

Investigation of the Effectiveness of Different Teaching Tools

Lo, Irene M C¹ and Young, Ben²

¹cemclo@ust.hk

²byoung@ust.hk

Department of Civil Engineering,
The Hong Kong University of Science and Technology

ABSTRACT

A 120-minute experimental classroom lecture was conducted in a class of 93 students to assess the effectiveness of the six different teaching tools. In this study, the effectiveness of a classroom lecture is defined as (i) understanding of lecture material and (ii) stimulating student interest in learning. The teaching methods of a diagram, model, worked example, short video clip, 3-dimensional computer animation, and 'incorrect' 'learn-from-mistakes' example to illustrate and explain a concept/theory were used during the 120-minute session.

The teaching method using a model is found to be the most effective tool, while diagram and worked example are slightly better than the short video clip and 3-dimensional computer animation. The 'learn from mistakes' example is relatively less effective. It must be emphasized that the above findings are based on one single experiment and also the mean scores for each teaching tool are rather close. In other words, no particular teaching tool is far better than the other tools. It is believed that the findings from this experiment could shed some light on how Hong Kong students learn a concept/theory.

Keywords

Classroom lecture, student learning, teaching effectiveness, teaching tool

INTRODUCTION

A variety of teaching tools is needed for clear and comprehensive explanations of theories and concepts. In classroom lectures, course instructors commonly use diagrams, models and worked examples to describe and explain concepts in the subject matter. However, the effectiveness of these teaching tools in student learning is unknown. Other than the above three teaching tools, methods such as short video clips, 3-dimensional computer animations, and 'incorrect' 'learn-from-mistakes' examples can be used for classroom teaching to illustrate the key components of a concept or an abstract theory. Effective teaching tools integrate the theory with the real world and hence stimulate the interest of the students in the subject matter. Unfortunately, research on the assessment of different teaching methods is rarely found. Therefore, the

ultimate objective of this study is to measure the effectiveness of the six different teaching tools (diagrams, models, worked examples, short video clips, 3-dimensional computer animations, and ‘learn from mistakes’ examples).

To achieve the ultimate objective of this study, a 120-minute large-class experimental classroom lecture was carried out in three phases: (i) delivering a classroom lecture by using each of the above six teaching tools; (ii) administering a questionnaire/survey after the classroom lecture; and (iii) analyzing the results of the questionnaire/survey to compare the effectiveness of each teaching tool. Large-class teaching requires a special teaching approach and teaching tools. Details of this teaching approach were reported by Young and Lo (2004). This paper focuses mainly on the use of different teaching tools. Instructors should benefit from the findings of this study on how students learn abstract theories/concepts and how to prepare effective teaching materials using different teaching tools.

EXPERIMENTAL CLASSROOM LECTURE

The emphasis of this study is on the use of the six teaching tools (diagram, model, worked example, short video clip, 3-dimensional computer animation, and ‘learn-from-mistakes’ example) to explain concepts/theories effectively and to stimulate learning interest among the students. Although there are many teaching methods that can be used in classroom lectures, such as small group discussions, student presentations, role plays and so on, they are normally more useful in small classes. The six teaching tools considered in this study can be used in both small and large classes.

To assess the effectiveness of the six teaching tools, a 120-minute experimental classroom lecture was conducted with a class size of 93 students, as shown in Fig. 1. The six teaching tools were used to deliver six different technical concepts/theories. The concepts/theories were chosen to have a similar level of difficulty. Each concept/theory was taught by the same instructor using a particular teaching tool. The main reason for this experimental setup was to ensure a fair comparison among the teaching tools by having the same group of students, maintaining a similar level of technical concepts and using the same instructor.



Figure 1. Experimental classroom lecture conducted on 8 March 2004

Procedures

The procedures of the 120-minute experimental classroom lecture are shown in Fig. 2. At the beginning of the lecture, a brief but clear introduction on the ultimate objective of this experiment was given to the first-year undergraduate students from the Civil Engineering Department at the Hong Kong University of Science and Technology (HKUST). The first session of the experimental classroom lecture was comprised of three concepts and each concept was taught for 10 ± 2 minutes using one of the three teaching tools (i.e., diagram, model, and worked example). A questionnaire was then administered to assess the effectiveness of each teaching tool. Similarly, the second session of the experimental classroom lecture comprised another three concepts, which were explained using one of the three teaching tools (i.e., short video clip, 3D computer animation, and 'learn-from-mistakes' example) followed by another questionnaire. In between the first and second sessions, a 10-minute break was taken to allow the students to relax their minds. At the end of the classroom lecture, students were asked to rank the six teaching tools and provide written comments on this experiment.

