

## Using Narrated Online Lectures

Ronald Bremer  
*Texas Tech University*

### Abstract

Software for narrating lectures and then making the lectures available online are becoming more common and easier to use. An implementation of online lectures and a study comparing the performance of students who viewed lectures online, in-class or who do not view lectures is presented. No significant difference in performance is found between students who view the material online versus those who view the lecture in-class for the early, more basic material. Significant differences are found later in the semester when more involved problems and procedures are covered.

### Introduction

Most college courses have a certain portion of the course content delivered via a lecture format. Education research has proposed many other teaching methods that if implemented would compete with in-class lecture time. Distance learning courses require the presentation of material to students and many professors are familiar and comfortable with a lecture format and are reluctant to change to methods they are not familiar with or that are difficult to implement online. Colleges with limited resources are forced to offer a small number of large sections for a course and find students are not happy with the class environment and limitations of these large sections. Many students are forced to balance coursework and employment and thus attending class is not always possible. The above examples are some of the motivations for having lectures or portions of the lectures available online or on a CD Rom or DVD.

Online lectures have several potential benefits. They can be used to provide additional examples and lecture material without using in-class time. Online lectures allow students to

view lecture portions they don't understand or review lecture material before exams. In course formats that use non-lecture components in-class, online lectures can be used so that course content discussion is not sacrificed. Online lectures can be made available for students who are not able to attend some classes. Clearly online lectures can be used as a component of a distance learning or hybrid class. In large section courses students can be given an option of viewing lectures online resulting in an improved environment for those who choose to view the lectures in-class.

Online lectures have been used by the author to ease problems that arose in teaching large sections of an introductory business statistics course. The course had two sections of 300-400 students each. Very limited teaching assistant help was available. By having all lectures online the author was able to teach two sections of a course but have live lectures in only one of the sections. A purely online version of the course was easy to develop once the online lectures were available. Online lectures have also been used to supplement the earlier material, which was assumed to have been covered in an undergraduate statistics course, in an MBA statistics course.

One goal of putting lectures online is to have the resulting performance of students at least as good as when the lecture is given in-class. One component of online lectures is to have lectures in a multimedia format. A study by (Hilton and Christensen, 2002) evaluated the impact of incorporating multimedia presentations into the traditional lecture format and found that performance was comparable to regular lectures. A study (Stephenson, 2001) investigated using videotaped PowerPoint presentations for presenting a statistics course to an industrial audience. No numerical evaluation of the effect was performed however. An online business statistics course was compared to an in-class section by Dutton and Dutton (2006) where some evidence

was found that the online students performed better. The online students had non-narrated PowerPoint slides corresponding to the live lectures. Other factors could not be ruled out as the source of the difference. A hybrid statistics course was compared to an in-class course by Ward (2004) where no significant difference was found. Only non-narrated PowerPoint slides were available online in addition to the other online tools.

The optimal use of class time has to be determined by an instructor for each course taught. The literature contains numerous suggestions on effective ways of presenting material in statistics classes other than by traditional lectures. The need for additional components such as projects and teams to create enthusiasm and to motivate students to learn has been promoted by Hogg, most noticeably in (Hogg, 1990, 1991). Cooperative and active learning techniques have been proposed by several authors including: (Garfield, 1993; Keller & Steinhorst, 1995; Fillebrown, 1994). It was found by Keller and Steinhorst (1995) that working in cooperative groups resulted in higher final grades. Learning activities such as the regular use of statistical packages and statistical simulations have been proposed by (Gnanadesikan et. al., 1997; Witmer, J., 1995) among others. Several authors such as (Cobb, 1991) have proposed more emphasis on examples and less on the theory and calculation details. Most recommendations contain lectures as a component of an overall strategy, but few recommend a pure lecture format. Many professors are reluctant to do away with too much lecture content thus placing a roadblock to the implementation of these other techniques. Putting the lectures dropped online so that other course components can be added in-class is an option.

There are many studies that compare online courses to in-class courses. No significant difference in performance is routinely found. The website named "The No Significant Difference Phenomenon" has been established with links to these studies

(<http://www.nosignificantdifference.org/>). Most of these studies compare the overall online course to the corresponding in-class course. Far fewer studies investigate individual components of online courses.

