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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 introducing screencasts into Civil Engineering classroom instruction to improve learning outcomes for students, including those with hearing disabilities. Screencasts are screen captures of learning materials, broken into detailed steps with narration and synchronized captions provided 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 focuses 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, and are open to all 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 were introduced. Another comparable Civil Engineering course without screencasts, Elementary Structures, was selected as a benchmark to evaluate 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 may enhance both deaf and hearing students' learning effectiveness.

Key words: streaming video, civil engineering, performance

INTRODUCTION

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

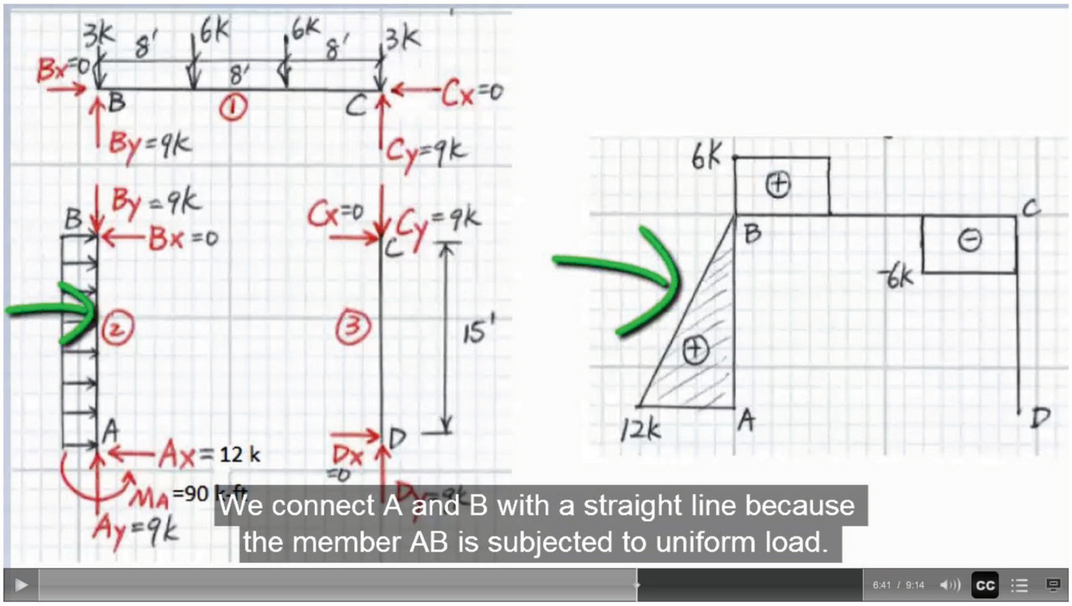

Figure 1. Sample Screencast.

traditional lecture-type instruction with interactive technological tools may enhance students' learning. Screencasts are a new form of computer-aided instruction in the classroom[6, 7, 8 and 11]. Screencasts are screen captures of learning materials broken into steps and combined with the instructor's narration and synchronized captioning (Figure 1). Screencasts have been used in general college courses such as mathematics, physics and chemistry for several years and have been proven to improve learning effectiveness[6, 7, 8, 11 and 12]. In these fundamental courses, screencasts are usually combined with the use of clickers or are applied as a flipped classroom approach[1, 4, 5 and 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 part of a flipped classroom, we use them as additional learning materials, to supplement traditional lectures. Students can choose to use the screencasts depending on their academic needs, after they learn the materials in the classroom.

In the environment of a traditional classroom, deaf and hard-of-hearing students face significant barriers to access and inclusion in STEM education[2 and 3]. According to U.S. Department of Education, National Center for Education Statistics: 2007–08 National Postsecondary Student Aid Study, the number of deaf students at postsecondary level was 136,000 and accounted for 0.73% of the total postsecondary enrollments[13]. The percentage of students with hearing impairments who pursue post-secondary and advanced degrees in STEM decreases longitudinally as shown in Figure 2.

