	2	1
3	50	0	1	1	0	1	5	1	1	2	3	4
4	4	1	2	1	0	0	4	1	1	2	4	3
5	36	0	1	1	0	1	3	1	1	3	4	2
6	38	1	1	1	0	1	5	1	1	2	3	4
7	48	0	1	1	0	1	3	1	1	2	3	4
8	1	0	3	1	0	1	3	1	1	3	4	2
9	18	0	1	1	0	1	2	1	2	3	4	1
10	55	0	1	1	0	1	1	1	4	3	2	1
11	94	1	3	1	0	0	1	2	1	2	3	4
12	89	0	2	1	0	0	2	1	1	3	4	2
13	70	1	2	1	1	1	5	1	1	4	3	2
14	5	0	1	1	0	1	4	5	4	3	2	1
15	45	1	1	1	0	1	4	2	4	3	1	2
16	68	0	1	1	0	1	1	1	1	2	3	4
17	67	0	2	1	0	1	5	1	1	4	3	2
18	21	0	1	1	0	0	1	1	1	2	3	4
19	33	0	2	1	0	0	3	2	3	4	2	1
20	53	0	1	1	0	0	3	2	1	2	3	4
21	75	0	2	1	0	0	5	1	1	2	4	3
22	99	0	2	1	0	1	4	1	1	2	4	3
23	66	0	1	1	0	0	3	1	1	2	3	4
24	9	0	1	1	0	1	4	1	2	4	3	1
25	15	0	3	0	0	0	1	1	1	2	3	4
26	62	0	1	1	0	0	3	5	4	3	2	1
27	19	0	1	1	0	0	5	1	1	3	4	2
28	39	1	2	0	0	0	1	5	4	3	1	2
29	37	1	2	1	0	1	5	1	4	3	2	1
30	93	1	3	1	0	1	3	1	1	2	3	4
31	91	0	2	1	0	0	2	1	3	2	1	4
32	58	0	2	1	0	1	4	2	4	1	2	3
33	52	0	2	1	0	1	5	1	1	4	2	3
34	44	0	1	1	0	0	1	1	1	2	4	3
35	83	0	2	1	0	0	1	1	4	1	2	3
36	59	1	3	0	0	0	1	5	4	3	2	1

Figure 4. Sample of Coded Raw Data from Student-produced Surveys from SexEd Group.

The students then used a spreadsheet to create pivot tables from their raw data for each simple random sample and produced bar graphs for their dichotomous data (Figure 5). They then interpreted this data and wrote a summary for later reporting and presentation.

