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Enhancing Learning Effectiveness by Implementing Screencasts into Civil Engineering Classroom with Deaf Students

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Abstract

This paper presents a teaching innovation of implementing screencasts into Civil Engineering classroom instruction to improve learning effectiveness of students including those with hearing disabilities. Screencasts are screen captures of learning materials broken into detailed steps with narration and synchronized captions by an instructor. With screencasts, students are able to follow the instructor's elaboration of the problem step by step to understand the underlying principles. Our screencasts approach is targeted at upper level technical courses in Civil Engineering, and is uniquely focused on inclusive Civil Engineering classroom with deaf students. A bank of thirty eight screencasts was developed in 2012 and has been applied to supplement a Civil Engineering undergraduate core course: Structural Analysis. The screencasts are posted on the instructor's teaching website open to all the students and interpreters participating in this course. The final calculated grades of the hearing students and the deaf students were collected for five consecutive academic years from 2011 to 2015. The grades of the hearing students and the deaf students were analyzed and compared before and after the screencasts being applied. Another comparable Civil Engineering course without screencasts: Elementary Structures was selected as a benchmark to study the effects of screencasts on students' learning. Surveys were performed to gather students' feedback about their experience in using screencasts. The research results show that implementing screencasts to supplement traditional Civil Engineering lectures enhances both deaf and hearing students' learning effectiveness.

Key words: screencast, civil engineering, learning effectiveness, deaf

Introduction

Students in Science, Technology, Engineering and Math (STEM) should leave the class with a functional understanding of the course material. Current research suggests that replacing the

traditional lecture-type instruction with interactive technological tools may enhance students' learning environment. Screencasts are one of the new forms of computer-aided instruction to make their way into the classroom [6, 7, 10]. Screencasts are screen captures of learning materials broken into steps with narration and synchronized captions by an instructor as shown in Figure 1. Screencasts have been used in general college courses such as mathematics, physics and chemistry for several years and have been proved to be valid in improving learning effectiveness [6, 7, 10, 12]. In these fundamental courses, screencasts are usually combined with clicker use or are applied as a flipped classroom approach [1, 4, 5, 6]. Our screencasts approach is targeted at upper level technical courses in Civil Engineering, and is uniquely focused on inclusive Civil Engineering classroom with deaf students. Instead of using the screencasts as a flipped classroom pedagogy, we implement them as additional learning materials to supplement traditional lectures. Most students use the screencasts depending on their academic needs after they learn the materials in the classroom.

