1. INTRODUCTION

When talking to people about the courses I teach, many reveal that statistics is a subject they found difficult or intimidating. In addition, many students think of statistics as something unrelated to their field of study or career goals. This makes introductory statistics a particularly challenging class to teach. Many methods have been proposed for engaging students in activities or discussions where hands-on learning or thought-provoking concepts can be utilized and explored (Melton 2004, Boyle 1999). However, as more online courses are being offered (Cox & Cox 2008), more instructors must find a way to engage students through this new delivery method. This trend is a double edged sword as it provides greater access to classes for students, although the quality or experience may or may not be the same (Webster & Hackley 1997, DeVaney 2010, Ward 2004). According to Galusha's 1998 report on distance learning, "Problems and barriers encountered by the student fall into several distinct categories; costs and motivators, feedback and teacher contact, student support and services, alienation and isolation, lack of experience, and training" (paragraph 14).

Roblyer & Ekhaml (2000) and others have reported that increased student involvement and interaction resulted in increased learning, improved grades, and improved student satisfaction in distance classrooms. There have been great developments in engaging students in statistics courses as well as in distance learning courses or online courses (Everson 2006, Everson & Garfield 2008, Brown 2001, Nicholson & Bond 2003, Ben-Zvi 2007, Wickstrom 2003, Cox & Cox 2008), and even using online components in a traditional statistics classroom (Ward 2004, Malone & Bilder 2001). Even these developments do not account for every situation. The use of the online discussion board described in this paper was implemented to address the challenges to discussing important concepts that arise when one class contains three types of students: traditional classroom students, distance students participating in real time, and asynchronous distance learners participating from around the globe.

Levine (2007) provides guidelines and tips for using an online discussion board and Harman & Koohang (2005) discuss the online discussion board's role as a learning object to incorporate elements of constructivism learning theory such as: "collaboration, cooperation, exploration, higher-order thinking skills, knowledge construction, learner driven goals and objectives, multiple perspectives, multiple representations of content/idea/concept, negotiation among learners, learners previous experience, real-world situations/problems, social disclosure, social negotiation, and the use of primary sources of data" (pp. 71). Many of these are elements that statistics instructors already diligently try to include in their classes, but may not have explored through the context of virtual discussion. Teikmanis & Armstrong (2001) have used a discussion board in a pathophysiology course to shift learning from "teacher orchestrated to student centered" and discussion boards have been used in rural medical rotations (Baker, Eley, & Lasserre 2005) and many other subjects (Cox & Cox 2008, Nicholson & Bond 2003, Wickstrom 2003, Rainsbury & Malcolm 2003, Nodder, Young & Joyce 2001), and have been effective in increasing student participation and understanding.

While the use of a discussion board is common practice for online courses, it is not often thought of as a tool that can be used in traditional classrooms or when the class contains a mixture of in person students, distance students participating in real time, and asynchronous distance students who are all evaluated in the same manner. Nodder, Young & Joyce (2001) have used a

discussion board to supplement classroom instruction for education students, but use of a discussion board as a supplemental tool in statistics courses could not be found aside from courses that were taught primarily or completely online (Everson 2006, Everson & Garfield 2008). The purpose of this paper is two-fold: to promote the use of an online discussion board as a valuable educational tool not restricted to use in purely online courses, and to describe two specific activities used to engage students, both those in and those out of the classroom, by using an online discussion board to promote critical thinking and discussion on a deeper level than what is allowed during scheduled class time. The activities described include one where students participate throughout the semester in a series of discussion topics provided by the instructor aimed to promote critical thinking (Section 2.1) and another where students post an article and their critique from their area of study for discussion among classmates with the objective of increasing awareness and appreciation of statistics among students (Section 2.2). While two activities are described, they can be used together in the same class, or one without the other. The proposed activities can be used in any type of class, and have been used by the author in graduate level introductory biostatistics courses of differing formats: regular lecture style classes, online classes, and classes that include a combination of in class students and both synchronous and asynchronous distance learners.