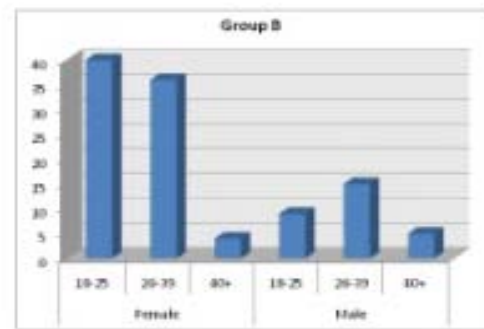
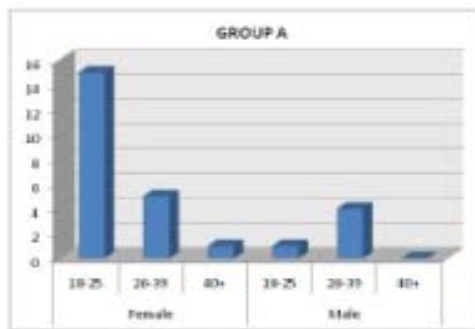
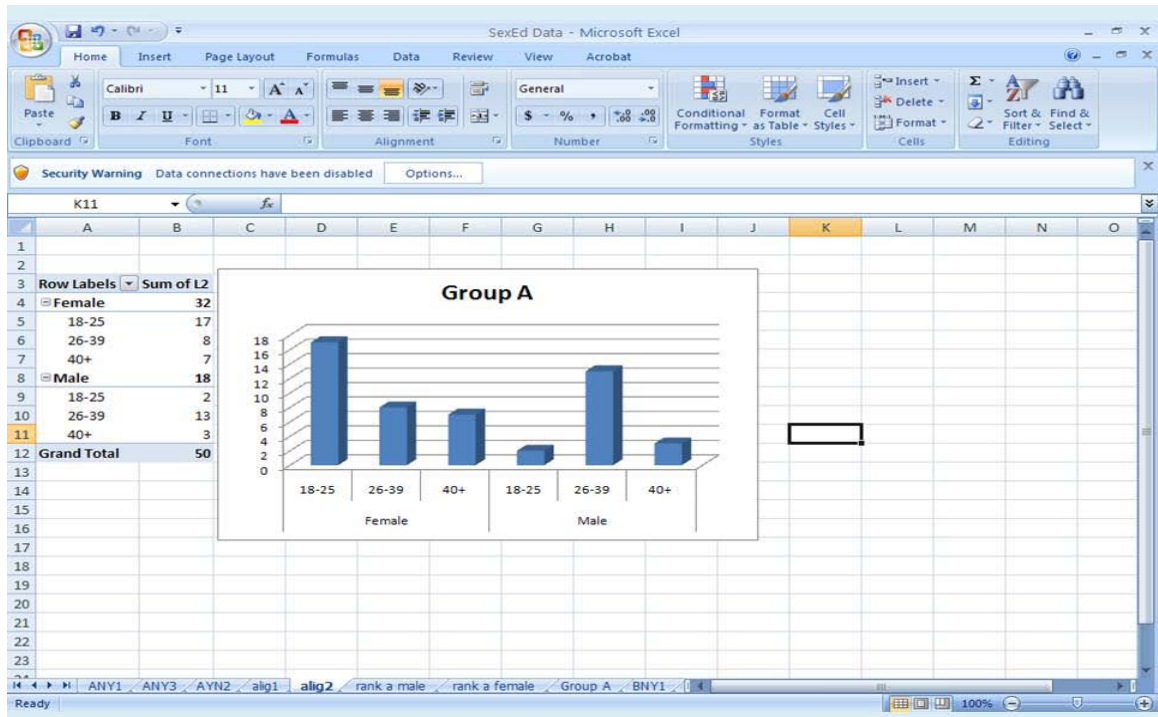


Do You Believe Sex Education Should Be a Part of School Curriculum?

Analysis of our yes and no data found that most students felt that sex education being taught in schools was more important than abstinence until marriage. Females felt more strongly than males that sex education should be taught in schools. Males age 26-39 felt more strongly about sex education being taught in school than the younger males we surveyed.

Figure 5. Example of a Student-interpreted Dichotomous Data from SexEd Group.

The students next used the spreadsheets to make additional pivot tables from their raw data for their dichotomous data from the simple random samples. They produced bar graphs (Figure 6), interpreted this data, and wrote a summary for later reporting and presentation.