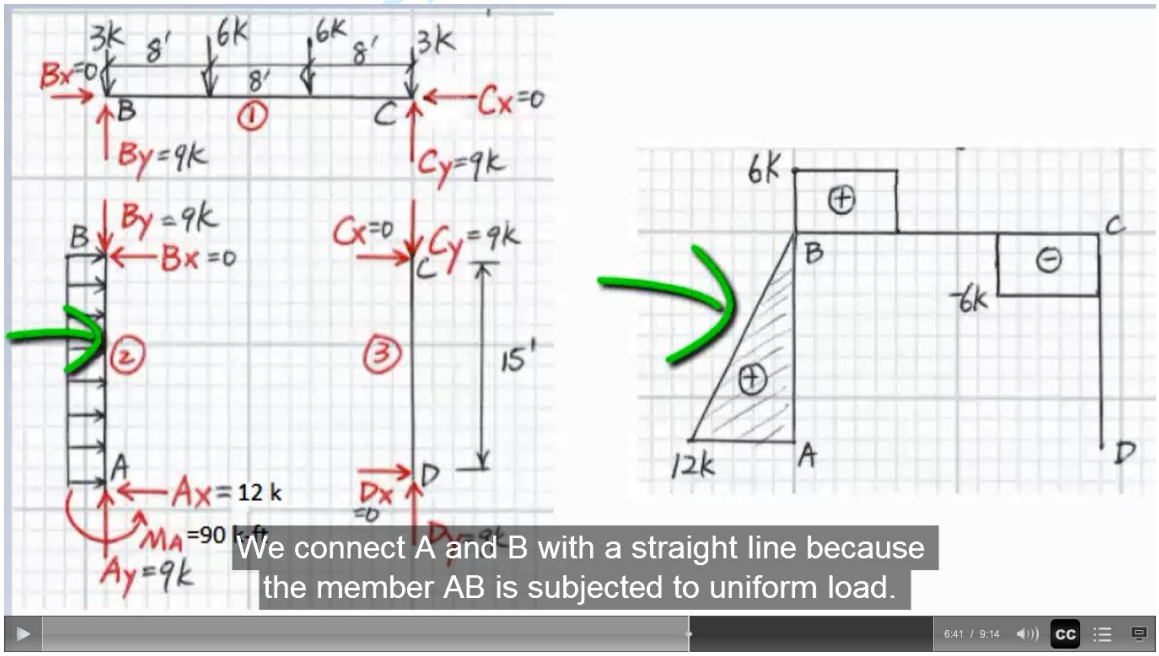

Figure 1: Sample Screencast

Under the environment of traditional classroom instruction, deaf and hard-of-hearing students face significant barriers to access and inclusion in STEM education [2, 3]. The percentage of students with hearing impairment pursuing post-secondary and advanced degrees in STEM decreases longitudinally as shown in Figure 2. Therefore, there remains a pressing need for resources to ensure that STEM instruction is accessible and inclusive to deaf and hard-of-hearing students.

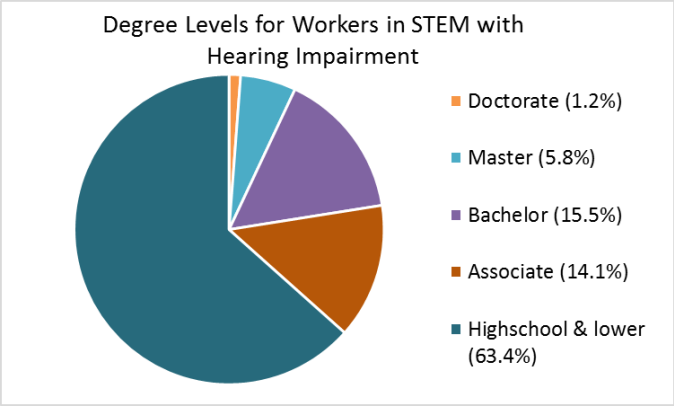

Figure 2: Percentage of STEM Students with Hearing Impairment

Research shows that deaf and hard-of-hearing students have difficulty learning in traditional lecture-based courses and need augmenting the lectures by visual aids, lecture notes or other materials [8]. The National Technical Institute for the Deaf (NTID) at Rochester Institute of Technology (RIT) is one of the world's largest technological colleges for students who are deaf or hard-of-hearing. A variety of communication strategies in teaching, including printed/visual aids and web-based instructional materials have been used to enhance deaf students' learning at RIT. The traditional teaching strategies include synchronized sign language interpretation, hearing aids, class note takers and captioning. The students from NTID take technical core courses and technical elective courses together with hearing students in engineering and engineering technology programs at RIT. Sign language interpreters are assigned to each class having deaf students.

Most civil engineering students consider courses in the structural engineering discipline challenging because these courses usually contain complex mathematics and mechanics. In our classroom practice, new interactive learning materials-screencasts were prepared to supplement the traditional lectures, allowing students to watch at their own pace. The screencasts include detailed solutions to example problems and instructions of how to use a piece of software. With screencasts, students will be able to follow the instructor's explanation and also read captions broken down each step of the problem in order to understand the problem in greater depth and how the problem relates to the underlying concepts [6, 7, 13, 14]. We notice that students usually show a wide spectrum regarding their learning pace in the same class. With screencasts, students can control the pace of the videos based on their own needs. For example, students may try doing the problem themselves before they start watching the screencast, if they get stuck by one step of the problem, they can repeat it over and over until they fully understand, and they can skip the steps when they feel them easy. These materials help improve teaching and learning effectiveness and focus on solving of difficult conceptual problems. The innovative use of screencasts appeals to the students of new technology generation, provides a new platform for deaf or hard-of-hearing students' and helps them master learning materials.