Some individual online components have been investigated in connection to statistics courses. In (Utts et. al., 2003) several online components were investigated, *CyberStats* in particular and no significant difference in performance was found. The inclusion of streamed demonstration animations for some topics in a statistics course was investigated by Wang (2006) and they were found to improve student performance. The inclusion of web based practice problems was investigated by Nguyen and Kulm (2005) where it was found that student performance was improved. Some form of courseware package is advisable when implementing online courses or course components. Using WebCT was investigated (Zhang, 2002) as an aid for teaching an online course but no numerical investigation of its effect was performed.

Details of an implementation of online lectures and other aspects of an introduction to business statistics course is given in the next section. A study that investigates the performance of students who viewed material in-class, online or who did not view the lecture material is summarized next. The investigation of self selection bias is summarized next, since random assignment of students into the different treatment groups was not possible. The study results are then summarized and final comments and recommendations are given.

## **AN IMPLEMENTATION OF ONLINE LECTURES**

This section summarizes an introduction to business statistics course that was developed using online lectures as a major component. The author taught two sections of 300-400 students each for five years with limited teaching assistant help. The university adopted WebCT as the

supported courseware package and this was used for the implementation. Most of the features used in this course are available in other courseware packages. The main components of the course were:

1. PowerPoint lectures. Narrated versions of the PowerPoint slides were available online. The lectures were designed as a jump-start to the learning process. Students could purchase hardcopies of the slides. Students could self select whether to view lectures in-class or online. Viewing lectures in-class or online was worth 5% of the grade. Online viewing was monitored using the tracking tool of WebCT.
2. A required textbook. This was intended to give a more in depth understanding of the topics.
3. Seven homework assignments composed of a total of over 300 multiple choice problems. A hardcopy of the problems was purchased by the students and they turned in their answers online using the quiz tool of WebCT as an electronic scantron. They received immediate feedback as to which problems they answered incorrectly. The key became available online immediately after the due date. The homework assignments were worth 20% of their grade.
4. A set of practice problems for each exam. It was encouraged that students work these problems as the first step in preparing for the exam. This allowed the student to self assess their problem areas. These problems were not mandatory and no credit was given for working the problems.
5. Three in-class midterm exams and a comprehensive in-class final exam were given. The low midterm exam grade was dropped. Exams were worth 75% of their grade. Questions on the exams had a format similar to the problems in the homework

assignments and practice problem sets. No problems from the homework or practice problems were used on the exams.

6. The Statpad add-on to Excel. For a number of problems on the homework assignment the students were required to produce the necessary output to answer the questions. Illustrations of the use of the add-on were made in the lectures. Discussion of the output from the add-on was routinely part of the lectures.
7. An announcement page, email, discussion board, chat rooms, online keys and online grades were used for communication. Students could access their complete grade history and the grade distribution for a particular grade component.
8. Help sessions led by teaching assistants were provided before each homework assignment due date and before exams. In the later years help sessions were provided only before exams since the other help sessions were very poorly attended.

The collection of multiple choice questions was developed over one school year. The multiple choice questions on the exams for the first year comprised a large proportion of the homework problems in the final homework set used in the later years. It was decided to provide hardcopies of the problems rather than have the problems online. This allowed students to work on homework without having to be online. The importance of understanding each type of homework problems was emphasized throughout the course. There was no way to prevent cheating on homework, so nothing was considered cheating with respect to homework.

The online lectures were developed over a one year period. PowerPoint was the software provided and supported by the university. Other presentation software that allows narration could also be used. The following steps were followed when constructing the online lectures.

1. Construction and fine tuning of PowerPoint slides for all lectures. This was accomplished over two semesters. Roughly 25% of the final slides were composed of those provided with the textbook. Each 1 hour 20 minute lecture was composed of 19-36 slides with most lectures having between 27-29 slides. Illustrations of the computer package were presented by using screen captures enhanced with arrows and the narration.
2. Each lecture was broken into 5-8 segments. The breakpoints for the segments were such that each segment became as close to a self contained mini lecture as possible. The segmentation served several purposes: it made the narration process easier, it made the streaming over the Internet more convenient, and it allowed students to view only certain segments at a time. The segment information was indicated in the hard copy of the slides.
3. Each lecture segment was narrated. The amount of time it took to narrate the lectures was less than twice the time it took to give the lectures in-class once. The more practiced one is with the lecture material the smoother the narration process will be. Narrating smaller segments of a lecture at a time minimized the consequences of messing up a narration.
4. The narrated PowerPoint files were published to the Web. Software tools such as Articulate Presenter, Impactica, RealPresenter, Centra or Breeze Presenter can make the streaming more efficient. In order to have the ability to track whether students viewed the lectures online the link to each lecture segment was put on a separate WebCT content page. WebCT's student tracking feature gave information on whether a student accessed the lecture segment. This allowed monitoring online attendance.