2. USING THE DISCUSSION BOARD

Incorporating an online discussion into class was initially done to allow students who could not participate in the classroom setting due to distance or time-zone the opportunity to discuss concepts with classmates. When thinking about ways to include all students in the discussion, two additional objectives came to mind: (1) Increasing students' interest in and appreciation for statistics by providing thought provoking, real life topics and opportunity for all to participate in discussions and (2) creating a (real and virtual) classroom of discussion, critical thinking, and inquiry when students do not all have the same classroom experience. Some students enrolled in the course are physically sitting in the classroom, some are viewing the class via distance technology from another classroom, some are viewing class via live stream technology from their own home, and some are viewing asynchronously from another country or time-zone. All of these students are enrolled in the same section of the course, complete the same assignments, and are evaluated using the same criteria. The goal is to make the learning experience as similar as possible for all these students, and give all a chance to participate and discuss important concepts with their classmates through activities using the online discussion board.

The course where the online discussion board was initially implemented is a graduate level introductory biostatistics course that many students take as a requirement for their program of study. The students in this course are typically very diverse in terms of age, program of study, and preparation for the course. Some students will be in their first semester of graduate or professional school while some will have already completed a graduate or professional degree and be seeking additional training. Some students have much exposure to statistics through their work or educational background, and others will have never had a statistics course with their most recent math class being two or three decades old. The typical enrollment is about 60-65 students per semester with a varying number of distance students. Some semesters have as many as 15 distance students, both domestic and abroad, with some viewing from their home and up to

7 or 8 viewing recordings asynchronously as a group from another classroom. This class meets once a week for two hours and 40 minutes. Each week is structured so there is about 45-60 minutes of lecture, 20-30 minutes for in-class practice problems that students may work on independently or in small groups, and then the same process is repeated with a new topic. The students also complete weekly homework assignments, a project, and 3 exams. As many instructors have experienced, class is barely enough time to cover the required topics, and does not allow for covering topics in detail or allow much time for discussion or critical thinking problems. Distance students find it difficult to participate in class discussion if they view through live stream because they must call in each time they have a question or comment, and find it impossible to participate if they are asynchronous distance learners. While these activities using the online discussion board were initially implemented as a way to include distance learners in discussion, they have been so valuable at increasing participation and extending learning beyond the classroom that they are now implemented even in courses without distance students.

2.1 Creating a Classroom of Discussion, Critical Thinking, and Inquiry that Includes Distance Students.

Statistics is not a subject that many students would relate with critical thinking or discussion. Students are used to math, where everything is black and white, and they may fall into the number crunching mode of solving problems (Garfield & Ahlgren 1988) instead of engaging critically with the material. Statistics, however, is not that way and many students find this a challenging part to mastering the subject (Garfield & Ahlgren 1988, Rossman, Chance & Medina, 2006, DeVeaux 2007). Helping students to learn the process of statistical thinking must include giving students experience with problems whose solutions are not black and white and therefore require critical thinking (Garfield & Ahlgren 1988, DeVeaux 2007, Cobb and Moore 1997, Moore 1997). Requiring thinking also requires that students have time to think, and extra time is not a luxury that most classroom instructors have. In a typical classroom these types of problems are often incorporated as group exercises either with or without guidance from the instructor. Students who are viewing from another classroom, their home, or using an archived video in another country lose out on these experiences and limited classroom time makes it difficult for in class students to thoroughly think through the problems. These experiences are so important for students to learn statistical thinking (Garfield 1995, Garfield & Ahlgren 1988, Moore 1997) that it is imperative they not be eliminated due to the challenges posed with this type of class or due to lack of class time.

The approach to address these issues was to put those types of problems on the course discussion board. Many universities provide course management systems for instructors to post materials and grades, and many of these systems include discussion boards. Posting on the discussion board allows for follow-up on the class material, but at a deeper level. After class, students can look at the topic, take time to think about it, and post their response. They are also able to read posts from other students and discuss the topic in more detail. The questions or topics posted always have multiple goals and objectives, are often questions that do not have a right or wrong answer, and are aimed at getting the students to look beyond the surface of a problem. They are designed for students to think about statistical topics critically and on a deeper level, or so they can put statistical concepts into familiar terms to aid in understanding. The topics selected are both health sciences focused and general statistical ideas, and are based on things that ideally would be discussed or experienced in class. Many of the problems used were adapted from

textbook or in class exercises or discussions, and others were created to address topics in the class where students often struggle. However, this approach allows more flexibility as students have more time to think on their own, it extends learning beyond the classroom, and importantly it allows all students to participate at an equal level.

Examples and detailed information of some discussion questions are presented in Section 2.1.1, while a list of questions and the corresponding topics can be found in the Appendix. Methods for implementation and participation requirements are outlined in Section 2.1.2.

