# Effective Use of Videos to Enhance the Teaching and Learning of Environmental Engineering

**Jianpeng Zhou, Ph.D., P.E., DEE**

**Department of Civil Engineering, Southern Illinois University Edwardsville**
**Edwardsville, IL, USA 62026-1800 Email: jzhou@siue.edu**

## Abstract

Three environmental engineering courses offered at Southern Illinois University Edwardsville involve in the teaching of water treatment subjects. In the past, field trips to local water treatment plants helped students to relate the knowledge they learned in the classroom to real-world applications. Since 9/11/2001, water treatment plants are closed to visits of the general public. Furthermore, increased students' participations in the teaching process are needed to improve the effectiveness of students' learning. This paper reports the experience and findings of a project where videos of water treatment subjects were used and integrated in the instructional activities of these courses. The impacts of videos on students' learning were assessed both qualitatively and quantitatively. Bloom's taxonomy on learning levels was used to design the assessment questions for each course. This project found that the use of appropriately selected videos improved the learning environment, increased students interests in learning by promoting active students participation in the learning process, promoted high levels of learning and naturally broke long class session into small attention units, where the effectiveness of student learning were increased. The use of videos also overcame the limitation of lack of field trip opportunities and helped to bring real-world applications to the classroom.

## Introduction

Environmental engineering is one of the three primary areas offered in the Department of Civil Engineering at Southern Illinois University Edwardsville (SIUE). Three environmental engineering courses offered at SIUE involve in the teaching of water treatment subjects. They are CE 380, a required introductory course; CE 487, an elective design course; and CE 592, a graduate course. Annual enrollment of these courses is approximately 80. In the past, there were field trip opportunities to visit local water treatment plants, which helped students to relate the knowledge they learned in the classroom to real-world applications. Since 9/11/2001, as a security measure, municipalities across the country have closed water treatment plants to visits of the general public. Furthermore, increased students' participations in the teaching process are needed to improve the effectiveness of students' learning. To response to above challenges, the author carried out a project, sponsored by a SIUE teaching enhancement grant, to assess if videos of water treatment subjects could be used to create significant and positive impacts on students' learning experience in these courses. This paper reported the experience and findings of this project.

The three studied courses, although each involved in water treatment subjects, differed in course objectives and emphasis, student compositions, and teaching approaches (Table 1). CE 380 covered broad topics of environmental engineering, which included water and wastewater treatment; solid wastes, hazardous and radioactive wastes management; noise and air pollution control. CE 380 aimed to introduce to students the basic concepts and knowledge of how the principles of chemistry, physics, biology, and mathematics were applied to solve environmental engineering problems. CE 487 focused on calculation and practical engineering design of major units of a typical water treatment process. Students in CE 487 were expected to have already taken CE 380, and commanded the basic knowledge of water treatment. However, students in CE 487 likely had not got the exposure and understanding on what considerations constitute appropriate design of a water treatment facility. CE 592 emphasized on contemporary issues of water quality and advanced water treatment processes, addressed rationales, fundamentals, and advanced technologies to remove special contaminates in water. The graduate students in CE 592 were expected to have already learned the principles of water treatment, and were able to evaluate and assess strategies and alternatives of water treatment in the context of regulatory requirements and public health protection.

**Table 1. Three studied environmental engineering courses**

| Course/Semester | Characteristics | Enrollment/Compositions | Class Schedule |
|---|---|---|---|
| CE 380/ (Spring 2004) | Introductory | 31/all undergraduate students | Twice/week 75 min./class |
| CE 487/ (Spring 2004) | Design | 18/including eight graduate students | Once/week 150 min./class |
| CE 592/ (Fall 2003) | Water quality, advanced processes | 12 /all graduate students | Once/week 150 min./class |

**Challenges in the teaching of the studied courses**

Each of the courses had its unique challenge in teaching and students' learning. Students in CE 380, in general, had little knowledge of water treatment. The teaching of CE 380 was geared towards the dissemination of facts, concepts, principles, and theories. The challenge was to help students to comprehend how the principles and theories were formulated and were linked to methods of solving engineering problems. As for CE 487, to learn the skills of engineering design, students were expected to understand the operational sequences and flow-through processes of water treatment, and relate the two dimensional schematics in the text book to the three dimensional facilities installed in full-scale plants. Many subjects taught in CE 592 were based on the most current research findings and contemporary approaches in solving water quality and treatment related issues. It is important to create an active student-centered learning environment to promote in-class discussions and debating, so students in CE 592 were able to develop their abilities of critical thinking and the skills of independent judgments.