No problems were encountered the semester the online lectures were made available. The smaller number of students in-class improved the environment greatly. The students attending the in-class lectures were there because they wanted to hear the lecture material, not to get credit for attending. The semesters before the online lectures were available, attendance was required and 5% of the grade was based on attendance. Attendance in these semesters was around 65%, but a steady stream of complaints was received about students not being able to hear the lecture because of students talking. The acoustical design of the room prevented the professor from hearing the chatter.

## **A STUDY INVESTIGATING ONLINE LECTURES**

### **Study Design**

This section summarizes a study to compare student performance for students who Did Not View lectures (DNV), Viewed lectures In-Class (VIC) or Viewed lectures OnLine (VOL). The assessment is based on exam performance in an introduction to business statistics course taken during Spring semester 2002. The course is a required course for all business majors and is generally taken in the student's sophomore or junior year. Four sections of the course were offered the semester the data was collected. All sections had Tuesday and Thursday lectures. Two sections met from 8:00-9:20AM and two sections met from 9:30-10:50AM. The students did not know a study was being undertaken. Two professors taught two sections each. Each section had roughly 200 students. Performance measures are based on the three midterm exams. The 8:00 and 9:30 sections had different exams, but were written so that comparable questions could be matched. Each section had three versions of the exam with the same questions in different orders. The same course format and PowerPoint slides were used in-class for each

section of the course. These were the same slides available as narrated online lectures. All exams were taken in-class. All other components of the course (text, hardcopy of the PowerPoint slides, homework and practice problems) were identical for all sections.

All students were given the option of viewing lectures in-class or online. This selection could be made separately for each in-class lecture or online lecture segment. Students could also choose not to view the lecture material and use only the other components of the course. Five percent of the grade was based on viewing the lecture material in-class or online. The self selection of the viewing method was determined for each student for the material pertaining to each exam question. In-class attendance was taken to determine whether the material was viewed in-class. Online viewing information was obtained by using the student tracking information provided by WebCT. For each student and each midterm exam question the following steps were performed:

1. For each midterm exam question the lecture segments with content pertaining to the question was determined. The material for a question was always within a single lecture. Each in-class lecture was broken into several segments for on line viewing.
2. For each midterm exam question it was determined whether a student attended the live lecture for which the material pertaining to the question was covered.
3. For each midterm exam question it was determined whether the student viewed all the lecture segments for which the material pertaining to the question was covered.

The material covered by the first exam was basic descriptive statistics and distribution plots. The most complex calculation was that of a standard deviation. The material covered by the second exam was basic probability concepts and calculations, describing and understanding two-way tables, the binomial distribution, the normal distribution, sampling distribution, the central limit

theorem and  $\bar{X}$ , R and P quality control charts. The material covered by the third exam was statistical inference (tests of hypotheses and confidence intervals) for a one sample mean and proportions and the comparison of the mean and proportion in a two sample problem.

The variables used in the data analysis are summarized in Table 1. The response variable is whether a student answered a particular question correctly. The main treatment of interest (Viewcat) is whether the student did not view the lecture corresponding to the question, whether they viewed it in-class or viewed it online. The exam questions were categorized into three problem types: calculation, interpretation or conceptual. To aid in isolating the viewing category effect an analysis of covariance approach within a generalized linear model framework was used to compare performance (probability of getting a question correct) for the different viewing categories. The covariates used in the analysis are summarized in Table 1. To account for the correlation between repeated measures (different questions) on the same student the Alternating