2.1.1 Examples of Discussion Topics

The first discussion board posting is on variable summary methods (adapted from DeVeaux 2007). Students are given a variable with no background information and asked to find the best way to summarize it graphically and numerically. This lesson has several important points. First, it gives students practice with concepts covered in the first week of class: types of data, graphical summaries, and numerical summaries. Second, students are able to really dig in and play with data right away on their own. Third, it gives practice working with the software package used in class. Finally, it reveals to them that it is difficult to do anything, even something as simple as making a graph, without any context (Cobb & Moore 1997, Aliaga et. Al, 2010). Of course, they are told during class that it is important to know background information, type of data, etc. before doing any analysis but this activity helps to reinforce that point. On the discussion board, students report being very frustrated by this activity as they are searching for the "right" answer, but they also enjoy looking at the data in many ways and exploring it themselves.

Another example of a topic that has been used in an online discussion is the classic problem of relating hypothesis testing to criminal trials (Pagano & Gauvreau 2000). Students are asked to think about criminal trials and put it in a hypothesis testing situation including stating the hypotheses, interpreting the conclusions if they were to reject or fail to reject the null, interpreting the two types of errors, and deciding which type of error has more serious consequences. The students discuss the last of these most, inevitably giving examples of when each type of error would be worse to make, and come away knowing that the worse error to make may depend on the situation and the consequences of the error. Students will usually notice that someone has said that if we fail to reject the null (innocence), then the conclusion is the defendant is "innocent" and point out that the correct answer is the defendant is "not guilty". This example helps students to put statistical terminology in familiar terms and to understand why the null hypothesis is not rejected instead of "accepted" by showing that lack of evidence against the null does not prove the null.

A third example includes students watching a video segment from a Good Morning America (GMA) Consumer Alert about an important public health topic, nutritional information on food labels (ABCNews 2008). The video describes how GMA hired a lab to sample one package of twelve different products and explains how food products are obviously mislabeled since their findings did not match the label on the product. Students are quick to point out that sampling one of each product is not enough to represent all products. It gives them a real life look at sampling variability, why sample size is so important, and why we make inferences about means instead of individual observations. This is also a way for students to see how statistical information can be misused by the media, and helps them become better consumers of information.

Another example is one that students complete as their last discussion board post of the semester. They are instructed to read the article "Watching our Language when we Teach Statistics" by Rumsey (2009) about terminology some students find confusing. Students must reflect on this article, if they agree or disagree with the specific terms the author mentions, suggest terms they found confusing for themselves, and offer alternatives that might be helpful. Students like this activity because it nicely recaps many of the course topics and lets them reflect on these at the end of the semester. They also find it comforting to know that others have struggled with the same material, and have offered very useful suggestions.

2.1.2 Methods and Suggestions for Implementation and Participation

While some of these examples of problems may not be new in themselves, the approach to class discussion of complex problems using an online discussion board is a creative and effective way to include or expand on topics with limited class time and students who are participating from around the globe. Using an online discussion board is helpful when students are not all in the room together, but it can also be a useful tool to supplement discussion in traditional classes and needs not be limited to use in online classes. Topics can be structured with predefined questions like those described above, and to further engage students, they can be supplemented with discussion topics derived from student interest or questions that arise in class.

In the initial trial of the discussion board activity, students could participate for extra credit. During this phase, the goal was to see if the topics chosen were interesting to students, if students were getting the desired information and experience out of each topic, and to assess acceptability of the discussion board by the students. When offered for extra credit, a little less than half of the students participated at some point, and about a quarter participated regularly. Once the questions were piloted, discussion board participation was incorporated as a small percentage of the overall grade. There are at least eight topics posted per semester, and students are required to participate in a minimum of four of the eight topics. Participation in at least two topics must include their original thoughts on the topic posted, and participation in at least two other topics must be meaningful responses to other classmates. Students are instructed that their responses to others must show evidence of critical thinking. They must respond with more than, "I agree with John" and provide justification or reasoning for that agreement to receive credit. The second requirement was to ensure that students would read each other's posts to start discussion. This seemed a reasonable amount for minimum requirements, although for smaller class sizes, more participation may be needed for good discussion.