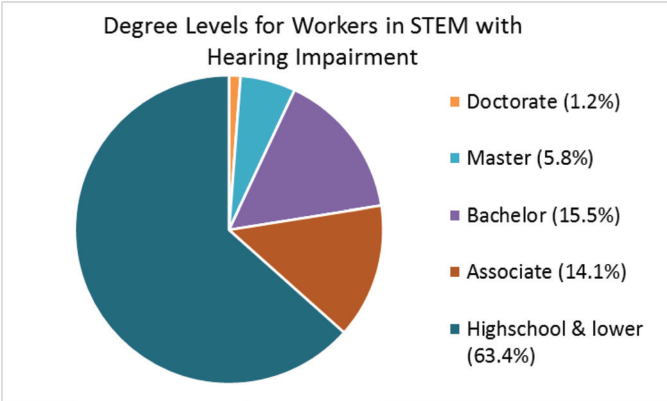

Figure 2. Degree Levels for Workers in STEM with Hearing Impairment.

Therefore, there remains a pressing need for resources to ensure that STEM instruction is accessible and inclusive to deaf and hard-of-hearing students.

Deaf and hard-of-hearing students have difficulty learning in traditional lecture-based courses and need the lectures to be augmented by visual aids, lecture notes or other materials[9]. 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. 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 in which deaf students are enrolled.

Most civil engineering students consider courses in structural engineering challenging because they usually contain complex mathematics and mechanics. In our classroom practice, new interactive learning materials-screencasts were prepared to supplement traditional lectures, allowing students to watch at their own pace. The screencasts include detailed solutions to sample problems and instructions of how to use a piece of software. With screencasts, students follow the instructor's explanation and read captions breaking down each step of the problem in order both to understand it in greater depth and to see how the problem relates to the underlying concepts[6, 7, 8, 13 and 14]. Students in any given class learn at a range of paces. With screencasts, students can control the pace of the videos based on their own needs. For example, students may try doing a given problem themselves before they start watching the screencast. If they get stuck on one step of the problem, they can repeat it over and over until they fully understand, and they can skip the steps when they find them easy. These materials help improve teaching and learning effectiveness when solving difficult conceptual problems. The innovative use of screencasts appeals to this generation of technically proficient students, provides a new learning platform for deaf or hard-of-hearing students, and helps them master instructional materials.

METHODOLOGY

All screencasts were created using Camtasia Studio and the exported video files were posted on the instructor's teaching website: http://baoteachingcet.com under the tab "Screencast" as shown in Figure 3. Students can get access to the screencasts by member login (username: test; password: 1234). The examples selected for screencasts were usually the long ones which take significant class time and focus on key concepts and problem-solving strategies. All screencasts were made by the instructor's research team which included the instructor and three research assistants. The process of making screencasts was 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. Each screencast is five to ten minutes long.