**Table 1.** Description of the response, treatment and covariates.

<b>Response</b>	
P	p=1 if exam question was answered correctly, 0 otherwise.
<b>Treatment</b>	
Viewcat	Treatment factor measuring whether the lecture material pertaining to the exam question was Viewed In-Class, Viewed Online, or Did Not View.
<b>Question level covariates</b>	
Pdiff	Question difficulty measured by the proportion of students answering the question correctly. This was calculated separately for each section.
Preli	Problem reliability as measured by the point-biserial correlation coefficient between the response and the students exam grade.
Ptype	Problem type (Calculation, Interpretation or Conceptual question).
<b>Exam level covariates</b>	
Eff1	Response to the question "How many of the 48 problems in practice set one did you work?" Possible responses were: between 1-9 of the questions, between 10-18 of the questions, between 19-27 of the questions, between 28-37 of the questions, or between 38-48 of the questions. The question appeared at the end of each exam and the question and responses were slightly different due to the different number of practice problems available for the material of each exam.
Eff2	Response to the question "How much time did you spend working problems in practice set one?" Possible responses were: less than 1 hour, between 1 and 2 hours, between 2-3 hours, between 3 and 4 hours or more than 4 hours. The question appeared at the end of each exam.

Logistic Regressions (ALR) algorithm (Carey, Zeger, and Diggle,1993) as implemented in the GENMOD procedure of SAS was used to model student performance. The logistic link function was used. The probability of getting a question correct was modeled. Separate analyses were performed for each midterm exam. The relationship between the response and the covariates was first empirically determined and then the viewing treatment was added. No significant interactions between the covariates and the treatment were significant. The section information

was not included since the problem difficulty (Pdiff) and problem reliability (Preli) measures were calculated separately for each section and acted as surrogates for the section information.

The total starting enrollment for the four sections was 828 students. Only students with complete information for the variables used in the model were used in the study. In particular if the student did not answer the effort questions on a particular exam they were excluded. To insure that the viewing categories were well defined student information for a particular exam question was used only if the student fell into one of the following categories.

1. The student did not view any of the lecture segments pertaining to the question either online or in-class.
2. The student viewed all of the lecture segments pertaining to the question in-class and did not view any of the lecture segments pertaining to the question online.
3. The student viewed all of the lecture segments pertaining to the question online and did not view any of the lecture segments pertaining to the question in-class.

One concern when self selection is used is that adequate sample sizes are present in each treatment level. The five number summary for the sample size distribution for the different viewing categories over the different questions on each exam are summarized in Table 2. There were roughly 653 students included (wholly or partly) in the exam 1 analysis, 607 in the exam 2 analysis and 527 in the exam 3 analysis. Table 2 indicates that adequate sample sizes are available for each viewing category for every question in the study. Also, no extreme unbalance is seen for the different viewing categories. Later in the semester an increase in the proportion of students viewing lectures online is seen with the increase coming from primarily those who viewed lectures in-class earlier in the semester.

**Table 2.** Sample Size Distribution Information for the Different Viewing Categories (DNV=Did Not View, VIC=Viewed In-Class, VOL=Viewed On Line)

	Exam1			Exam2			Exam3		
Viewed	DNV	VIC	VOL	DNV	VIC	VOL	DNV	VIC	VOL
Max	224	207	289	213	192	308	218	128	333
Q3	187	204	271	157	185	294	171	123	313
Med	184	204	265	138	183	286	156	116	255
Q1	176	193	243	130	176	258	129	106	246
Min	153	182	223	116	154	232	83	75	215

## Study Results

The proportion of correct responses for all questions and students for the different viewing categories and problem types are summarized in Table 3. For exams 1 and 2 there are no big differences in the proportion of questions answered correctly for those who viewed the material in-class versus those who viewed the material online. Larger differences are observed between these two categories for exam 3. Lower proportions (3 to 8 percent lower) of problems are answered correctly by students that Did Not View the lecture material versus those that Viewed In-Class and Viewed Online. This is true for all problem types and exams.