The first semester that discussion board participation was required, it was announced in class when a topic had been posted and students were given a week to respond, but many students would forget to post and would run out of topics in the semester before completing the four posts. To address this, each discussion is now included in the syllabus with the course schedule. This lets students know which course topics have corresponding discussions and their due dates, which are approximately one week after the lecture in which the material was covered. All assignments are due by the beginning of the following class, and due times are the same for all students. Participation is much better than when discussion was extra credit or announced in class; students have noted in course evaluations they planned to participate early to get it out of the way, and then continued to participate even though they had met the requirements because

they enjoyed the thought-provoking topics and discussion with other students. The discussion is followed by the instructor throughout the week to ensure proper etiquette on the discussion board and to give hints or clues if the discussion gets off track. Otherwise, the discussion during the week is left to the students. Often students are eager to learn the "right" answer to the problem, and email the instructor or comment on the discussion board wanting to find out more. Each discussion ends with a brief summary posted to the discussion board and wrap-up at the beginning of the following class period. This is a great way for all students to be involved in a discussion no matter their location or time-zone, and lets them think and respond on their own time.

In semesters for which use of the discussion board has been part of the students' grades, participation has increased, as well as understanding of concepts. The first semester (where discussion assignments were announced in class and were not listed in the course schedule), 63% of students completed the minimum requirements with 48% of students going beyond the minimum. The first semester that the discussion assignments were listed in the schedule, 88% completed the minimum and 50% participated more than required. Of those who did not complete the minimum requirements, most students received partial credit for completing two or three topics, with only one or two students not doing any. One student's comment reflects many that have been received:

> "I may not have commented on all of the discussion topics, but my favorite was listening to the ABC News piece on nutritional labeling. I learned a lot, but better yet, I could see some of the concepts that we had covered in biostats coming out in the broadcast. I have had that experience several times this semester independently, listening to NPR, reading articles in the newspaper, or reading journal articles for other classes. Things that I would've skipped over before make sense to me now because I can deduce what's going on or call foul on bad sampling or sample sizes where I wouldn't have noticed before."

Based on comments from students and end-of-course evaluations, most students enjoy these postings and there have been noticeable differences in students' abilities to explain concepts and interpret results as compared to previous classes, which was one of the goals of this activity. A second result was an improvement in the quality of the projects submitted. Prior to implementing these critical thinking activities, when students were given a dataset and description for their final project, many were lost on what to do even if given specific instructions. Now they do not find it as overwhelming as they have been exposed to exercises in critical thinking and data exploration beyond typical homework problems prior to their final project.

2.2 Increasing Interest in and Appreciation for Statistics in the Health Sciences Student.

Another instance in which an online discussion board can be a useful tool is when used to help students personally connect with statistics and see how the subject will be relevant to them. In addition to finding statistics challenging, many students view it as something they must do, rather than something to do because it is important to their study or career goals. In beginning of semester questionnaires, when asked why they were taking the course, students would respond, "My advisor made me", "It's required for my program", or something similar. Recent efforts for national changes in statistics curricula that emphasize numerical literacy and statistics in the "real world" have helped address this problem (Aliaga et. al., 2010) in undergraduate education.

The issue described above also exists in graduate level biostatistics classes, but another somewhat opposite issue is introduced at this level. Most students who take this introductory biostatistics class are medical, pharmacy, nursing, basic science or public health students. From this diverse group of students emerge two themes. The first is that mentioned above, where students may not think the course is relevant or useful to their training. In the second, many students have been exposed to research and statistical methods on a variety of levels, from attending journal clubs in their department where statistical methodology is discussed, to reading journal articles containing statistical results, and possibly even publishing their own paper that includes the use of statistical methods. This second group also views the course as irrelevant to their study or career, but for different reasons as they may view their knowledge of statistics as beyond the level of the class. The need for more in-depth exercises and understanding of concepts for these future scientists and health professionals is one that had to be addressed. Since this class has students from very diverse statistical backgrounds, a second activity to address these issues was designed to benefit students of differing preparation levels. This second activity works well for students just exploring how statistics is used in their field and graduate students who have had more statistical experience as they can question on a deeper level based on their experiences.

2.2.1 Article Critique and Reflection

This approach to increase appreciation for statistics works for students with or without prior statistical knowledge and includes assigning each student to do an article critique. They can choose any article from a popular news source or scientific journal, but it must be closely related to their own field of study or career goals. Article critiques are done in other courses at this institution, but the additions to this assignment for students to connect with statistics on an individual level and the discussions surrounding them are what make it unique. This assignment is another example of where an online discussion board can be used, in addition to the structured discussion topics previously mentioned. Students' discussion posts and written critiques have provided interesting insight to the benefits of this assignment. The assignment and some of these insights are described below.