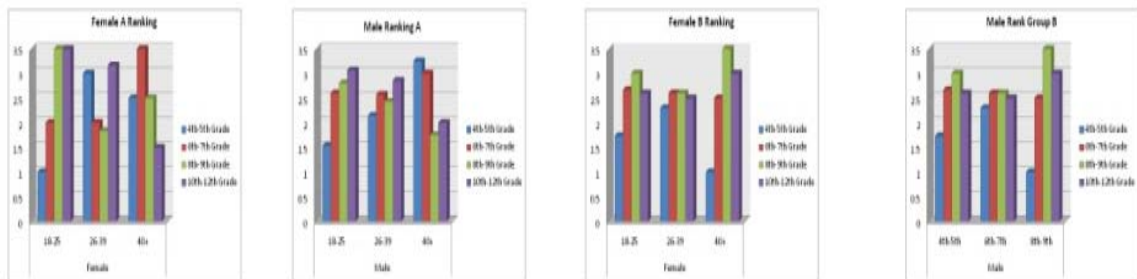
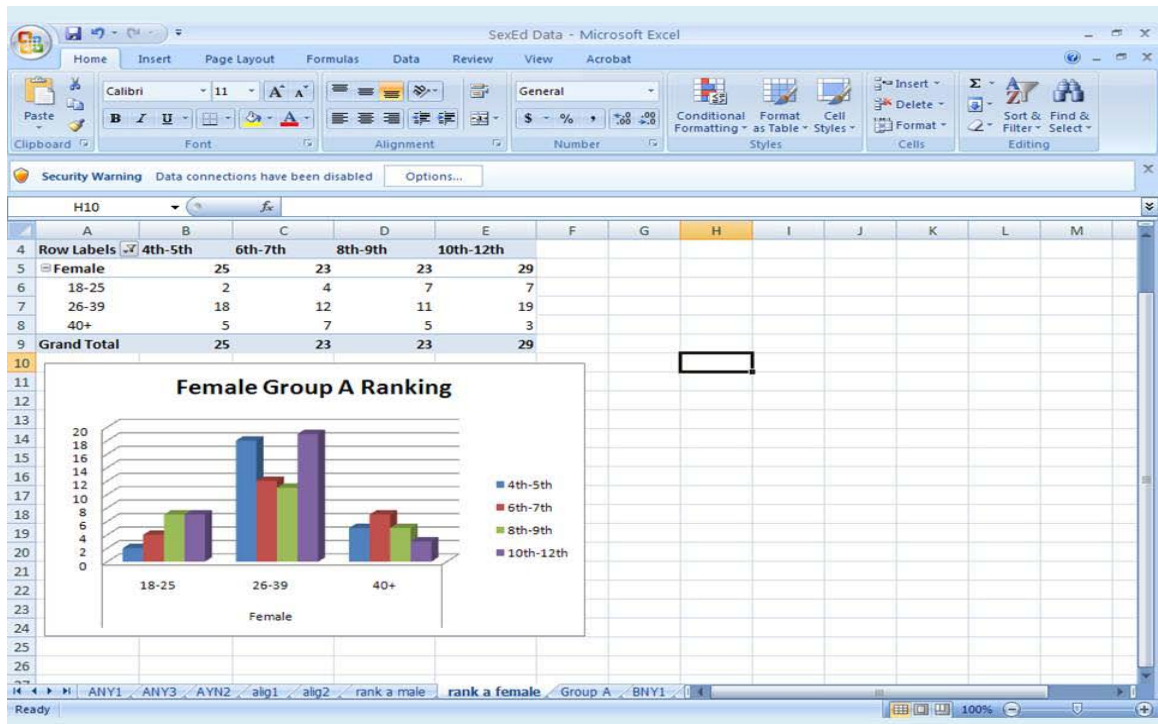


Sex Education Should Be Taught to Include Pregnancy Prevention and STD Awareness

Analysis of our Likert data found that students felt that abstinence until marriage should be taught in schools rather than STD and pregnancy prevention. Females in both groups felt more strongly about the topic than did males. There were students that felt STD and pregnancy prevention should be taught but abstinence until marriage was more strongly liked.

Figure 6. Example of a Student-interpreted Likert Data from SexEd Group.

Finally the student groups used spreadsheets to make another set of pivot tables from their raw data for their ranking data from the simple random samples. They produced bar graphs (Figure 7) to interpret the data, and wrote a summary for later reporting and presentation.



Rank At What Grade Level Should Sex Education Begin to Be Taught 1-4; 4 Being the Most Preferred and 1 Being Least Preferred

For our ranking questions we asked students what grade do they feel it was most important for sex education to be taught. Females 18-25 showed that most of them believe that sex education should begun being taught in the eighth and ninth grade. Males 18-25 believed sex education should be taught from the tenth to the twelfth grade.

Women and men 26-39 varied greatly between fourth and twelfth grade of when they believed sex education should taught. Women 40+ were even between sixth - seventh and eighth and ninth grade as the beginning age for sex education. Men 40+ were again varied with what age they believed sex education should be introduced.

Figure 7. Example of a Student-interpreted Ranking Data from SexEd Group.

The summaries and sets of bar graphs were incorporated into Word documents as a summary. After interactions from both the instructor and the other groups, adjusted summaries and graphs were imported into a template to make a 36 inch x 56 inch poster (Figure 8). These were then presented before judges and the general public in a poster session.