Methodology

The screencasts were created using Camtasia Studio and the exported video files were posted on the instructor's teaching website: http://baoteachingcet.com as shown in Figure 3. The examples selected for screencast lessons are usually the long ones which take a great amount of class time and focus on key concepts and problem solving strategies. All the screencasts were made by the instructor's research team including the instructor and three research assistants. The procedure of making screencasts is: breaking each example into steps, recording the screen of each step for the required time of elaboration, recording narration, and then adding captions to the video. The typical length of each screencast example is five to ten minutes.

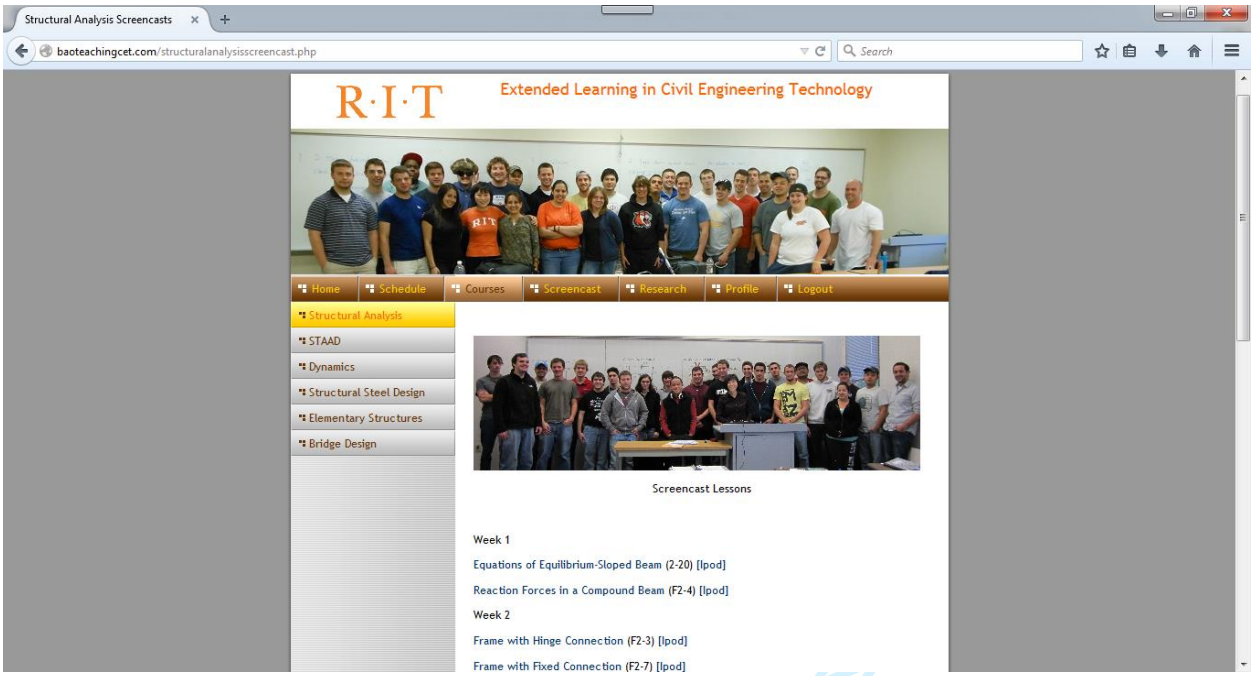

Figure 3: Screencasts posted on Instructor's Teaching Website

Deaf and hard-of-hearing students at RIT take technical core courses and technical elective courses together with hearing students in engineering programs, and sign language interpreters work with the instructor and provide synchronized interpreting in each class that deaf and hard-of-hearing students attend. The interpreters are well-trained for sign languages, but not necessarily have the background of engineering. In traditional lecture-type classroom environment, deaf and hard-of-hearing students' learning heavily relies on the accuracy of real-time interpretation of the course materials. From our classroom observations, deaf students' learning effectiveness may be improved if the interpreters have engineering background. However, our statistics show that the average grades of deaf and hard-of-hearing students have been consistently lower than their peers in the same class in the traditional lecture-type courses. In addition to the accuracy of interpretation, the time lag between the instructor and the interpreter also contributes to deaf students' learning difficulties. Interpreters need time to

understand the materials that the instructor delivers and then translate them into sign languages, and therefore, the information that deaf students receive is usually behind what the instructor shows on the writing board and/or on the slides. In order to improve students' learning experience, screencasts with narration and synchronized captions have been developed to supplement the regularly scheduled lectures for a Civil Engineering core course CVET-332: Structural Analysis since 2012.

The screencasts emphasize the most important concepts in the course, illustrate how to solve complex problems in steps, address extended applications, transform ideas in new contexts, and provide tutorials of finite element analysis software. The screencasts are classified into two categories: hand-calculation examples and computer software instruction examples. Figure 1 shows an example of hand calculations and Figure 4 shows an example of software instruction. Each screencast is about five to ten minutes long. These materials help foster a teaching/learning strategy that focuses on interactive solving of difficult conceptual problems.

The data collected to assess the effectiveness of screencasts include the students' overall course grades, students' course success rate quantified by the number of students getting the final grade "C" or above and students' evaluation of instruction.