For the assignment, the students first summarize the article and critique the use of statistical methods. The first thing students realize is that statistics can be found almost everywhere, in any media, and they report having a difficult time choosing an article, not because they cannot find one, but because there are so many choices. This is very surprising to them if they had thought statistics was not relevant to their area of study. The next thing they realize, especially if choosing a journal article, is they do not understand a lot of the methods used. Even students who are very familiar with the subject matter report not understanding all of the statistical methods and results. The students are told to expect this, but they are still very surprised at the volume of topics they come across that are not covered in class. A very important lesson that comes from this assignment is that there are many more statistical methods than one class can cover and an introductory level class only scratches the surface. Often students will report looking up the methods they do not understand and being curious to learn more about them or other methods commonly used in their field of study. Some students have even mentioned that

they have taken a second biostatistics course to learn more about statistical methods they were exposed to by completing this assignment.

The second part of the assignment is for students to write about how things we cover in class have contributed to their understanding of the statistical methods used in the article. Students will sometimes write that they understood a term incorrectly and that the class has helped them to understand it better, or that they now read parts of articles that before they would have skipped. Third, students must provide their opinions on the uses of statistics in the article and how it contributed to or detracted from the understanding and clarity of the article and provide suggestions for improvement. They only need discuss the parts of the article containing material covered in class, which usually consist of summary statistics, graphs, and basic tests or confidence intervals. Students often comment on the graphs, either they were helpful or very difficult to understand, and are able to see the differences in how statistical information is presented in journal articles versus in media articles. It is a valuable learning experience for students to look at their own area of study, not as a subject matter expert alone, but through the eyes of one who has some exposure to statistical concepts.

The fourth part of the assignment is the most interesting for me as the instructor. Here, students are asked to write about how statistics is used in their field, why it is important to their field, and how they anticipate they will use statistics throughout their career. This portion of the assignment is an opportunity for students to look closely at their field of study, think about their career goals and realize that statistics is everywhere, and is part of every discipline in the health sciences. They may not be conducting their own analyses, but they discover why it is important to understand various topics even if they will not be actively using the methods themselves. This part is very informative for an instructor and can help to provide ideas for more real life examples for future classes.

2.2.2 Methods and Suggestions for Implementation and Participation

Students post their articles and critiques on the course discussion board to share and discuss with other students. Where most article critiques would be turned directly into the instructor, discussion of articles and their uses of statistical information is a valuable learning experience made possible through the online discussion board.

The assignment is designed so that different students submit at different times during the semester, and other students are given one week to read and respond to articles and critiques. This allows students to focus on current topics of class in their critiques and to build on what they have learned as the semester progresses. After several posts, students are able to see and discuss the differences in presentation of statistical information between popular media sources and scientific journals, and to see that statistics is important and useful not only in their field, but in others areas as well. In this particular course, grading is separate for the critique itself, but reading and responding to article critiques of classmates is counted in the discussion board grade as a response to another student post, as described in Section 2.1.2. I use both activities (guided topics and article critique) in the same class with varying due dates, but they could be used one without the other if the instructor so chose.

In their discussion board postings, students have reported surprise that so many fields utilize statistical methods in so many ways, and that they never thought of statistics as very useful until

this assignment. Students are able to see the importance of how statistical information is reported both in journal articles and in the media, and how that impacts the message delivery and understanding of the information. Some students will post and critique a media article, and then find the journal article cited by the media story to compare and contrast presentation of statistical information. In the end of course evaluations, many students have reported that this was their favorite part of the class and it led them to gain a deeper appreciation for statistics in general, its use in their field, and relevance to their everyday lives. One student commented,

> "…statistics are essential to my education and career goals. In nursing school we were not required to take a statistics course, only a basic research class. Already this course has helped me read research articles with a better understanding of the study findings… understanding probabilities and odds, p-values, types of errors, confidence intervals, and how to describe data has been very beneficial thus far. I predict that the content of this course will continue to be useful as a public health professional."

Another student said,

> "As a specialist in pediatric infectious diseases, I am using information from the medical literature on a daily basis for the care of patients, as well as for the development of policies that impact patients on an institutional level. An understanding of the statistical analysis presented in an article is paramount to being able to correctly interpret the meaning of the data as well as provide critique to the authors and others who might be reading the report-- especially in instances such as this where the data are clearly being presented to help convey a particular point of view. Without an ability to interpret the statistical analysis, one is left taking the authors at their word and may miss the subtleties in how the data can be used to substantiate a particular position."