Questions Asked in the Questionnaire

In the questionnaire, five questions regarding each teaching tool were asked: (Q1) The level of difficulty of this part of lecture material; (Q2) The ability of this teaching tool to illustrate the concept/theory clearly and to help the students to understand the lecture material; (Q3) The ability of this teaching tool to stimulate the student's interest in learning the lecture material; (Q4) A technical question on the concept; (Q5) The effectiveness of this teaching tool in a classroom lecture. The questions in the questionnaire for each teaching tool were identical, except for the technical question, which was specially designed for the particular concept. A sample questionnaire on 'Diagram' is given in Appendix I. Furthermore, questions on ranking the six teaching tools and written comments were asked at the end of the survey, as shown in Appendix II.

RESULTS AND DISCUSSION

A total of 93 questionnaires were collected and analyzed after the experimental classroom lecture. Table 1 shows the mean and standard deviation of the responses to each question. The scale of Q1, Q2, Q3 and Q5 is in the range of 1.0 to 5.0 with an interval of 0.5. As seen, the variation in the numbers (from 2.7 to 4.0) for questions 2, 3 and 5 was relatively small, indicating that no single teaching tool stood out from the others. In addition, there was a large standard deviation in the overall effectiveness of each teaching tool. For instance, the mean score for the diagram was 2.8 but its standard deviation was 1.4. This indicates that the perceptions of the students of each teaching tool were quite different.