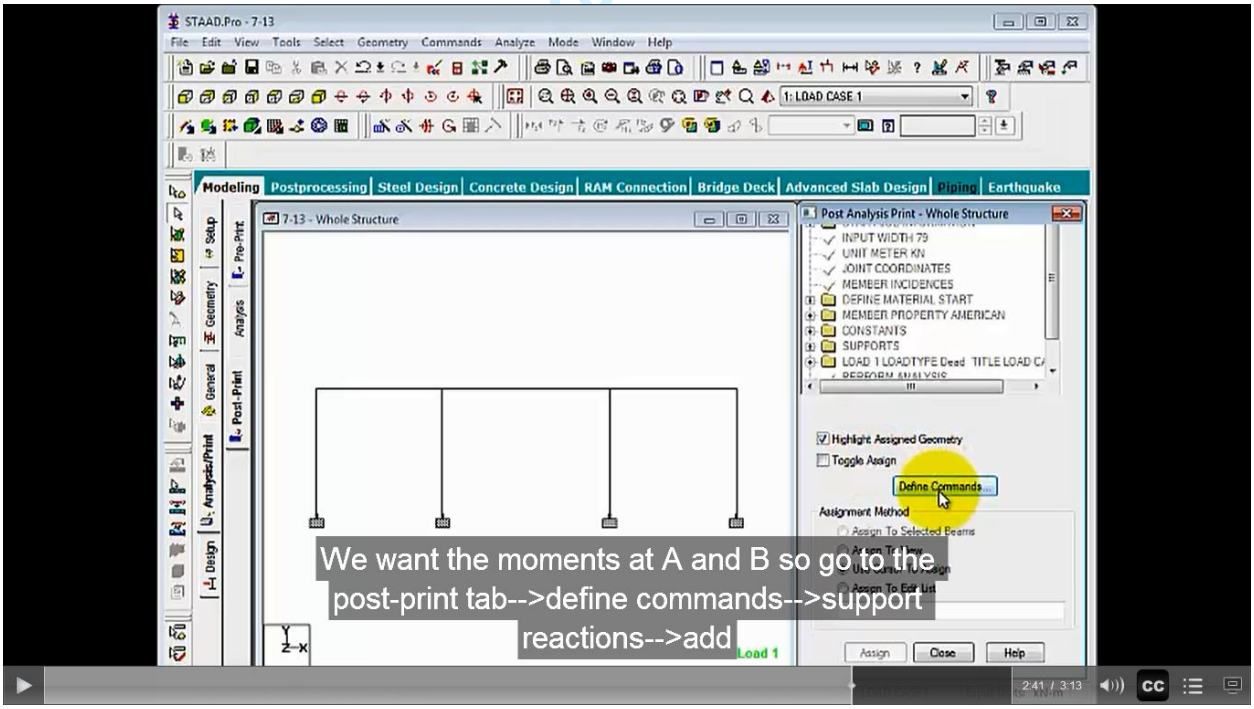

Figure 4: Sample Screencast for Software Instruction

In order to show the effect of screencasts on students' learning, the course CVET-230 Elementary Structures are used to compare to CVET-332 Structural Analysis. The reasons why the course CVET-230 was chosen as the counterpart of CVET-332 are as follows:

1) Both courses are required course and the students who took both courses were the same students.
2) The same instructor taught both courses from 2011 to 2015.
3) Both courses are structural engineering courses sharing the common features in terms of fundamentals of mechanics and calculation.
4) CVET-230 Elementary Structures is the pre-requisite for CVET-332 Structural Analysis.
5) CVET-230 is offered in the spring semester and CVET-332 is offered in the fall semester in the same calendar year.
6) CVET-230 was taught by using the traditional lecture-type instruction and no screencasts were developed to supplement the course from 2011 to 2015.

Therefore, CVET-230 was identified as a reasonable benchmark to compare with CVET-332.

Results

Screencasts were developed and implemented into the course CVET-332: Structural Analysis in 2012 and the screencasts have been made minor updates every year according to students' feedback. The final calculated grades were collected and analyzed for five consecutive years from 2011 to 2015. The final grades in this study were calculated based on weighting homework, mid-term tests and final exam. The formula was 20% homework plus 40% mid-term test grades plus 40% final exam grades. The problems of the mid-term tests and the final exams kept the same every year from 2011 to 2015 in order to make rational comparisons. The tests were not returned to the students and kept confidential. In order to limit the subjectivity in grading to the lowest level and keep the grading criteria consistent over the five years, the detailed itemized