AC 2010-895: USING HISTORY TO REINFORCE ETHICS AND EQUILIBRIUM

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Using History to Reinforce Ethics and Equilibrium

Abstract

The American Society of Civil Engineers in the 2nd edition of the "Body of Knowledge" (BOK2) document identify the level of achievement for outcome 11 (Contemporary Issues and Historical Perspectives) as:

> *Analyze the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and analyze the impact of engineering solutions on the economy, environment, political landscape, and society.*

This is not an outcome that is readily achieved in most civil engineering undergraduate classes when taught in their traditional format. To address this, the author decided to introduce a segment into each offering of two different classes, the classes being statics and bridge engineering. The statics class is taught twice a week over a semester (15 weeks) and the bridge engineering class is taught one evening a week, again over a semester.

In both classes a segment was introduced entitled "Bridge of the Day" comprising a brief presentation (albeit somewhat more detailed in the bridge engineering class) on a famous bridge. In the bridge engineering class, a second presentation was also given entitled "Bridge Failure of the Day" in which a bridge failure (which was not always a bridge collapse) was discussed.

This paper explores the value of these segments both at addressing outcome 11 of the BOK2 and at improving students understanding of the mechanics involved in the two classes.

Introduction

There has been a clear understanding developing over the past decade and longer that the methods of teaching engineering need to change[1]. One aspect of this has been the changes in the accreditation requirements of ABET[2]. Additionally, the American Society of Civil Engineers (ASCE) has developed a number of documents describing the body of knowledge that a civil engineer needs in order to be able to practice civil engineering effectively. Most recently, in the 2nd edition of the "Body of Knowledge" (BOK2)[3] the required knowledge has been expressed, in part, as a number of outcomes that must be satisfied by students upon their graduation. These outcomes are expressed in terms of Bloom's Taxonomy[4] and also identify the level of achievement required. For outcome 11 (Contemporary Issues and Historical Perspectives) this required achievement is expressed as:

> *Analyze the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and analyze the impact of*

engineering solutions on the economy, environment, political landscape, and society.

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The purpose of this paper is to examine the extent to which these segments helped students achieve outcome 11 of the BOK2. Further, the paper explores how much the segments assisted students in learning the course material in general.

Statics Class

Statics is a required course for all engineering majors at the University of Iowa, and is typically taken in their second year of study (although students in electrical engineering often delay taking the class until late in their degree). The course has two 50 minute lectures each week and one 50 minute discussion or recitation session each week. The author teaches the course in the spring semester, and typical enrolments are in the range of 40 to 70 students although enrolment for Spring 2010 is currently over 100 students.

In 2007 the author introduced the Bridge of the Day presentation for about half the classes in the semester, and conducted a survey at the end of the semester to see whether students felt that this presentation and various other visual aids had helped their learning. Results are presented fully below, but in general students were supportive, and so the number of presentations has been increased significantly. Table 1 lists the bridges used in these presentations.

The general format of each presentation was one single photograph of the bridge. The instructor showed the bridge at the start of each class, told students a few facts about the bridge (where it was located, when it was built, why it is or was significant, and so forth) and then entertained questions. In most cases, there were not any questions. The whole presentation lasted no more than three minutes, which is critical in a class such as statics in which time is very precious.

Table 1 shows the bridges that were and are currently being used in the bridge of the day presentations for statics. Many of them are historical bridges rather than modern (e.g. constructed over the past 100 years) but this reflects the author's own interests rather than

any special desire to meet outcome 11 of BOK2 (which had not been written when these presentations were first introduced in 2007).

Table 1: Bridges used in Statics Class for Bridge of the Day Presentations

Ironbridge, Shropshire, England	Tarr Steps, Somerset, England
Pont Neuf, Paris, France	Roman Alpine Bridge, Verazsco Valley, Switzerland
Menai Straits Bridge, Anglesey, Wales	Pons Fabricius, Rome, Italy
Forth Rail Bridge, Edinburgh, Scotland	Sunshine Skyway Bridge, Tampa Bay, Florida
Forth Road Bridge, Edinburgh, Scotland	Viaduc de Millau, Millau, France
Swan Bridge, Hokkaido, Japan	Erasmusbrug, Rotterdam, Netherlands
Novy Most, Bratislava, Slovakia	Great Seto Bridge, Honshu-Shikoku, Japan
Humber River Pedestrian and Cyclist Bridge, Toronto, Canada	Ponte Coperto, Pavia, Italy
Meiko Nishi Ohashi Bridge, Nagoya, Japan	Millennium Bridge, London, England
Mackinac Bridge, Straits of Mackinac, Michigan	Various movable bridges in Chicago, Illinois
Normandy Bridge, Honfleur, France	

Toward the end of the semester in Spring 2007 and in-class survey was conducted, which asked the students to respond to six statements using a five point Likert scale[5]. The statements together with student responses are shown in table 2. Thirty six students completed the survey out of a final enrolment of 44 students.