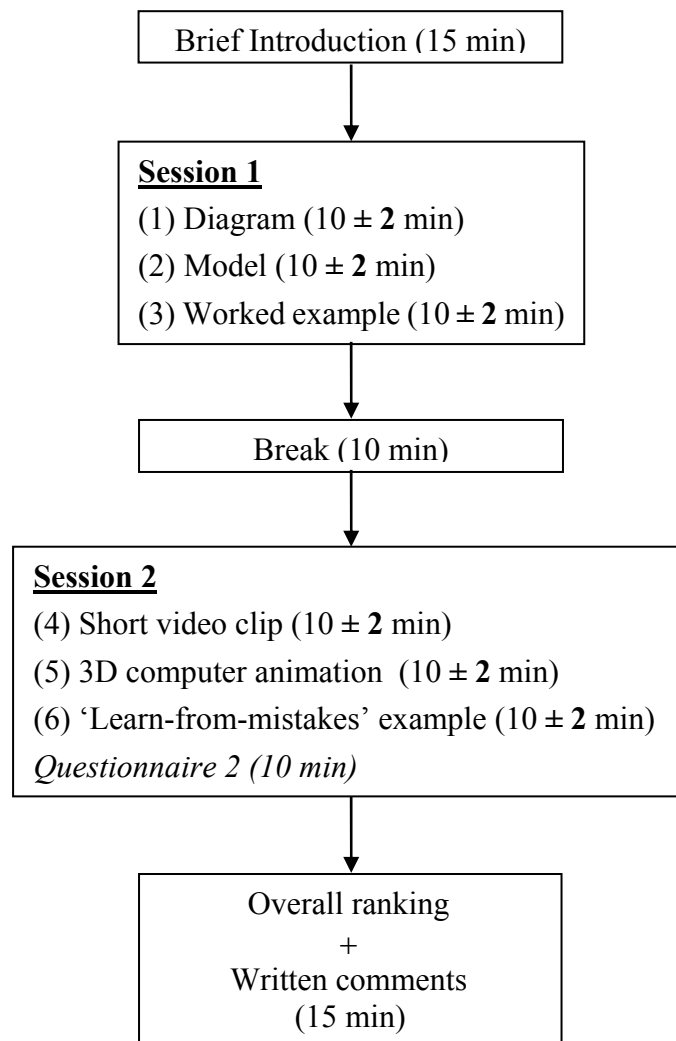


Figure 2. Procedures of 120-minute experimental classroom lecture

	Level of Difficulty (Q1)		Illustrating Concepts Clearly (Q2)		Stimulating Interest (Q3)		Individual Effectiveness (Q5)		Overall Effectiveness	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Diagrams	2.7	0.7	3.6	0.7	3.1	0.7	3.4	0.7	2.8	1.4
Models	3.2	0.8	4.0	0.8	3.8	0.7	3.8	0.7	2.0	1.2
Worked Examples	2.0	0.9	3.5	0.7	2.8	0.9	3.4	0.8	3.1	1.5
Video Clips	2.6	0.8	3.4	0.8	2.7	0.8	2.8	0.8	4.7	1.1
Animation	3.3	0.6	3.1	0.7	3.4	0.8	3.5	0.7	3.5	1.5
Wrong Examples	4.2	0.7	2.7	0.9	2.7	1.0	2.8	1.0	4.9	1.5

Remark 1: number of samples = 93; SD = standard deviation; Q1 = question 1 in the questionnaire
 Remark 2: the scale of Q1, Q2, Q3 and Q5 is in the range of 1 to 5 with an interval of 0.5, while the ranking scale for the question on overall effectiveness is from 1 (very effective) to 6 (not so effective).

Table 1. Statistical findings of the six teaching tools

The first question in the questionnaire was asked to prove our assumption that the difficulty of each concept/theory was nearly the same. The numbers shown in Fig. 3 are the mean scores of the level of difficulty for each teaching tool. As seen, the level of difficulty varied from 2.0 to 4.2. It appears that our students considered some concepts a bit more difficult than the others.

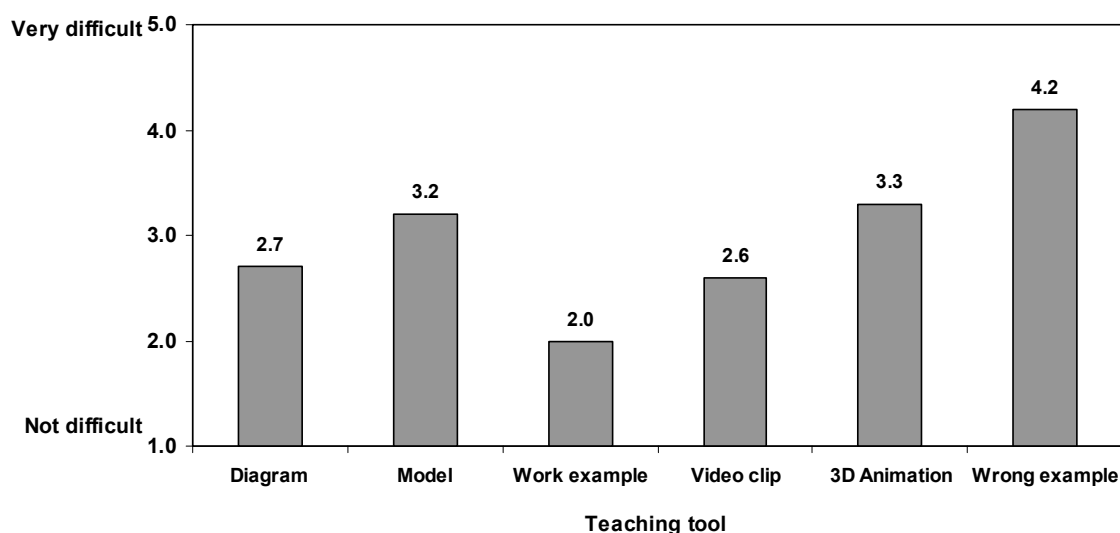


Figure 3. Level of difficulty of the six teaching tools

The second and third questions in the questionnaire were designed to collect the general impressions of students on a particular teaching tool in terms of (i) the understanding of the lecture material and (ii) the student interest in learning the subject matter. The fourth question was used to test the understanding of the students on the lecture material by asking a technical question and also to counter-check the results of the second question. The findings are plotted in Fig. 4. The first three conventional teaching tools (diagram, model and worked example) were generally regarded as methods that were able to illustrate a concept. Particularly, the model was considered as the most effective method of illustrating a concept as well as stimulating a student's interest.