grading sheets were created and the grading points were assigned to each broken step and answer. Another Civil Engineering course CVET-230: Elementary Structures was selected to compare with the course CVET-332: Structural Analysis. The same students took both courses, but no screencasts were developed in the course CVET-230. The numbers of students in one class during the five years are listed in Table 1. Statistical analyses using unpaired t-test were performed to verify the grades difference between the deaf students and the hearing students [9]. Table 1 shows the t-test results of CVET-332 Structural Analysis and CVET-230 Elementary Structures. Average grade, standard deviation, t-value and p-value are listed and compared from 2011 to 2015. The statistical significance between the grades of deaf students and hearing students are compared.

The box-whisker plots of the final calculated grades of the students from 2011 to 2015 in the courses CVET-332 and CVET-230 are shown in Figure 5 and Figure 6, respectively. The grades used in the box-whisker plot are hearing students' grades only. The deaf students' grades are plotted separately using the triangular marks in order to compare with the grades of the hearing students.

Table 1: Statistical Analyses for CVET-332 and CVET-230: t-test

Year	Student Type	Number of Students	CVET-332				CVET-230			
			Avg. Grade	Standard Deviation	t-value	p-value	Avg. Grade	Standard Deviation	t-value	p-value
2011	Hearing	27	80.6	9.06	1.4193	0.0834	87.0	6.80	1.6827	0.0518
	Deaf	3	76.5	3.66			80.9	2.24		
2012	Hearing	33	81.2	10.27	0.0715	0.4720	86.5	8.51	2.8748	0.0034
	Deaf	4	81.1	5.67			73.2	5.99		
2013	Hearing	31	81.7	7.81	0.5264	0.3012	85.6	8.22	1.7342	0.0461
	Deaf	4	81.9	7.79			79.8	9.74		
2014	Hearing	31	83.9	10.12	0.1954	0.4231	86.0	8.19	2.1024	0.0216
	Deaf	4	82.9	6.65			80.7	3.02		
2015	Hearing	36	85.9	11.75	0.2222	0.4127	86.8	6.86	2.3045	0.0134
	Deaf	4	87.3	5.12			78.7	4.42		