As shown in Table 1, both CE 487 and CE 592 were scheduled as weekly class of 150 minutes each. The long duration of each weekly session hindered the effectiveness of students' learning. Vesilind[1] indicated that students' attention span was limited in a lecturing environment. Although, almost 100% students paid attention at 10 minutes into lectures, only 15% of students

remained attentive at 30 minutes into lectures, and essentially all students were lost at the end of 75 minutes lectures. Vesilind[1] suggested that class should be broken into "attention units" by using teaching techniques of variation.

The field trip opportunities were important to students. In the feedbacks of a course where field trip was not organized, students commented that "the course is perfect, but 2-3 site visits would help to know the subject matter practically" and suggested to "take the students to the plants so they could have practical knowledge".

**Role of videos to enhance the teaching and learning**

The appropriate use of instructional technologies can improve the effectiveness of student learning. Rutz et al.[2] found that both student satisfaction and their final grades of the technology-enhanced class (where either interactive video, web-assisted class, or streaming media was used) were all statistically higher than those of traditional class. There was no significant difference, when different instructional technologies were compared on their impacts on students' learning.

Technical video is a simple and practical technology that is often used in classroom teaching. A well-selected video, showing examples of practical applications of various water quality and treatment processes and facilities, can readily demonstrate how principles and concepts were formulated and applied to solve practical problems. Instructors can show segments of instructor's choice and engage students to class discussions on issues and problems presented in the video, therefore, place students at the center of the learning process. The use of videos can also help to break long class session into short "attention units". Studies have shown that appropriate use of videos can adequately promote in-class discussions and interactive student learning and to improve the effectiveness of students' learning[3, 4, 5].

**Selection of videos**

A survey of the market revealed that the videos produced by American Water Works Association (AWWA, www.awwa.org) are most appropriate and relevant to meet the needs of teaching water treatment subjects. AWWA is an authoritative technical organization in USA, which is made of professionals in the water industry and provides technical resources for the latest information, education, and standards for the water industry. Selected videos used in the three courses are summarized in Table 2.

**Integration of videos in the teaching and learning process**

Before showing videos to the class, discussion questions were proposed to students who were asked to take notes while watching the videos. Students were expected to contribute to the discussion session that followed the video session. The development of the proposed discussion questions considered the subject that was taught and the nature of the selected video. Some videos were selected to bring real-world applications to classroom. For example, the video "Membrane" showed a full-scale membrane water treatment plant. Students were able to see the major components and operation of a membrane facility without actual visit to the plant. The discussion questions related to this video were (a) "why and where can we use membrane

technology for water treatment?", (b) "what are major classifications and differences among different membrane technologies?". The primary focus of students' efforts was facts-finding by extracting information from the video shown.

**Table 2. Selected videos to teach water treatment subjects**

| Course | Selected Videos*/Length of Video |
|---|---|
| CE 380 | 1. "Coagulation, Flocculation, Sediemtation"/15 min.<br>2. "Disinfection"/15 min.<br>In addition, two other videos on wastewater and industrial wastes management were used in CE 380 |
| CE 487 | 1. "Coagulation, Flocculation, Sediemtation"/15 min.<br>2. "Filtration"/15 min.<br>3. "Disinfection"/15 min. |
| CE 592 | 1. "Is It Safe to Drink?"/30 min.<br>2. "Case Studies in Source Protection"/17 min.<br>3. "Membrane"/15 min.<br>4. "Disinfection By-product Control"/11 min. |

*All of listed videos were produced by AWWA

In contrast, some videos were selected to promote a student-centered interactive learning environment in the class. As an example, the video "Case Studies in Source Protection" used in CE 592 aimed to illustrate how options for protecting water supply sources were analyzed and evaluated. The video presented a case study on how the Water Department of Dayton, Ohio handled the problem of contamination in its groundwater supply sources, how a community-based comprehensive program was developed to protect their water supply sources. Interviews for opinions of environmental engineers, water managers, and general publics were shown in the video. The video illustrated the complexity of a real-world problem relating to water supply and demonstrated the connection between engineering principles and their applications. The two discussion questions proposed to the class were (a) "what are the major sources that contaminate water supply sources, by human activities vs. natural reasons?", (b) "what can we do to protect water supply sources?". After the video was shown, students were divided into groups of three to conduct approximately 15 minutes discussions and to develop answers to each question. Students were then asked to report their answers to the whole class. The instructor moderated the discussion session to ensure that each student had an opportunity to contribute to the final answers of each question. Interactive learning occurred among the students themselves. When one student offered an answer, the instructor directed the answer to the class to see if the whole class was in agreement and invited other students to elaborate or expand the answers. Interactions occurred among students, also between students and the instructor. In addition, the use of videos naturally broke the long class session into small attention units, therefore, improved the learning environment.