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

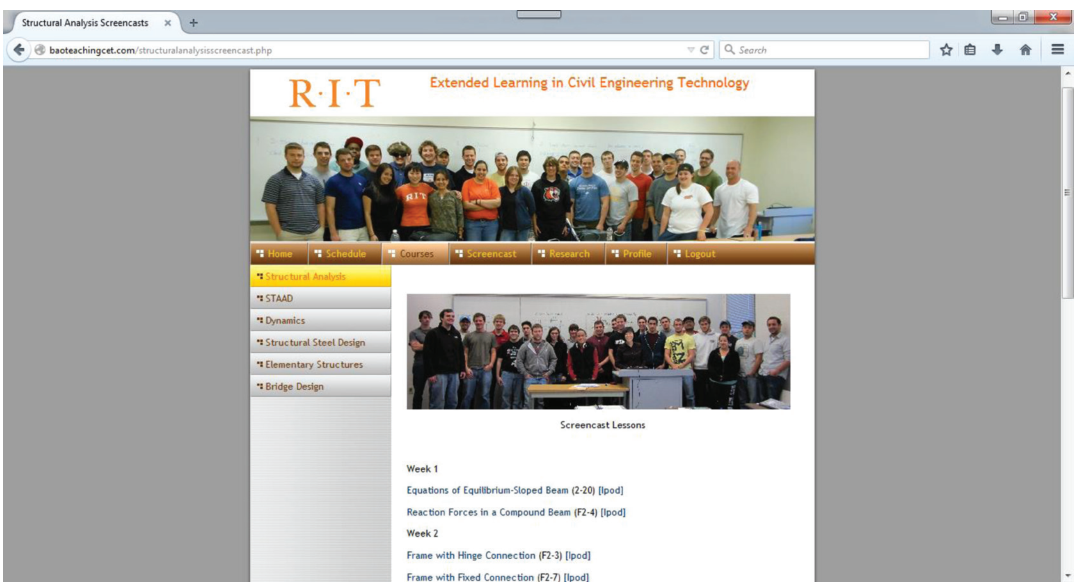

Figure 3. Screencasts posted on Instructor's Teaching Website.

attend. The interpreters are well-trained in sign language, but not necessarily in engineering. In traditional, lecture-based classroom environments, deaf and hard-of-hearing students' learning relies heavily on the accuracy of sign-language interpreters' real-time understanding and communication of course materials. From our classroom observations, deaf students' learning effectiveness may be improved if the interpreters have an 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 lecture-style class. 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 which they then translate into sign language. Therefore, the information that deaf students receive usually lags 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.

Screencasts emphasize the most important concepts in the course. They 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. These

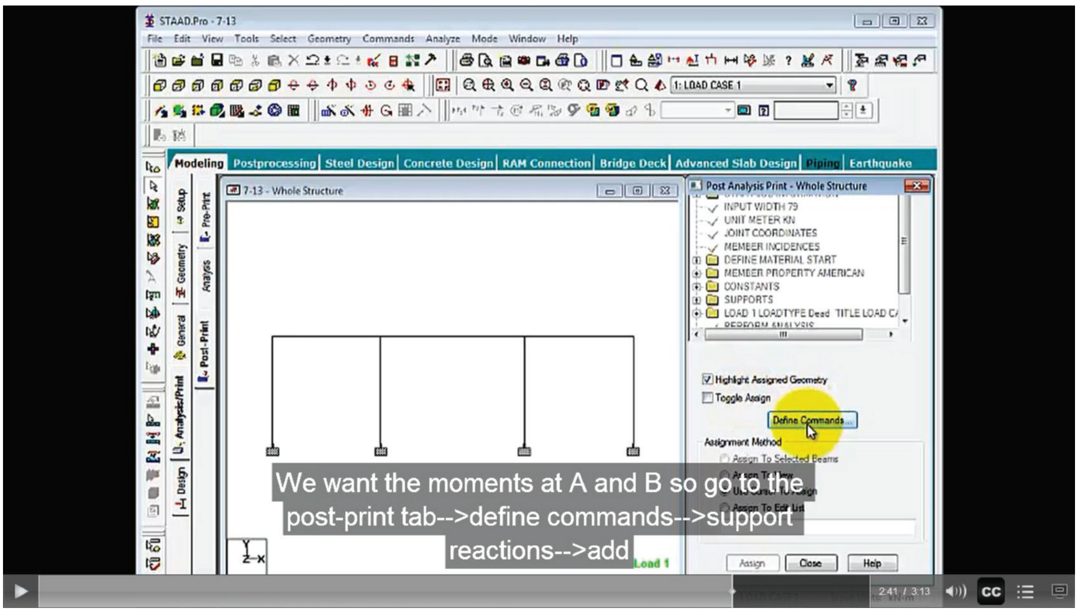

Figure 4. Sample Screencast for Software Instruction.

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 includes the students' overall course grades, students' course success rate quantified by the number of students earning a final grade of "C" or above, and students' evaluation of the course.