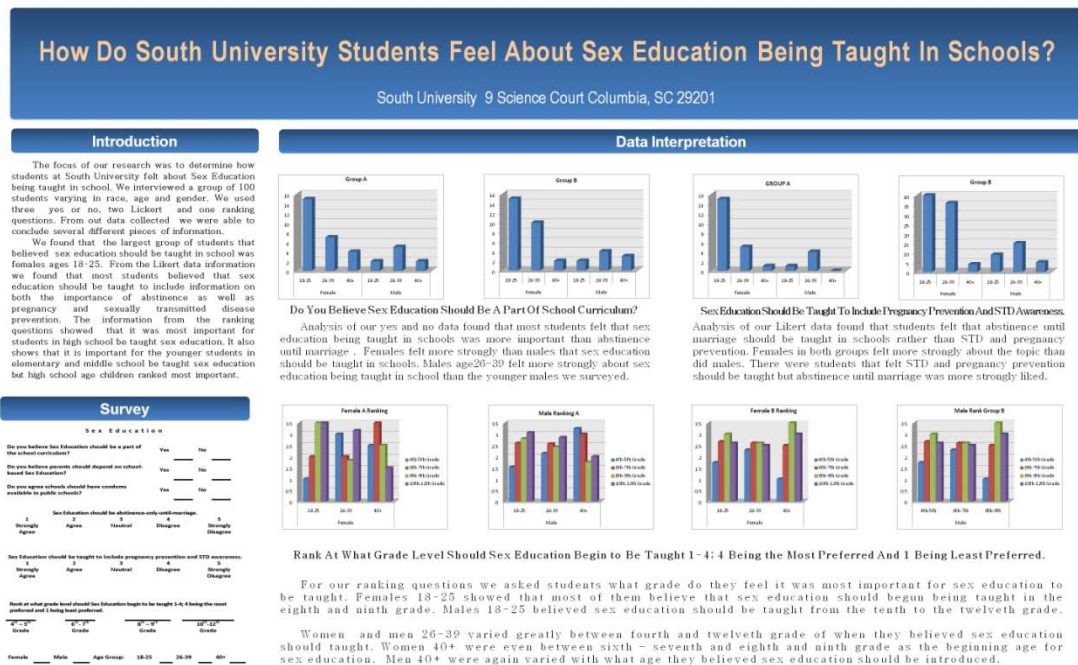


Figure 8. Example of a Student-produced Poster from SexEd Group.

The results of the Peer Group Evaluation Form indicated that the group peer average ratings ranged from 4.56 to 5.00 (Table 2). This provided evidence that three groups rated each other very highly as contributors. Only one group rated a single member as a poor contributor.

Table 3.

Group Peer Ratings by Student. 5 = Awesome, 4 = Reliable, 3 = Good, 2 = Ok, 1 = Poor

Group/Student	1	2	3	4	Average
Group A	5.00	4.50			4.75
Group B	4.33	4.67	4.67		4.56
Group C	5.00	5.00	5.00		5.00
Group D	5.00	5.00	5.00	5.00	5.00

Results from the Statistical Poster Judging rubric (Appendix C) used by the judges indicated a more moderate assessment of all three group projects (Table 3). Judges rated Group D higher (3.3 to 3.7) on methodology, data interpretation and their

interactions with the judges. The other three groups were rated lower, especially on data interpretation (2.8 to 3.1). The judges' interaction with the students was considered a positive input by the students. One student wrote, "The feedback given by judges were helpful."

Table 4.
Judge Ratings of Poster Session (Rubric scored 1 to 4)

Ratings by Judges	Group A	Group B	Group C	Group D
Poster Layout	3.3	3.3	3.3	3.3
Method	3.1	3.2	3.1	3.5
Data Interpretation	2.8	3.1	2.8	3.7
Student Interaction	3.2	3.4	3.2	3.7

INTERPRETATION

Survey and qualitative data from the triangulation matrix included student-produced posters plus the peer and judge assessments of their posters. These data converge to indicate that my students learned statistical content from the treatment. The students demonstrated critical thinking in their decisions on a survey topic and development of a theme into questions designed to produce data. They also had find patterns in the raw data to interpret in summaries.

Their interpretations were used to produce an APA style summary that included references of their sources and documentation of their findings. This process increased student's statistical language and vocabulary skills. The project also helped the students to increase their presentation and group skills. They learned about collaboration, how to do research, how to write a survey and to gather data. They also demonstrated their

ability to assess and to interpret dichotomous, Lickert, and ranking data. They also designed their posters to present their findings to both their peers and expert judges.