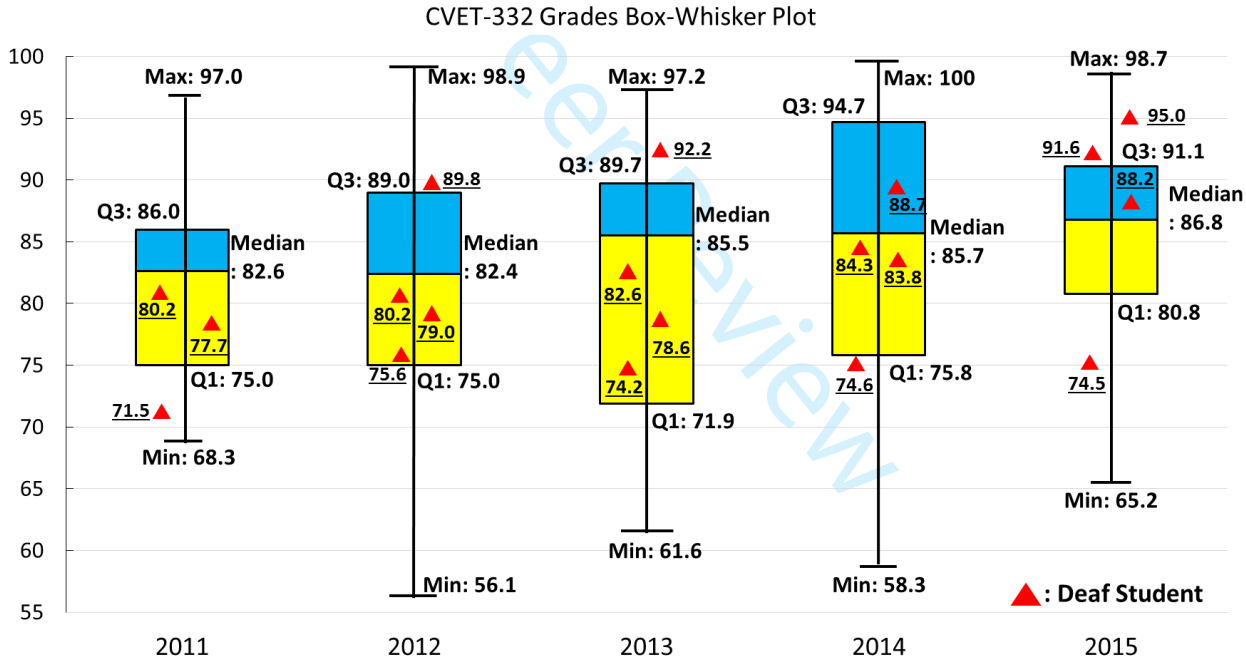

Figure 5: Final Calculated Grade Box-Whisker Plot for CVET-332: Structural Analysis

From Table 1, we found that the p-values for CVET-332 after the screencasts being implemented are relatively high ($p > 0.3$), and the high p-values mean the grade differences between the deaf students and the hearing students are not significant at all. In a t-test, the common cutoff p-value is 0.05. The differences between two groups are significant when p-value is no greater than 0.05, and vice versa. The data of CVET-332 in Table 1 are consistent with the data shown in Figure 5

and support the conclusion that the grades of the deaf students are comparable to the grades of the hearing students by implementing screencasts.