The results of the survey would appear to indicate that students valued the bridge of the day presentations, along with various other multi-media aids, and felt that these aids assisted their learning. However, a survey of student feelings is not definitive with regard to their learning.

Perhaps the most that can be said on the basis of these survey results is that the bridge of the day presentations (and other multi-media aids) were:

conducive to a friendly atmosphere more than anything

as one student noted on their survey forms. Clearly, some more rigorous form of testing is required to have any degree of confidence that students have attained the level required in outcome 11. As discussed further below, work is ongoing on what this might be, but for now it seems that the bridge of the day presentations in statics lay a foundation for student understanding of the historical and contemporary issues surrounding bridges, at the least. A question not addressed herein but nonetheless significant, is whether such understanding is best achieved by including short presentations into existing classes or by dedicating courses to achieving this understanding. The former risks short-changing the level of student understanding, while the latter strains an already full curriculum.

Table 2: Student Responses in Statics Class, Spring 2007

Statement	**Strongly agree**	**Somewhat agree**	**Neither agree nor disagree**	**Somewhat disagree**	**Strongly disagree**
The "bridge of the day" presentations helped me understand statics in a broader context	19	14	3	0	0
The Wacky Fun Noodle helped me concentrate in class	19	12	5	0	0
The daily music selections helped me prepare for class	25	8	3	0	0
The demonstration of the method of sections with the K'Nex truss and the hatchet helped me understand the method of sections	23	11	2	0	0
The tools that we examined in the machines and frames part of the course helped me understand their analysis	25	1	0	0	0
The cardboard "fridge" in the friction section of the class helped with my understanding of friction	21	14	0	0	0

Bridge Engineering

In fall semester 2009 a new course entitled Bridge Engineering was introduced into the civil engineering curriculum as an elective for both senior undergraduates and for graduate students. The course goals were given as:

At the end of this course, students should be able to:

- *describe and contrast the different types and purposes of bridges*
- *list and describe the components of typical bridges*
- *discuss the factors that contribute to bridge aesthetics and evaluate the role of aesthetics in bridge design*

- *explain the different types of load that must be considered in bridge design*
- *analyze bridge loading using influence lines and other appropriate techniques, and*
- *develop, recommend, and evaluate designs for steel bridges.*

The course was taught one evening each week (Monday) for two and a half hours. The single class period provides significant benefits for doing design studies, as it allows a lot of material to be covered in one sitting, but there is no doubt that student attentiveness (and instructor energy) can lag if preventative steps are not taken. To help with attentiveness, it was decided to break the class period into three parts, with presentations separating the three parts. At the end of the first part of the class, a "Bridge of the day" presentation was given, while at the end of the second part of the class, a "Bridge failure of the day" presentation was given. Table 3 lists these bridges.

Table 3: Bridge of the Day and Bridge Failure of the Day Presentations for the Bridge Engineering Class

Bridge of the Day	Bridge Failure of the Day
Viaduc de Millau, Millau, France	Tacoma Narrows Bridge, Tacoma, Washington
Millennium Bridge, London, England	Millennium Bridge, London, England
Tower Bridge, London, England	I-35 W Bridge, Minneapolis, Minnesota
Erasmusbrug, Rotterdam, Netherlands	Dee River Bridge, Chester, England
Langkawi Bridge, Langkawi National Park, Malaysia	Broughton Suspension Bridge, Greater Manchester, England
Brooklyn Bridge, Brooklyn, New York	Tay River Bridge, Dundee, Scotland
Menai Straits Bridge, Anglesey, Wales	Yarra Bridge, Melbourne, Australia
Golden Gate Bridge, San Francisco, California	Angers Bridge, Angers, France
Mackinac Bridge, Straits of Mackinac, Michigan	Silver Bridge, Kanauga, Ohio
Meiko Nishi Ohashi Bridge, Nagoya, Japan	Quebec Bridge, Quebec City, Canada
Normandy Bridge, Honfleur, France	Oakland Bay Bridge (2009), Oakland, California
Ponte Coperto, Pavia, Italy	Various Bridges due to flooding in Cumbria, England.