The findings of the treatment were consistent with the recommendations made by the American Statistical Association's (ASA) *GAISE* project on how students' best learn statistics. First, implementing a student-designed survey and poster project gave an opportunity for my students to learn statistics by constructing their own knowledge. The emphasis on statistical literacy allowed the students to develop their statistical thinking.

The student-designed survey and poster project allowed the students to learn statistics through the *GAISE* emphasis on the use of real data. Students had to take the raw data from their simple random sets of survey responses. Students transformed and constructed usable knowledge from their survey data by coding and interpreting it into bar graphs.

The student-designed survey group projects were also consistent with *GAISE* recommendations to foster active learning and assessment through open-ended investigative projects as groups. The projects also stressed conceptual understanding rather than mere knowledge of procedures and had assessments designed to improve and evaluate student learning.

GAISE recommended that statistical thinking should have modeled content. My students received consistent and helpful feedback on their performance from their peers and through interactions with me and judges. My students were allowed to construct their knowledge while being supported and augmented to help them reason a path to understanding.

GAISE recommended the use technology to develop conceptual understanding and to analyze data. My students used spreadsheets to discover analysis from their own data. They also used presentation and word processing software to produce presentations as executive summaries and posters. One student wrote, “The project was great and very fun! I loved working as a group.” Another student wrote, “The class was great I liked working in groups and I liked how everyone’s hard work showed in the end.”

VALUES AND CLAIMS

The project demonstrated that the students could work at the higher levels of analysis, application, and synthesis with statistical student-produced data. The students also demonstrated critical thinking, questioning and expansion of their world views. One student wrote, “I think it was an excellent way for us to learn statistics, rather than doing strictly book work.” Another student wrote, “The project provided a broader outlook of stats for me.”

I personally learned from the feedback of these projects and have modified each iteration. This group project to poster technique has since been expanded to my own chemistry and biology course. Judges from the poster session have since used this type of project in microbiology and the general nursing curriculum.

This treatment helped me to develop as a constructivist teacher. I learned to release control of learning and to allow students to construct their own statistical knowledge. I had to allow some assessment to be made by judges and the students themselves (as peers). I had to assume the roles of expert and coach and to continually scaffold concepts and process to help them reason a path to understanding. I learned that

project-driven versus content-driven design gives responsibility, accountability, and self-actualization to students. And as a result, students can thrive in an open, self-directed environment. And this process takes them further in their learning than I could have ever have taken them using a content-driven design. I learned that I can you use peer learning across all subjects. Finally, I learned that when I step back, dictate less, and support more the students break out of the teacher-imposed restrictions and student-imposed restrictions on how learning occurs.

An extension of my treatment was to transfer project-driven posters to other science courses. In my introductory biology, students researched systems biology topics of their choice and presented during a poster session their findings (Figure 9). In my nursing chemistry, nurses chose a pharmacological drug class and some representative molecules and presented their findings during a poster session (Figure 10).