3. CONCLUSION

This paper has presented approaches for dealing with pressing issues in statistics classes in a new way utilizing existing technology. The online discussion board activities described in this paper were designed to allow for discussion in a class with students participating from around the globe, and with two additional points in mind. The first point is that of using guided discussion topics to foster discussion in classes where time is short, and making discussion possible through an online format in classes where students are not all in the same room or not all viewing class at the same time. The second point is to illustrate using an online discussion board to post and discuss article critiques which stimulates critical thinking, understanding of, and appreciation for a subject that for many is foreign and difficult.

The main challenge to implementing these activities is the time commitment required to read and respond to posts in a timely manner, but the opportunities and benefits far outweigh this challenge and use of the online discussion board need not be limited to use in purely online classes. In summary, incorporating an online discussion board into class allows all students equal opportunity to participate, gives students time to think carefully about problems, lets students interact with more students than they might in class, continues to reinforce concepts outside of class time, and lets students apply and discover things on their own. All of these give students an opportunity to provide great ideas and insight that might be missed, or not possible to contribute, in a class discussion and help to extend learning beyond the classroom experience. These

approaches can be modified or used to supplement any class, whether it is a traditional lecture style or an online class, statistics or another subject area; they are easy to employ, increase student interaction with other students as well as the instructor, help the instructor facilitate discussion, and are successful and well received by the students.

4. REFERENCES

ABCNews (2008), Available at http://abcnews.go.com/Video/playerIndex?id=4602602&affil=ketv

Aliaga, M., Cuff, C., Garfield, J., Lock, R., Utts, J. and Witmer, J. (2010), "Guidelines for Assessment and Instruction in Statistics Education (GAISE): College Report," Published by American Statistical Association.

Baker, P., Eley, D., and Lasserre, K. (2005), "Tradition and Technology: Teaching Rural Medicine Using an Internet Discussion Board," Rural and Remote Health, 5(4).

Ben-Zvi, D. (2007), "Using Wiki to Promote Collaborative Learning in Statistics Education," Technology Innovations in Statistics Education, 1(1).

Boyle, C.R (1999), "A Problem-Based Learning Approach to Teaching Biostatistics," Journal of Statistics Education, 7(1).

Brown, R. E. (2001), "The Process of Community-Building in the Distance Learning Class," Journal of Asynchronous Learning Networks, 5(2).

Cobb, G.W. and Moore, D.S., (1997), "Mathematics, Statistics, and Teaching," American Mathematical Monthly, 104, 801-823.

Cox, B. and Cox, B. (2008), "Developing Interpersonal and Group Dynamics through Asynchronous Threaded Discussions: The Use of Discussion Board in Collaborative Learning," Education, 128(4), 553-565.

DeVaney, T.A. (2010), "Anxiety and Attitude of Graduate Students in On-Campus vs. Online Statistics Courses," Journal of Statistics Education, 18(1).

DeVeaux, R. (2007), "Math is Music—Stats is Literature," [presentation] Available at http://web.williams.edu/go/math/rdeveaux/

Everson, M. (2006). Group discussion in online statistics courses. eLearn Magazine, http://www.elearnmag.org/.

Everson, M. G. and Garfield, J. (2008), "An Innovative Approach to Teaching Online Statistics Courses," Technology Innovations in Statistics Education, 2(1).

Galusha, J. M. (1998), "Barriers to Learning in Distance Education," Available at http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED416377

Garfield, J. (1995), "How Students Learn Statistics," International Statistical Review, 63(1), 25-34.

Garfield, J. and Ahlgren, A. (1988), "Difficulties in Learning Basic Concepts in Probability and Statistics: Implications for Research," Journal for Research in Mathematics Education, 19(1), 44-63.

Harman, K. and Koohang, A. (2005), "Discussion Board: A Learning Object," Interdisciplinary Journal of Knowledge and Learning Objects, 67-77.

Larsen, R. J., and Marx, M. L. (1990). Statistics: Annotated instructor's edition. Englewood Cliffs, NJ: Prentice Hall.

Levine, S.J. (2007), "The Online Discussion Board," New Directions for Adult and Continuing Education, 113.

Malone, C.J. and Bilder, C.R. (2001), "Statistics Course Web Sites: Beyond syllabus.html," Journal of Statistics Education, 9(2).