In order to show the effect of screencasts on students' learning, data from the course CVET-230 Elementary Structures was compared to that of CVET-332 Structural Analysis. The course CVET-230 was chosen as the counterpart of CVET-332 for the following reasons:

1. Both courses are required, and the same cohort of students was enrolled in both courses.
2. The same instructor taught both courses from 2011 to 2015;
3. Both courses are structural engineering courses sharing 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 using the traditional lecture-type instruction withno screencasts developed to supplement the course from 2011 to 2015.

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

RESULTS

Screencasts were developed and introduced into the course CVET-332: Structural Analysis in 2012. Every year since, the screencasts have been given minor updates based on 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 (20%), mid-term tests (40%) and a final exam (40%). The problems on the mid-term tests and the final exams were kept the same every year from 2011 to 2015 in order allow for appropriate comparisons. The tests were not returned to the students and their content was kept confidential. To minimize the impact of subjectivity in grading and to keep grading criteria consistent over five years, detailed, itemized grading sheets were created, and the grading points were assigned to each discrete step of every problem. Results of student performance in CVET-332 were compared with those of the same students in CVET-230: Elementary Structures. Although the same students took both courses, no screencasts were developed in the course CVET-230. Table 1 shows enrollment in both classes over time and the results of analysis. Statistical analyses using unpaired t-test were performed to verify

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

			CVET-332				CVET-230			
Year	Student Type	Number of Students	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		

the grades difference between the deaf students and the hearing students[10]. 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

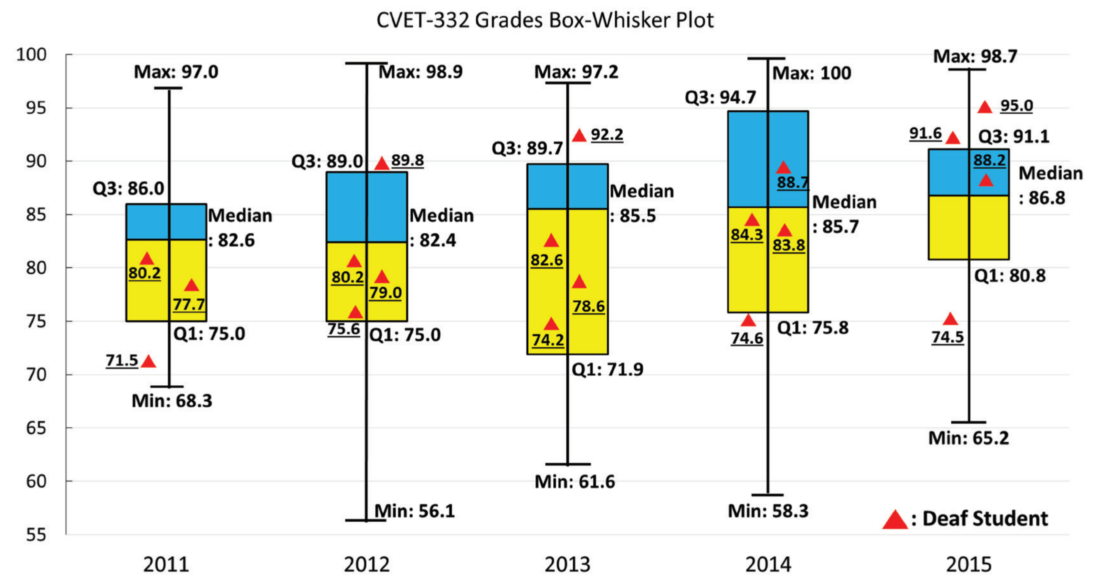

Figure 5. Final Calculated Grade Box-Whisker Plot for CVET-332: Structural Analysis.