The bridge of the day presentation used many of the same bridges as for the statics class, but went into considerably more detail for each bridge. Thus, instead of a single photograph, a brief PowerPoint presentation of five to seven slides was given (and subsequently made available to students on the course web site, which is password protected). There was one exception to this format for the Millau Viaduct. In this case,

not only were slides shown but a video taken by the author of driving across the bridge was also shown.

In one case, the same bridge served as the bridge of the day and the bridge failure of the day (the Millennium Bridge, London, England) which served to make the point that while bridges often fail by collapsing, they may also fail in other ways (in the case of the Millennium Bridge, the failure was too much vibration).

The bridge failure of the day presentation would almost always include a discussion about the ethics of the situation that resulted in the failure. The goal here was to help students understand that their actions as professional engineers would have consequences. An additional purpose of the presentations was to make students think about the fact that failures could still happen even today. The intent at the start of the semester was to use the I-35 W failure to stress this most heavily, and this was done, but the issue was underlined by events during the semester, and the class was able to discuss the failure of an eye-bar on the Oakland Bay Bridge on October 27, 2009, and the extensive flooding of a number of bridges in Cumbria on November 21, 2009 which resulted in the collapse of one bridge and serious damage to at least one more bridge.

Discussions for these presentations were by design both longer and more lively than in the statics class. There were many questions, and much discussion not only about ethics, but also about aesthetics, and in one case (the Tay Bridge) about truly awful poetry[a] written about the disaster by William McGonagall[6].

As for the statics class, feedback was sought from the students by way of an in-class survey, again using a five point Likert scale. The statements in the survey and the student responses are shown in Table 4. Thirty two students completed the survey (out of a total of 38 students enrolled). In the survey form the abbreviations BOD and BFOD were used for bridge of the day and bridge failure of the day respectively.

On the basis of the results of the survey, the one area where there is not strong agreement with the statements is on the final topic, the degree to which understanding of mechanical behavior of bridges was improved by the bridge failure of the day presentations. This is perhaps not surprising, given that many bridge failures are rather complex and as such not easily explained or understood. Further, the goal of the presentations (which were intended to last about 5 to 10 minutes) was to present information about the failure rather than to conduct an in-depth analysis of the failure.

As with the findings in the statics class, the issue remains that student surveys are imperfect means of measuring student learning. In particular, for students to say that their ethical understanding has been enhanced by a facet of a given course is relatively easy when they are surveyed in that course. The context almost "gives away" the desired response. With this in mind, the author is currently exploring with the department the

[a] McGonagall's Poem, the Tay Bridge Disaster, begins "Beautiful Railway Bridge of the Silv'ry Tay! Alas! I am very sorry to say That ninety lives have been taken away On the last Sabbath day of 1879, Which will be remembered for a very long time." and goes rapidly and inexorably downhill from there.

possibility of including some open ended questions in a survey taken by graduating seniors, to see whether the ethics learned in the bridge engineering class get carried forward and remembered outside the context of that class. If so, that would give much more strength to the idea that the bridge failure of the day presentations helped enhance students ethical understanding. Of course, it would still be a survey of student feelings or opinions, and thus less than compelling. Nonetheless, it would be a suitable first step toward measuring student achievement with respect to outcome 11.

Otherwise, based on the survey it is clear that students enjoyed the two presentations each class. The instructor did also, not least as a change of pace in a long class period.

Table 4: Student Responses in Bridge Engineering Class, Fall 2009

Statement	**Strongly agree**	**Somewhat agree**	**Neither agree nor disagree**	**Somewhat disagree**	**Strongly disagree**
The BOD improved my understanding of how engineering solutions impact society.	20	11	1	0	0
The BOD improved my understanding of the role of civil engineering in history.	20	8	4	0	0
The BOD enhanced my appreciation for aesthetic bridge designs.	23	8	1	0	0
The BFOD improved my understanding of the ethical responsibility of design engineers.	26	6	0	0	0
The BFOD helped me see how bridge design has developed in response to bridge failures.	24	7	1	0	0
The BFOD improved my understanding of the mechanical behavior of bridges	12	15	4	1	0

Conclusions

In two classes, presentations relating to bridges (the "bridge of the day" and the "bridge failure of the day" have been used to enhance student learning, in particular with regard to outcome 11 of the ASCE BOK2. Based on student survey it would appear that students feel the presentations have enhanced their learning in a number of ways. However, more rigorous measurement of student learning will be required in the future. Nonetheless, the results suggest that presentations of this sort would be of value in helping students achieve outcome 11.

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