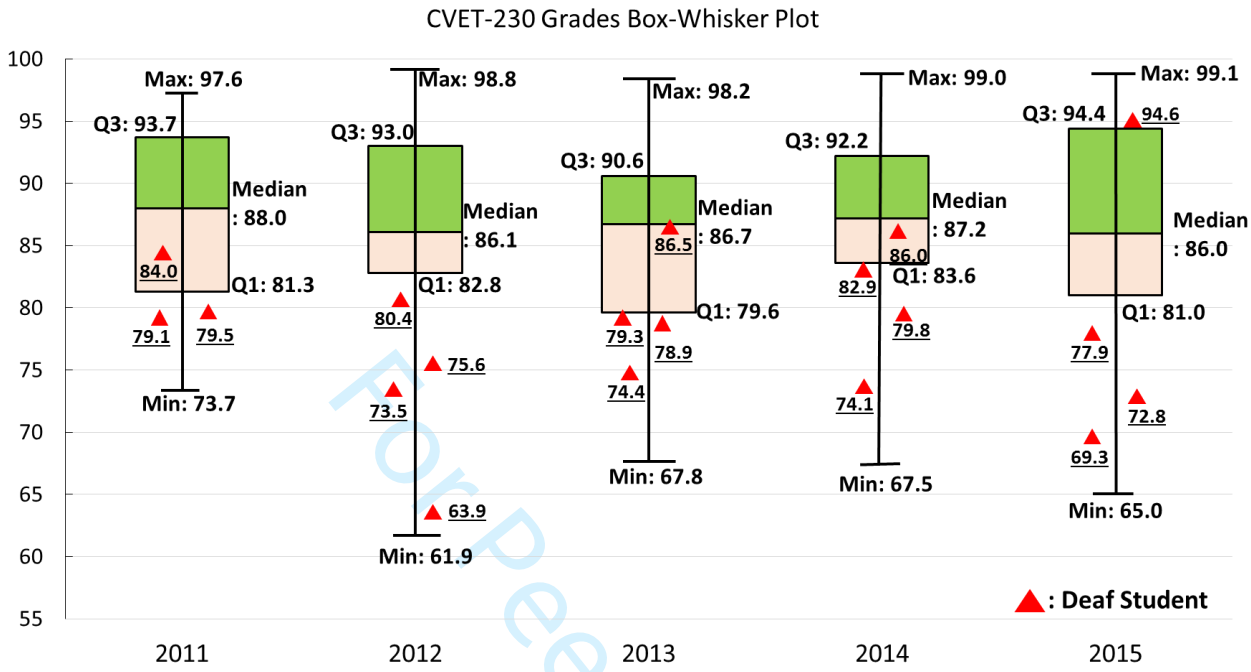

Figure 6: Final Calculated Grade Box-Whisker Plot for CVET-230: Elementary Structures

By contrast, the p-values for CVET-230 in Table 1 are relatively small, and the p-values are less than 0.05 for all the years except the year 2011 barely exceeds 0.05. The p-values of CVET-230 indicate that the grade differences between the deaf students and the hearing students are significant. The data of CVET-230 in Table 1 align with the data in Figure 6, which supports the hypothesis that the grades of the deaf students are significantly lower than their hearing peers in the traditional lecture-type class environment.

From Figure 5, we found that:

1) The medians of grades show a trend of improvement since 2012 when screencasts were implemented into CVET-332.
2) The grades of deaf students have continuously improved in the course of CVET-332 after the screencasts being used.
3) By using screencasts as the supplement learning materials in CVET-332, the grades of the deaf students had been consistently comparable to the hearing students' grades from 2012 to 2015.

The plots of Figure 6 show that:

1) The majority of the deaf students' grades were below the lowest quartile for the all the years from 2011 to 2015.

2) The deaf students' grades had been consistently lower than the hearing students' grades, and the grade differences between the deaf students and the hearing students were significant.
3) The deaf students' grades fluctuated more than the hearing students' grades. As mentioned earlier, deaf students' learning in a traditional lecture-type class depends on many factors, especially the quality of real-time interpreting.