The results for the comparison of performance for the different viewing categories, using the general linear model for exam performance, are summarized in Table 4. Also given are the effect estimate (converted to be the difference in the estimated probabilities) and p-values for the pair wise comparisons. Significant

**Table 3:** Proportion of correct responses for each exam for the different viewing categories and problem types. (DNV=Did Not View, VIC=Viewed In-Class, VOL=Viewed On Line)

Problem Type	Exam1			Exam2			Exam3		
	DNV	VIC	VOL	DNV	VIC	VOL	DNV	VIC	VOL
Calculation	63.45	71.42	70.77	50.62	53.88	53.78	47.92	59.47	49.02
Interpretation	64.62	73.21	71.65	*	*	*	46.94	53.83	46.09
Conceptual	54.10	63.04	64.89	53.21	65.42	56.09	35.58	43.72	40.44
All Problems	62.83	71.22	70.56	51.30	55.57	54.39	45.69	54.35	46.03

\*There were no interpretation questions on exam 2.

**Table 4.** P-Values for Main Effect Test and Effect Estimates and P-Values for the Pair Wise Comparisons.

Viewcat Main Effect	P-value	Exam 1	Exam2	Exam3
Viewed In-Class - Viewed Online	Est	0.0098	-0.0192	0.1475
	P-value	0.8790	0.6953	0.0179
Viewed In-Class - Did Not View	Est	0.2902	0.1800	0.2420
	P-value	<0.0001	0.0005	0.0003
Viewed Online - Did Not View	Est	0.2804	0.1992	0.0944
	P-value	<0.0001	<0.0001	0.1013

differences in performance are detected for the different viewing categories on each exam. For the main comparison (Viewed In-Class versus Viewed Online) there is no significance difference in performance for exam 1 and exam 2 but there is a significant difference for exam 3. For the more involved problems associated with tests of hypotheses of exam 3, the students who viewed the live lectures did significantly better than those who viewed the lectures online.

Interactions between the treatment and the covariates terms were investigated, but no significant interactions were found. In particular the viewing category treatment did not interact with the problem type. This implies that the relationship in performance for the different viewing categories is not significantly different for the different problems types. This result was consistent for each exam.

The results indicate that online lectures can be as affective as in-class lectures. This is not guaranteed, however. In particular the study suggests that special care must be taken with more involved topics and procedures. This has special significance to using online lectures for advanced technical courses. More time and attention to the online lecture construction for more advanced topics may be needed to get equivalent results to in-class lectures. In addition additional online materials and methods may be added to help guarantee students are picking up these more involved topics. Ways for students to obtain more timely feedback to questions pertaining to more complex material could to be incorporated into the online course design.

### **Self Selection Bias**

Random assignment of students to particular viewing categories was not possible in the environment available. Thus, self selection bias is a possible problem when comparing the performance for the different viewing categories. The main source of the self selection bias to be investigated is a differential in effort between students in the different viewing categories. Little self selection bias should be present when comparing the Viewed Online group to the Viewed In-Class group, since both groups represent a complete viewing of the material for the question. Thus, neither group represents more or less effort. When comparing the Viewed Online group or the Viewed In-Class group to the Did Not View group, more self selection bias seems reasonable. This is supported by a study (Francis, 2002) in which groups of students who self selected to work independently was compared to those who self selected to attend class. The classification of a student was made once for the overall course. It was admitted that many students used a mixed strategy. A significant difference was found in performance, but closer

investigation found other factors related to the self selection likely contributed to the difference. Three methods to investigate the self selection bias are summarized below.

A first look at the self selection bias was made by performing Chi-square tests of independence for the two-way tables of counts created from the viewing category versus the self reported effort measures (Eff1 and Eff2 as defined in Table 1). The test was performed for each question on an exam separately. The effort measures used for an exam question were the effort measures on that particular exam and were the same for each question on the exam. Significance would indicate a differential amount of effort for students in the different viewing categories. If the overall chi-square test was significant when using all three levels of the viewing category the test was repeated for the pair wise levels of the viewing category. The number of questions for which the viewing category was significantly related to the effort measure is summarized in Table 5. Little evidence of self selection bias is found when comparing the Viewed In-Class to the Viewed Online categories. Some evidence of self selection bias is detected when comparing the Did Not View category to either the Viewed In-Class to the Viewed Online categories, especially when using Eff1.