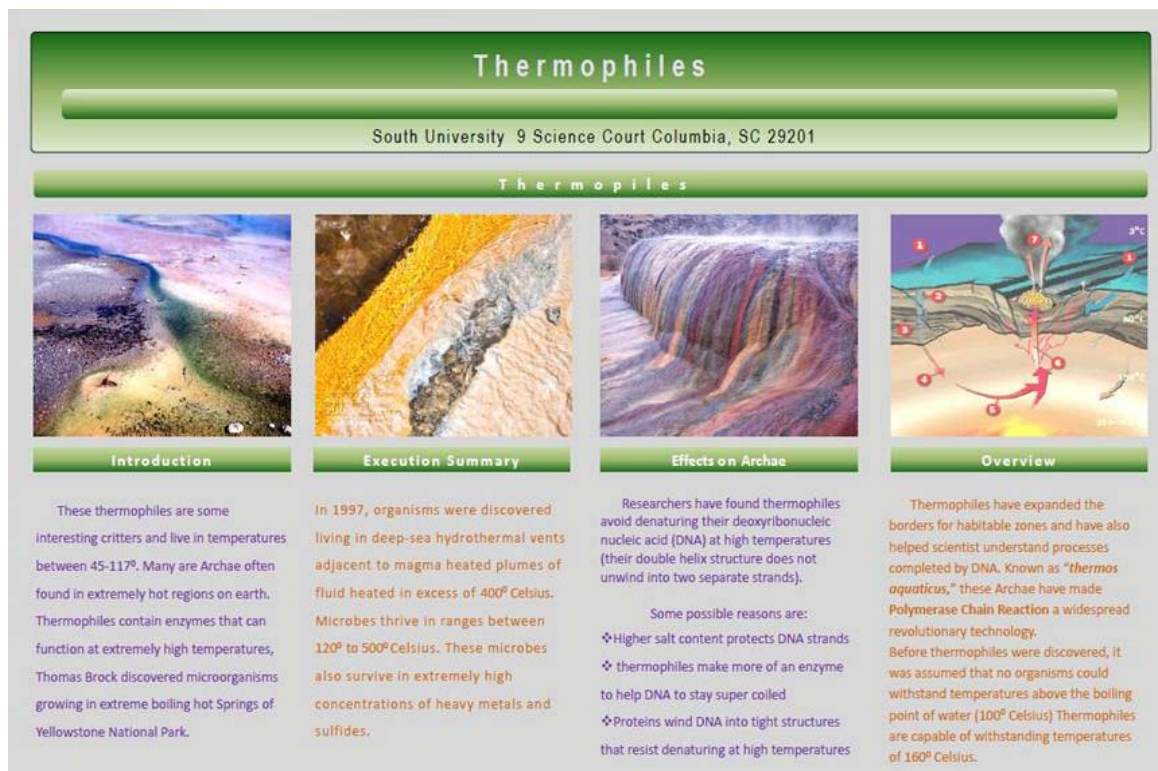
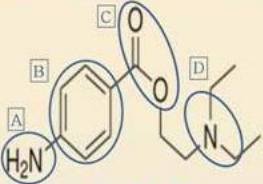
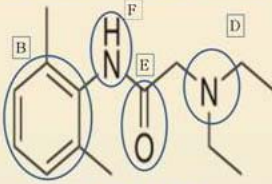
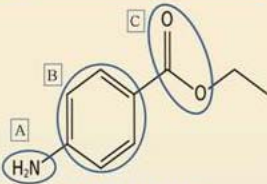


Figure 9. Example of a Student-produced Poster from Introductory Biology.

Additionally, professors from microbiology, anatomy and physiology, and department chairs of nursing and business have requested my help in implementing project-driven posters in their courses and programs.

Anesthetics

SOUTH UNIVERSITY 9 SCIENCE COURT COLUMBIA, SC 29201

Introduction	Anesthetic Molecules		
The purpose of our project is to show the therapeutic actions, indications, contradictions, cautions, adverse effects and interactions of anesthetics. We were interested in the simplicity and similarities of their molecular structures. These drugs have been used since the 1800's and continue to be widely used today.	 Procaine Absorption, Distribution, Metabolism, and Excretion	 Lidocaine Absorption, Distribution, Metabolism, and Excretion	 Benzocaine Absorption, Distribution, Metabolism, and Excretion
Therapeutic Actions of Anesthetics An anesthetic is a drug that causes anesthesia—reversible loss of sensation. Analgesics (or painkillers) relieve pain without eliminating sensation. These drugs are generally administered to facilitate surgery. A wide variety of drugs are used in modern anesthetic practice. Many are rarely used outside of anesthesia, although others are used commonly by all disciplines. Anesthetics are categorized in to two classes: general anesthetics, which cause a reversible loss of consciousness, and local anesthetics, which cause a reversible loss of sensation for a limited region of the body while maintaining consciousness.	Procaine is an ester anesthetic. It is metabolized in the plasma by the enzyme <i>pseudocholinesterase</i> through hydrolysis into <i>para-aminobenzoic acid</i> (PABA), which is then excreted by the kidneys into the urine. Procaine is an anesthetic agent indicated for production of local or regional anesthesia, particularly for oral surgery. Procaine, like cocaine has the advantage of constricting blood vessels which reduces bleeding, unlike other local anesthetics like Lidocaine.	Lidocaine stabilizes the neuronal membrane, this is accomplished by inhibiting the ionic fluxes required for the initiation and conduction of impulses. As a result of this, local anesthetic action is effected. The plasma binding of Lidocaine is dependent on drug concentration, and the fraction bound decreases with increasing concentration. Plasma binding is also dependent on the plasma concentration of the alpha-1-acid glycoprotein. Lidocaine is metabolized by the liver very quickly. The drug is excreted by the kidneys. The elimination half-life of Lidocaine after an intravenous injection is typically one and a half to two hours. Because of the rapid rate at which Lidocaine HCl is metabolized, any condition that affects liver function can alter the kinetics of Lidocaine.	Benzocaine is the ethyl ester of <i>para-aminobenzoic acid</i> (PABA). Esters of PABA work as a chemical barrier, stopping the sodium from entering the nerve ending. Benzocaine is visually very similar to Cocaine and therefore does not detract from the appearance of quality. One of the other features of this substance is that it remains within the Cocaine when it is subjected to Crack manufacture and has subsequently been attributed the slang name of 'magic'.