**Assessment of the impact of videos on students' learning**

The impacts of videos on students' learning were assessed both qualitatively and quantitatively. For the qualitative assessment, a questionnaire was distributed to CE 592 class after the showing of the first two videos. The students were asked to comment on "were the two videos shown to

the class helpful with your learning of issues and applications of water quality and treatment? If yes, how did they help your learning? If no, what would be the reason?". All of the 11 students surveyed answered "yes" to this question. Students elaborated that "they (videos) were very helpful. I do believe this increases the learning process. It is informative too"; "They are real world examples of what are current challenges in this field. Actual examples from people involved in the community were provided"; 'Real world examples always help to put theory in perspectives". Students reported that "we could see the actual site conditions, what's happening"; "we could listen to the views and different people as well".

The quantitative assessment of each of the three courses was conducted as part of the semester-end teaching evaluation. The assessment questions, which were worded in the same format as all other standard teaching evaluation questions, are summarized in Table 3. Students can choose their answer among five possible choices of "strongly agree", "agree", "neutral", "disagree", or "strongly disagree". The assessment results of CE 380 and CE 487 are illustrated in Fig. 1 and 2, respectively.

**Table 3. Assessment questions on the impact of videos on learning**

| Course | Assessment Question/Bloom's Taxonomy Learning Level |
|---|---|
| CE 380 | Q1. The videos helped to illustrate diversified issues in environmental engineering/"Application"<br>Q2. The videos helped you to relate class topics to practical applications/"Analysis" |
| CE 487 | Q1. The videos helped to illustrate water treatment design issues/"Application"<br>Q2. The videos helped you to relate class topics to practical applications/"Analysis"<br>Q3. The videos helped you to design water treatment components/"Synthesis" |
| CE 592 | Q1. The videos helped you to relate class topics to practical applications/"Analysis"<br>Q2. The videos helped you to integrate issues of water quality/"Synthesis"<br>Q3. The video helped you to assess options of water treatment/"Evaluation" |

The Bloom's taxonomy on learning levels was used as the basis to design the assessment questions. The Bloom's learning levels are defined by students' cognitive behaviours and are achieved with well-defined learning objectives, which progress from "knowledge" (to learn facts, languages, concepts, principles, theories et al.), to "understanding" (to learn how to manage the learned knowledge), "applications" (to learn how to use the understood knowledge), "analysis" (to dissemble and understand components of application), "synthesis" (to assemble components of understood application to solve a new problem), and finally "evaluation" (to assess and appraise the synthesized programs and alternatives). It was suggested[6] that relevant and characteristic verbs were use to develop questions for use to assess each level of learning. For example, the questions to assess the learning level of "analysis" may contain verbs such as "analyse, calculate, categorize et al."; the questions to assess the learning level of "evaluation" may contain verbs such as "appraise, compare, contrast, select, assess et al.". A Bloom's learning level was proposed for each assessment question and shown in Table 3.