In addition to the grades, surveys about using the screencasts were handed out to all the students who took CVET-332 Structural Analysis. The surveys were anonymous, but the students need to check if they were deaf or hearing. The instructor left the classroom during the survey and the completed surveys were returned to the instructor in a sealed envelope after the surveys were done. The survey questions and answers are listed in Table 2. Question number 4 was only answered by the students who answered "Yes" for Question number 1.

Table 2: Survey Questions and Answers

Number	Question	Hearing Students		Deaf Students	
1	Do you use screencasts on the instructor's teaching website?	Yes	No	Yes	No
		87%	13%	100%	0%
2	Do you think screencasts are better than posting solutions?	Yes	No	Yes	No
		96%	4%	100%	0%
3	Do the screencasts help you understand the examples better?	Yes	No	Yes	No
		87%	13%	100%	0%
4	Which type of the screencasts do you use more frequently: hand-calculation examples or computer software instruction examples?	Hand Calculation	Software	Hand Calculation	Software
		38%	62%	42%	58%
5	Do you like the screencasts to supplement the lectures?	Yes	No	Yes	No
		90%	10%	100%	0%
6	Do the screencasts save your time doing homework?	Yes	No	Yes	No
		93%	7%	100%	0%
7	Do the screencasts reduce your office hour visits?	Yes	No	Yes	No
		93%	7%	100%	0%

There were spaces for the students to leave written comments in the surveys, and 40% of the total students provided written comments on using screencasts. 100% of the written comments about the screencasts are positive. Some representing written comments are listed in Table 3.

The results show that implementation of the latest screencast technology in classroom instruction enhances students' learning effectiveness.

Table 3: Selected Written Comments from the Surveys

Hearing Students	• "It is a great learning tool to supplement what I learn in the classroom and helps reinforce those concepts." • "One of the best things made, wish all classes had these." • "The problems are much easier to understand when you can follow along with the screencast steps."
Deaf Students	• "I really think this feature helps a lot with enhancing my understanding of course content. I think other professors should adopt this idea." • "I think the screencast is the perfect idea in terms of taking advantage of the technology to help understand the topic." • "I think the screencast is a fantastic idea. There is plenty of room to move forward with it."

This study collects data for five consecutive years from 2011 to 2015, and many approaches have been used to control the consistency and accuracy of the results. The results show the effect of long-term use of screencasts on learning effectiveness in Civil Engineering classroom with deaf students. In this study, there are some factors beyond the researchers' control, such as the number of deaf students, course offering semesters, class enrollment numbers, students' previous academic background and so on. These uncertainties may affect the results.

Conclusions

In this study, a bank of thirty eight screencasts have been created and posted on the instructor's teaching website: http://baoteachingcet.com to supplement one of the Civil Engineering core courses: CVET-332 Structural Analysis at Rochester Institute of Technology since 2012. The screencasts are open to all the students who take the course including those with hearing disabilities and sign language interpreters. The final calculated grade averages of the deaf students and the hearing students in the two courses: CVET-332 Structural Analysis and CVET-230 Elementary Structures were compared and analyzed for five consecutive years from 2011 to 2015. Surveys about the students' experience in using the screencasts were conducted to collect feedback.

Based on the statistical analyses and the students' feedback, we can conclude that:

1) Implementing screencasts to supplement Civil Engineering courses can improve students' learning effectiveness.
2) Screencasts with synchronized captions can notably enhance deaf students' learning.
3) With the help of screencasts, deaf students' grades are comparable to their hearing peers in the same class.

4) Students can save time in doing their homework and reduce their office hour visits by using the screencasts posted on the instructor's website.
5) There is a great need for the screencasts of computer software instructions from the students. Screencast technology is an effective way to improve teaching and learning for the courses with computer-assisted teaching materials.
6) The positive effect of screencasts with synchronized captions on deaf students indicates that application of screencasts could also be a very promising way to improve learning effectiveness of students with English as a second language.

Acknowledgements

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Supplement Document for screencasts:

Teaching Website: http://baoteachingcet.com
Screencasts Access: Log in: Username: **test**
Password: **1234**