Functional Group Key:
 A. Primary Amine
 B. Benzene
 C. Ester
 D. Tertiary Amine
 E. Ketone
 F. Secondary Amine

Figure 10. Example of a Student-produced Poster from Nursing Chemistry.

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APPENDICES

APPENDIX A

LEARNING THROUGH OUR STATISTICS PROJECT SURVEY INSTRUMENT

Learning Through Our Statistics Project?

Please rate each statement below by circling your choice.

Working as a group reduced my anxiety about doing a complex project.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
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Designing our survey helped me to think about how to collect statistical data.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
----------------------	----------	---------	-------	-------------------

Having student-made surveys and posters as models helped our group to design our own.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
----------------------	----------	---------	-------	-------------------

Modeling by our instructor helped our group to use technology during our project.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
----------------------	----------	---------	-------	-------------------

Having graphs generated from our survey results helped me to understand our data.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
----------------------	----------	---------	-------	-------------------

Designing and collecting survey data first helped me to understand statistical concepts later.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
----------------------	----------	---------	-------	-------------------

Knowing peers reviewed my contributions helped me to be actively involved in our project.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
----------------------	----------	---------	-------	-------------------

Doing a complex project helped me to learn statistical content.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
----------------------	----------	---------	-------	-------------------

Learners gain knowledge through their interactions with more knowledgeable others.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
----------------------	----------	---------	-------	-------------------

Is there anything else you'd like me to know about our statistics project?

APPENDIX B

PEER GROUP EVALUATION INSTRUMENT

Last	First	Circle Each Group Member by their helpfulness and reliability to the Group Project				
		Awsome	Reliable	Good	Ok	Poor
		Awsome	Reliable	Good	Ok	Poor
		Awsome	Reliable	Good	Ok	Poor

APPENDIX C

STATISTICAL POSTER JUDGING

Statistical Poster Judging

Poster Name: _____

CATEGORY	4	3	2	1
Poster Layout	Each element in the Poster had a function and clearly served to illustrate some aspect of the experiment. All items, graphs etc. were neatly and correctly labeled.	Each element in the Poster had some function and served to illustrate some aspect of the experiment. Most items, graphs etc. were neatly and correctly labeled.	Each element in the Poster had a function and served to illustrate some aspect of the experiment. Most items, graphs etc. were correctly labeled.	The Poster seemed incomplete or chaotic with no clear plan. Many labels were missing or incorrect.
Data Collection Method	Poster Group describes in detail how data was collected and analyzed from identified target population.	Poster Group describes how data was collected from identified target population.	Poster Group describes how data was collected but target population was not clearly identified.	Poster Group does not describe how data was collected and does not state the intended population studied.
Qualitative Data Interpretation	Students allow data to interpret itself and can clearly compare and contrast the results.	Students let the data interpret itself but have no clear understanding of contrasts or comparisons.	Students have data but cannot interpret any contrasts or comparisons	Students make the data fit a pre-established goal or selectively interpret data.
Student Interaction	Students clearly know their data and relation to the hypothesis and can answer all questions about their project.	Students know their data and relation to the hypothesis and may answer some questions about their project.	Students do not know their data or relation to the hypothesis and can not answer questions about their project.	Students were not present or can not answer any questions about their project.