**Table 5.** Number of Questions with a Significant Chi-Square Test/Number of Questions: An Investigation of Self Selection Bias

	Exam1		Exam2		Exam3	
	Eff1	Eff2	Eff1	Eff2	Eff1	Eff2
Overall	1/20	0/20	24/25	6/25	13/27	0/27
Viewed In-Class vs. Viewed Online	NA*	NA*	0/25	0/25	5/27	0/27
Did Not View vs. Viewed In-Class	NA*	NA*	24/25	6/25	20/27	0/27
Did Not View vs. Viewed Online	NA*	NA*	23/25	6/25	5/27	0/27

\*Cell counts where not large enough in each cell to perform a Chi-Square test.

The second method for investigating self selection bias was to consider questions on exams 1 and 3 for which the material pertaining to the questions were not covered in-class. For exam 1 there were two lectures and for exam 3 there was one lecture which was online with no in-class equivalent. On exam 1 there were 10 questions with online content but no in-class content and on exam 3 there were 4 such questions. If a student was in a particular viewing category for 16 or more of the 20 questions on exam 1 (20 of the 26 questions on exam 3) the student was considered in that category for this analysis. To assess the self selection bias when comparing the Viewed In-Class group to the Viewed Online group, the performance of those students who were generally classified as Viewed In-Class but viewed online the lecture not available in-class was compared to those generally classified as Viewed Online. This comparison of performance was made only on the questions for which no in-class lecture was available using the general linear model equivalent to that of the main analysis. To assess the self selection bias for the comparison of the Viewed In-Class group to the Did Not View group, the performance of those students who are generally classified as Viewed In-Class but did not view the lecture material not available in-class will be compared to those generally classified as Did Not View. The results of these tests are summarized in Table 6 and they are consistent with the first method. No evidence of a difference between Viewed In-Class group and the Viewed Online group is detected. A significant difference is seen between the Did not View group and the Viewed In-Class group is seen for exam 1.

**Table 6.** P-Values for Self Selection Bias Test Based on Questions With No In-Class Lectures in the General Linear Model.

	Exam 1	Exam2
Viewed In-Class vs. Viewed Online	0.5924	0.6054
Did Not View vs. Viewed In-Class	0.0008	0.2789

Little evidence of self selection bias is seen for the comparison of the Viewed In-Class group to the Viewed Online group; the main comparison of the study. This result is consistent for all three exams and both methods. When comparing the Did Not View group to either the Viewed In-Class group or to the Viewed Online group some evidence of self selection bias is seen. The evidence for self selection bias is strongest when comparing the Did Not View group to the Viewed In-Class group. These comparisons are of only secondary interest to this study, so no attempt will be made to correct for the bias. The self selection bias when comparing those who viewed lectures in-class or online to those who did not view the lectures will tend to increase the significance for these comparisons.

## **SUMMARY AND CONCLUSIONS**

Lectures are a fundamental component of most college courses. Courses offered in a distance learning format are no exception. Other teaching methods are competing for class time traditionally used for lectures. Putting the lectures online is an option under these and other situations. One option for online lectures is a narrated lecture as similar to an in-class lecture as possible. Placing narrated lectures online is becoming easier every year.

A fundamental question is “Does the performances of students suffer if lectures are viewed online versus live in-class?” A study is presented in which all components of the in-class and online courses are identical except the online course has narrated PowerPoint slides online while the in-class lectures cover the same PowerPoint slides live. The results support the conclusion that student performance is not significantly different for students who viewed course material in-class and those who viewed the material online. The exception to this result was for

the most involved technical material. For this material there is significant evidence that the students who viewed the material in-class performed better than those who viewed it online.

The results of this study supports using narrated online lectures in distance learning courses with the resulting student performance comparable to the same course with live lectures. If class time is used for teaching methods other than lectures and a narrated lecture is put online the positive benefit of the lecture need not be lost. The positive impact of the active learning components and the lecture can be realized. As the material becomes more involved more care needs to be taken in constructing the online lecture and/or additional learning components need to be considered so that student performance matches that of a corresponding in-class experience.