Melton, K. I. (2004), "Statistical Thinking Activities: Some Simple Exercises with Powerful Lessons," Journal of Statistics Education, 12(2).

Moore, D. S. (1997), "New Pedagogy and New Content: The Case of Statistics," International Statistical Review, 65, 123-137.

Nicholson, S.A. and Bond, N. (2003), "Collaborative Reflection and Professional Community Building: An Analysis of Preservice Teachers' Use of an Electronic Discussion Board," Journal of Technology and Teacher Education, 11(2), 259-279.

Nodder, C., Young, A., and Joyce, D. (2001), "Using an Electronic Discussion Board to Supplement Classroom Sessions with Post Graduate Teacher Education Students," Proceedings of Society for Information Technology & Teacher Education International Conference 2001, 2864-2867.

Pagano, M. and Gauvreau, K. (2000), Principles of Biostatistics, 2nd Edition, Pacific Grove, CA: Duxbury.

Rainsbusry, E. and Malcolm, P. (2003), "Extending the Classroom Boundaries—an Evaluation of an Asynchronous Discussion Board," Accounting Education, 12(1), 49-61.

Roblyer, M.D. and Ekhaml, L. (2000), "How Interactive are YOUR Distance Courses? A Rubric for Assessing Interaction in Distance Learning," Proceeding of the Distance Learning Administration Conference.

Rossman, A., Chance, B., and Medina, E. (2006), Some Important Comparisons between Statistics and Mathematics, and Why Teachers Should Care. In G.F. Burrill & P.C. Elliot (Eds.), *Thinking and reasoning with data and chance*: 2006 NCTM yearbook, (pp.323-334). Reston, VA: National Council of Teachers of Mathematics.

Rumsey, D. J. (2009), "Watching our Language when We Teach Statistics," Journal of Statistics Education, 17(1).

Scanlon, T. J., Luben, R. N., Scanlon, F. L., and Singleton, N. (1993), "Is Friday the 13th Bad for your Health?" British Medical Journal, 307(6919), 1584-1586.

Teikmanis, M. and Armstrong, J. (2001), "Teaching Pathophysiology to Diverse Students Using an Online Discussion Board," Computer Informatics Nursing, 19(2), 75-81.

Ward, B. (2004), "The Best of Both Worlds: A Hybrid Statistics Course," Journal of Statistics Education, 12 (3).

Webster, J. and Hackley, P. (1997), "Teaching Effectiveness in Technology-Mediated Distance Learning," The Academy of Management Journal, 40(6), 1282-1309.

Wickstrom, C.D. (2003), "A "Funny" Thing Happened on the Way to the Forum: A Teacher Educator Uses a Web-Based Discussion Board to Promote Reflection, Encourage Engagement, and Develop Collegiality in Preservice Teachers," Journal of Adolescent & Adult Literacy, 46(5), 414-423.

5. Appendix

Examples of Discussion Questions and Corresponding Topics

Topic	Discussion Question	Reference
Variable Summary	A philanthropic organization has a database of millions of donors that they contact by mail to raise money for different charities. The organization would like to determine which donors should be sent their current mailing. Upon inspection of previously collected data, the variable "TCODE" turned out to be highly predictive of who was likely to donate and how much. The organization has asked you to summarize the variable "TCODE" (graphically and numerically) to help them gain further insight on whom to send the mailing. The dataset is posted under the assignments tab. Investigate the variable "TCODE" and determine the best method(s) of summarization.	DeVeaux 2007
Probability	Think about sensitivity/specificity and PPV/NPV and what they measure. Which of these values do you think is most important in terms of diagnostic testing? What would false positive/false negative error rates be related to? Is it possible to have high sensitivity and specificity (a very accurate test), and have low positive or negative predictive values? Why or why not?	Pagano & Gauvreau 2000
Normal Distribution	The following letter appeared in the "Dear Abby" column in the Tennessean (Nashville) on the 20th of January in 1973. "Dear Abby, You wrote in your column that a woman is pregnant for an average of 266 days. Who said so? I carried my baby for 10 months and 5 days (approx. 310 days), and there is no doubt about it because I	Larsen & Marx 1990