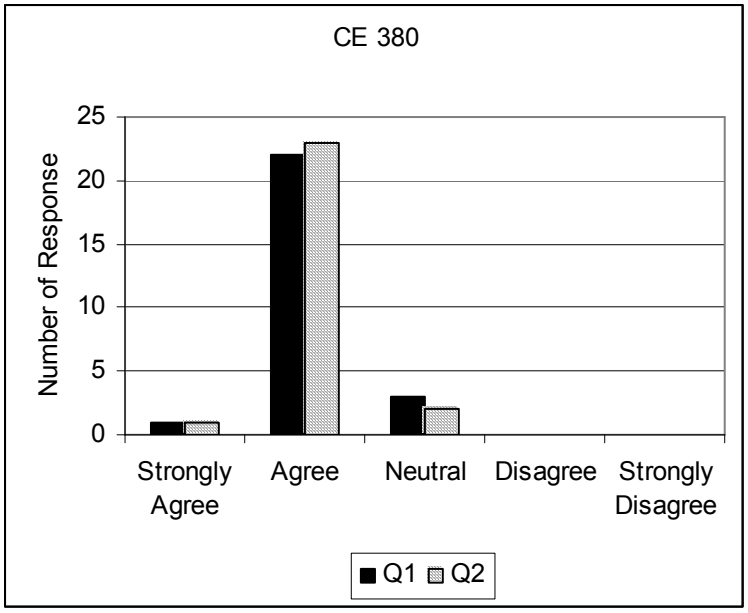


**Fig. 1. Assessment results of CE 380 (n = 26)**

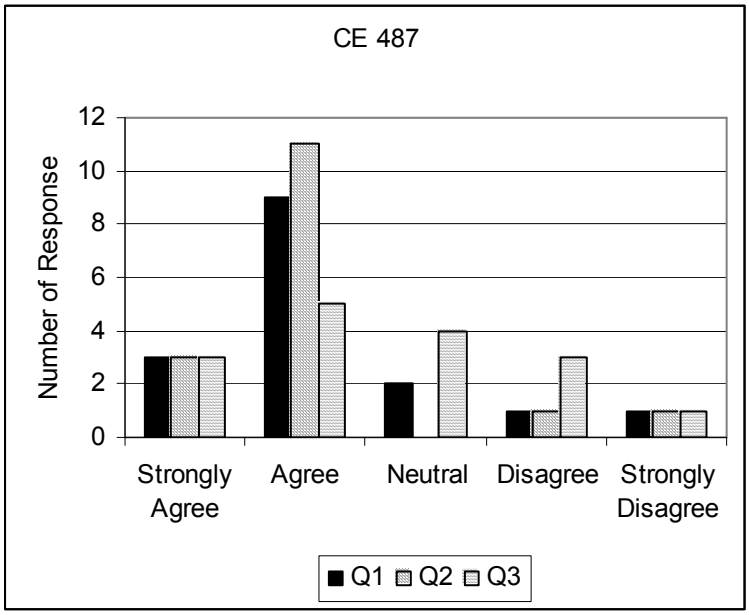


**Fig. 2. Assessment results of CE 487 (n = 18)**

As shown in Fig. 1, 88% of students (23 of 26) in CE 380 "agreed" or "strongly agreed" that the videos helped their learning of diversified issues of environmental engineering (assessment question 1), 92% of students (24 of 26) "agreed" or "strongly agreed" that videos were helpful to develop their analytical ability in relating class topics to practical applications (assessment question 2). Similarly, 86% of students (6 of 7) in CE 592 (data were shown in Zhou[7]) felt that the videos were helpful and promoted their learning at all levels of "analysis", "synthesis", and "evaluation". Assessment results shown in Fig. 2 revealed that the majority of students in CE 487 "agreed" or "strongly agreed" that videos were helpful by illustrating design issues (75%, 12 of 16) and relating class topics to practical applications (88%, 14 of 16). However, only 50% of

students (8 of 16) in CE 487 felt the videos helped to improve their learning in the design of water treatment components, which indicated that those selected videos were not highly effective to teach the design aspect of the course. Such a finding suggested that alternative approach of teaching or different videos should be used, if students' learning at level of "synthesis" is to be further improved.

## Summary and Conclusions

Findings of this project indicated that the use of appropriately selected videos improved the learning environment, increased students interests in learning by promoting active students participation in the learning process, promoted high levels of learning and naturally broke long class session into small attention units, where the effectiveness of student learning were increased. The use of videos also overcame the limitation of lack of field trip opportunities and helped to bring real-world applications to the classroom.

## Acknowledgement

The videos used in this study were purchased with the support of a 2003-2004 *Excellence in Undergraduate Education* grant from Southern Illinois University Edwardsville, IL.

## References

[1] Vesilind, P.A. *Association of Environmental Engineering & Science Professors Newsletter*, Vol. 39, No. 1, 2004, pp. 15
[2] Rutz, E., Eckart, R., Wade, J.E., Maltbie, C., Rafter, C., and Elkins, V. "Student Performance and Acceptance of Instructional Technology: Comparing Technology-Enhanced and Traditional Instruction for a Course in Statics," *Journal of Engineering Education*, Vol. 92, No. 2, 2003, pp. 133-140.
[3] den Ouden, P. "Let Students Show What They Know" *The Teaching Professor*. Vol. 16, No. 8, 2002, pp. 3.
[4] Lowman, J. *Mastering the Techniques of Teaching*. 2nd Ed. 1995, Jossey-Bass of John Wiley & Sons, NY.
[5] Weimer, M. "Active Learning: Implementation of Our Best Intentions" *The Teaching Professor*. Vol. 16, No. 9, 2002, pp.1-3.
[6] SIUE. "Assessment Use of Bloom's Taxonomy", 2003, SIUE Undergraduate Assessment Office
[7] Zhou, J. "Achieving Balance between Student-Centered Learning and Instructor-Centered Teaching – A Case Study of an Environmental Engineering Course" *Proceedings of 2004 ASEE International Colloquium*, Sept. 6-10, 2004, Beijing, China.

## Biography

JIANPENG ZHOU is an assistant professor of environmental engineering in the Department of Civil Engineering, Southern Illinois University Edwardsville, IL. He is a *Professional Engineer* licensed in WA and a *Diplomate Environmental Engineer* certified by AAEE. Dr. Zhou earned his Ph.D. and M.A.Sc. degrees in Environmental Engineering from the University of British Columbia, Canada; his M.Eng. and B.Eng. degrees in Environmental Engineering from Tsinghua University, Beijing, China. He is a member of ASEE.