Judge's Name: _____

APPENDIX D

INSTITUTIONAL REVIEW BOARD



MEMORANDUM

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

960 Technology Blvd. Room 127
 c/o Veterinary Molecular Biology
 Montana State University
 Bozeman, MT 59718
 Telephone: 406-994-6783
 FAX: 406-994-4303
 E-mail: cherylj@montana.edu

Chair: Mark Quinn
 406-994-4707
 mquinn@montana.edu
Administrator:
 Cheryl Johnson
 406-994-6783
 cherylj@montana.edu

TO: Ralph Spraker

FROM: Mark Quinn, Ph.D. Chair *Mark Quinn*
 Institutional Review Board for the Protection of Human Subjects

DATE: December 1, 2010

SUBJECT: "How Does My 'Just-In-Time' Scaffolding of Descriptive and Inferential Statistics within an Existing, Quarter-Long, group Poster Presentation of Survey Data Impact My Undergraduate Statistics Students' Ability to Apply Their Learning?" [RS120110-EX]

The above research, described in your submission of November 29, 2010, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- ☐ (b)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ (b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- ☐ (b)(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- ☐ (b)(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ (b)(5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ (b)(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

Title: Subject Consent Form for Participation in Human Research at Montana State University**Project Title: How Statistics Students Learn**

You are being asked to participate in a research study that examines the use of group projects, active learning, and modeling in teaching Statistics. For this project, you will be asked to complete a survey and may be asked to use other instruments to evaluate other students. All data collection instruments fall within the area of common classroom assessment practices.

Rationale of Research and Benefits:

There are several benefits to be expected from participation in this study. The improvement of the professor's and others instruction from use of group projects and modeling could be demonstrated by the study.

Identification:

All students in Dr. Spraker's statistics class were included in the research but your identification will be kept strictly confidential. Your involvement in this research will remain unidentified in any way, and your level of environmental interaction will be assessed and noted. Nowhere in any report or listing will your first or last name or any other identifying information be listed.

Risks:

There are no foreseeable risks or ill effects to you from participating in this study. All treatment and data collection falls within what is considered normal classroom instructional practice. Participation in this study is voluntary, and you are free to withdraw consent and to discontinue participation in this study at any time without prejudice from the investigator. Furthermore, participation in the study can in no way affect your grades for this or any course, nor can it affect academic or personal standing in any fashion whatsoever.

Should you have any questions about the research, please contact Dr. Ralph E. Spraker, Jr. at rspraker@southuniversity.edu. If you have additional questions about the rights of human subjects they can contact the Chair of the Institutional Review Board, Mark Quinn, (406) 994-4707 [mquinn@montana.edu].

Authorization:

I have read the above and understand the discomforts, inconvenience and risk of this study. I, _____ (*name of subject*), agree to participate in this research. I understand that I may later refuse to participate, and that I may withdraw from the study at any time. I have received a copy of this consent form for my own records.

Signed: _____

Investigator: Dr. Ralph E. Spraker, Jr.

Date: _____

**APPROVED
MSU IRB**

12-01-2010

Date approved

NA

Expiration date

APPENDIX E

STUDENT INFORMED CONSENT FORM

Dr. Spraker's Statistics Students Informed Consent Form.

The purpose of this research project tentatively entitled, "How Statistics Students Learn," examines the use of group projects, active learning, and modeling in teaching Statistics. For this project, students will be asked to complete a "Learning Through Our Statistics Project" survey and may be asked to use other instruments to evaluate each other. All data collection instruments fall within the area of common classroom assessment practices.

Identification of the students involved will be kept strictly confidential. All students involved in this research will remain unidentified in any way, and their levels of environmental interaction will be assessed and noted. Nowhere in any report or listing will students' first or last name or any other identifying information be listed.

There are no foreseeable risks or ill effects from participating in this study. All treatment and data collection falls within what is considered normal classroom instructional practice. Participation in this study is voluntary, and students are free to withdraw consent and to discontinue participation in this study at any time without prejudice from the investigator. Furthermore, participation in the study can in no way affect grades for this or any course, nor can it affect academic or personal standing in any fashion whatsoever.

There are several benefits to be expected from participation in this study. The improvement of Dr. Spraker's and others instruction from use of group projects and modeling could be demonstrated by the study.

Please feel free to ask any questions of Dr. Ralph E. Spraker, Jr. via e-mail, phone, or in person before signing the Informed Consent form and beginning the study, and at any time during the study.

Student signature: _____

Monday, November 01, 2010