	know the exact date my baby was conceived. My husband is in the Navy and it couldn't possibly have been conceived any other time because I saw him only once for an hour, and I didn't see him again until the day before the baby was born. I don't drink or run around, and there is no way this baby isn't his, so please print a retraction about the 266-day carrying time because otherwise I am in a lot of trouble. San Diego Reader" Some points for discussion: a. Assuming that the standard deviation of pregnancy length is 16 days, and the lengths follow a Normal Distribution, what do you think about San Diego Reader's claim? b. How would you advise Abby to respond? c. With what you know about the Normal Distribution, do you think it is reasonable to assume this distribution for the variable pregnancy lengths?	
Sampling Distribution	http://abcnews.go.com/Video/playerIndex?id=4602602&affil=ketv View the video news piece about food labels and comment on the statistical issues that are raised keeping in mind things we have discussed in class.	ABCNews 2008
Hypothesis Testing	Hypothesis Testing is often compared to a criminal trial, where we hear the phrase "innocent until proven guilty". The assumption of innocence can be thought of as the null hypothesis. Remember that in hypothesis testing, we assume the null hypothesis is true unless we have sufficient evidence that it is not. Likewise, in a trial, we assume the defendant is innocent unless we have sufficient evidence that he or she is not. Some points for discussion: 1. What would a type I error be using the example of a criminal trial? 2. What would a type II error be using the example of a criminal trial? 3. Which type of error would be worse to make? 4. If we reject the null hypothesis, what conclusion can be reached in terms of the trial? 5. If we fail to reject the null hypothesis, what conclusion can be reached in terms of the trial?	Pagano & Gauvreau 2000
Comparing Means	In 1993, the British Medical Journal published an article titled, "Is Friday the 13th Bad for Your Health?" Researchers in Britain examined how Friday the 13th affects human behavior. One question was whether more people were admitted to emergency rooms on Friday the 13th than on a Friday other than the 13th. They examined the number of people admitted to the emergency rooms for vehicular accidents on 12 Friday evenings (6 each on the 6th and 13th):	Scanlon et. Al, 1993

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<tr><th>Year</th><th>Month</th><th>6th</th><th>13th</th></tr>
<tr><td>1989</td><td>October</td><td>9</td><td>13</td></tr>
<tr><td>1990</td><td>July</td><td>6</td><td>12</td></tr>
<tr><td>1991</td><td>September</td><td>11</td><td>14</td></tr>
<tr><td>1991</td><td>December</td><td>11</td><td>10</td></tr>
<tr><td>1992</td><td>March</td><td>3</td><td>4</td></tr>
<tr><td>1992</td><td>November</td><td>5</td><td>12</td></tr>
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Determine which testing procedure is most appropriate to answer this question.
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<td>Comparing Proportions</td>
<td>In a study of intraobserver variability in the assessment of cervical smears, 3325 slides were screened for the presence or absence of abnormal squamous cells. Each slide was screened by a particular observer and then rescreened six months later by the same observer. The results of the study are shown below. Based on the study design, which is the correct way to display the data and why is it correct? What would be the correct way to analyze the data? For the incorrect option, why is it incorrect? How would you analyze that data and what would be the consequences?

Option 1
<table>
<tr><th rowspan="2">Abnormal Cells</th><th colspan="2">Screening</th><th rowspan="2">Total</th></tr>
<tr><th>First</th><th>Second</th></tr>
<tr><td>Present</td><td>2252</td><td>2166</td><td>4418</td></tr>
<tr><td>Absent</td><td>1073</td><td>1159</td><td>2232</td></tr>
<tr><td>Total</td><td>3325</td><td>3325</td><td>6650</td></tr>
</table>
Option 2
<table>
<tr><th rowspan="2">First Screening</th><th colspan="2">Second Screening</th><th rowspan="2">Total</th></tr>
<tr><th>Present</th><th>Absent</th></tr>
<tr><td>Present</td><td>1763</td><td>489</td><td>2252</td></tr>
<tr><td>Absent</td><td>403</td><td>670</td><td>1073</td></tr>
<tr><td>Total</td><td>2166</td><td>1159</td><td>3325</td></tr>
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<td>Pagano & Gauvreau 2000</td>
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<td>Language of Statistics (end of semester)</td>
<td>Read the article by Deb Rumsey about the language used when teaching statistics. She discusses several terms that are commonly used in introductory statistics courses that she thinks are confusing for students or make the subject more complicated than needed. Do you agree with her assessment? What words could be used in place of these? Are there other terms we have used that you find confusing? What words could be used in place of these to make things simpler?</td>
<td>Rumsey 2009</td>
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