## REFERENCES

- Carey, V., Zeger, S.L., and Diggle, P. (1993). Modeling Multivariate Binary Data with Alternating Logistic Regressions. **Biometrika**, 80: 517-526.
- Cobb, G. W. (1991). Teaching Statistics: More Data, Less Lecturing. **AmStat News**, 182: 1-4.
- Dutton, J. and Dutton, M. (2006). Characteristics and Performance of Students in an Online Section of Business Statistics. **Journal of Statistics Education**, 13(3). Retrieved September 18, 2006, from <http://www.amstat.org/publications/jse/v13n3 /dutton.html>
- Fillebrown, S. (1994). Using Projects in an Elementary Statistics Course for Non-Science Majors," **Journal of Statistics Education**, 2(2). Retrieved September 18, 2006, from <http://www.amstat.org/publications/jse/v2n2 /fillebrown.html>
- Francis G. (2002). Choosing to study independently – When is it a bad idea? In B. Phillips (Ed.), **Proceedings of the 6th International Conference on Teaching Statistics**, Voorborg, The Netherlands: International Statistics Institute.
- Garfield, J. (1993). Teaching statistics using small-group cooperative learning. **Journal of Statistics Education**, 1(1). Retrieved September 18, 2006, from <http://www.amstat.org/publications/jse/v1n1 /garfield.html>

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

Gnanadesikan M., Scheaffer R. L., Watkins A. E., and Witmer J. A. (1997). An Activity-Based Statistics Course. **Journal of Statistics Education**, 5(2). Retrieved September 18, 2006, from <http://www.amstat.org/publications/jse/v5n2/gnanadesikan.html>

Hilton, S. C., and Christensen, H. B. (2002). Evaluating the Impact of Multimedia Lectures on Student Learning and Attitudes. **Proceedings of the Sixth International Conference on Teaching Statistics**, ed. B. Phillips, Voorburg, The Netherlands: International Statistical Institute.

Hogg, R. V. (1990). Statisticians gather to discuss statistics education. **American Mathematics and Statistics News**, 169: 19-20.

Hogg, R. V. (1991). Statistical education: Improvements are badly needed. **The American Statistician**. 45: 342-343.

Keeler C. M. and Steinhorst R. K. (1995). Using Small Groups to Promote Active Learning in the Introductory Statistics Course: A Report from the Field. **Journal of Statistics Education**, 3(2). Retrieved September 18, 2006, from <http://www.amstat.org/publications/jse/v3n2/keeler.html>

Nguyen, D.M. and Kulm, G. (2005). Using Web-based Practice to Enhance Mathematics Learning and Achievement. **Journal of Interactive and Online Learning**, 3(3). Retrieved September 20, 2006, from <http://www.ncolr.org/jiol/issues/pdf/3.3.1.pdf>

Stephenson, W. R. (2001). Statistics at a Distance. **Journal of Statistics Education** , 9(3). Retrieved September 18, 2006, from ([www.amstat.org/publications/jse/v9n3/stephenson.html](http://www.amstat.org/publications/jse/v9n3/stephenson.html))

Utts, J., Sommer, B., Acredolo, C., Maher, M. W., and Matthews, H. R. (2003). A Study Comparing Traditional and Hybrid Internet-Based Instruction in Introductory Statistics Classes. **Journal of Statistics Education** 11(3). Retrieved September 18, 2006, from ([www.amstat.org/publications/jse/v11n3/utts.html](http://www.amstat.org/publications/jse/v11n3/utts.html) )

Wang, S.K. (2006). Learning Hands-on Skills in an Online Environment: The Effectiveness of Streaming Demonstration Animation. **Journal of Interactive Online Learning**. 5(1). Retrieved September 20, 2006, from <http://www.ncolr.org/jiol/issues/pdf/5.1.1.pdf>

Ward, B. (2004). The Best of Both Worlds: A Hybrid Statistics Course. **Journal of Statistics Education**, 12(3). Retrieved September 18, 2006, from <http://www.amstat.org/publications/jse/v12n3/ward.html>

Witmer, J. (1998). Using activities in Stats 101. In Lionel Pereira-Mendoza, Kea, L.S., Kee, T.W. & Wong, W.K. (Eds.), **Proceedings of the Fifth International Conference on Teaching Statistics**, 139-144. Singapore: International Statistical Institute.

Zhang, J. (2002). Teaching Statistics On-Line: Our Experiences and Thoughts. **Proceedings of the Sixth International Conference on Teaching Statistics**, ed. B. Phillips, Voorburg, The Netherlands: International Statistical Institute.