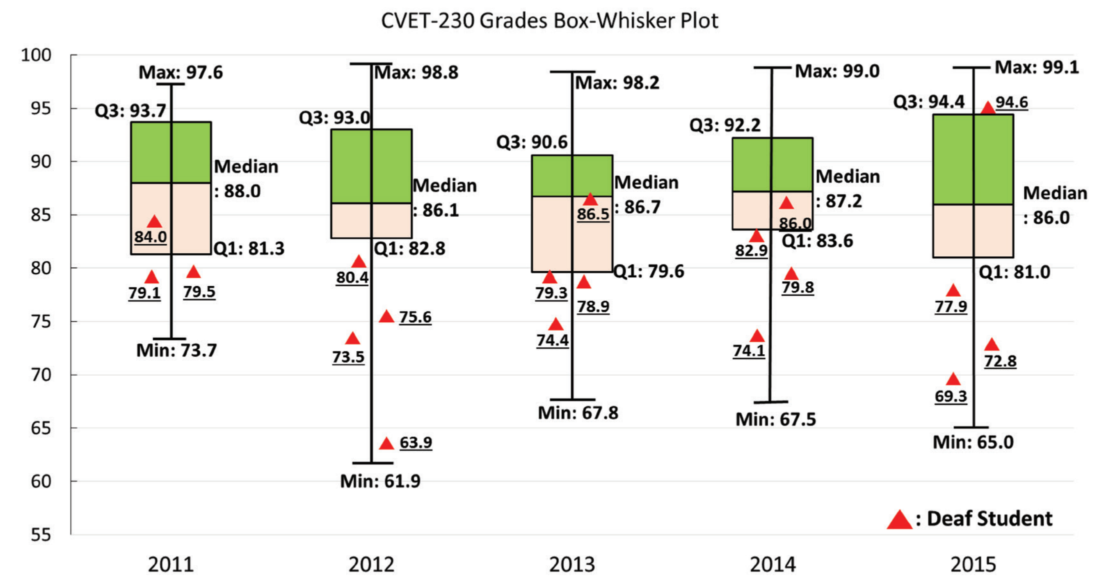

Figure 6. Final Calculated Grade Box-Whisker Plot for CVET-230: Elementary Structures.

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.

From Table 1, we found that the p-values for CVET-332 after the screencasts were implemented are relatively high ($p > 0.3$). The high p-values mean the grade differences between the deaf students and the hearing students are not at all significant. 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 when screencasts are used.

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, which 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 environments.

From Figure 5, we found that:

1. Median grades show a trend of improvement since 2012 when screencasts were introduced into CVET-332.

2. The grades of deaf students have continuously improved in CVET-332 after the screencasts have been used.
3. By using screencasts as the supplement learning materials in CVET-332, the grades of the deaf students have been consistently comparable to the grades of hearing students from 2012 to 2015.

The plots of Figure 6 show that:

1. Most of the deaf students' grades were below the lowest quartile for the all years from 2011 to 2015.
2. 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 grades of hearing students. 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 needed to self-identify as either 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. There were spaces for the students to

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%

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."

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 were positive. Some representative written comments are listed in Table 3.

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

This study collects data for five consecutive years from 2011 to 2015, and many approaches including course materials, instructors, interpreters and grading criteria, 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. Some factors remained beyond the researchers' control, such as the number of deaf students, course offering semesters, class enrollment numbers, students' previous academic background, and the like. These variables may affect the results.

CONCLUSIONS

In this study, beginning in 2012, a bank of thirty-eight screencasts were 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. The screencasts are available 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 gain further understanding of students' experiences.

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

1. Implementing screencasts to supplement Civil Engineering courses can improve students' learning.
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. Students express a great need for screencasts of computer software instruction. Screencast technology is an effective way to improve teaching and learning for 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.

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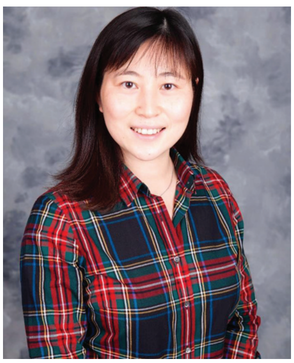

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