Fig. 4 shows that visualization methods such as the video clip and 3D animation have similar scores to those of the diagram and worked example. However, the students who thought the video clip was able to illustrate a concept (mean = 3.4 on Q2) did not score well on the technical question (only 44.1% of the students obtaining a correct answer). Perhaps the technical question asked on the subject taught with use of the video clip was too difficult. As a result, students were confused by what they perceived. This could partly explain why the students did not rank this method high.

The mean score of the second question for 3D animation was 3.1. This was slightly lower than the scores for diagrams, worked examples and video clips, but 81.7% of the students chose the correct answer for the technical question. Two possible reasons to explain this finding are: (1) the tool was quite effective in illustrating the concept of the subject matter and/or (2) the technical question was relatively less difficult. On the

contrary, this tool is regarded as an effective method stimulating the interest of the student learning (mean = 3.4 on Q3).

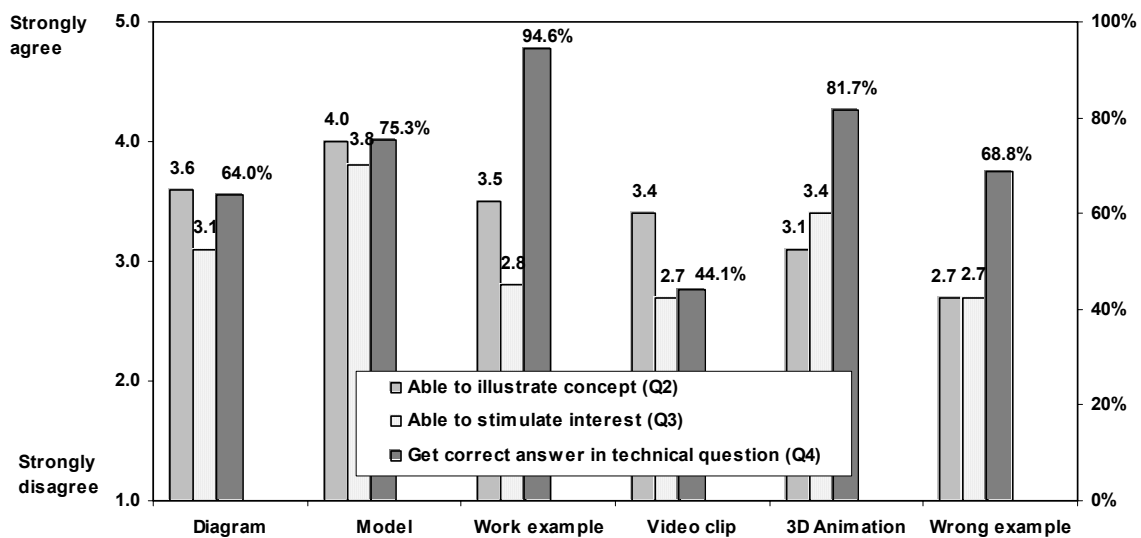


Figure 4. Usefulness of the six teaching tools in terms of illustrating a concept and stimulating interest of learning

As shown in Fig. 4, using a deliberately incorrect example for teaching a concept/theory was not considered as an effective tool compared with the other five methods. The original purpose of using an ill-structured example is to stimulate student thinking and to help students to remember the subject matter after they learn from mistakes. It should be considered as an innovative teaching method that can be used occasionally. The lowest score for this method is perhaps due to the fact that a limited time was allocated to this method and that students were thus unable to identify what was the true theory and finally felt confused by the theory.

CONCLUSIONS

A 120-minute experimental classroom lecture to some 93 students was carried out in three phases: (i) delivering classroom material by using each of the six tools (diagrams, models, worked examples, short video clips, 3D computer animations, and ‘incorrect’ examples); (ii) conducting a survey after each session; and (iii) analyzing the survey results and comparing the effectiveness of each tool.

The statistical data from the survey indicated that the conventional methods (e.g., diagrams, models and worked examples) are slightly more effective than the visualization methods (e.g., video clips and animations) and ‘incorrect’ examples. It is important to note that no single teaching tool was found to be significantly better than the others in this study. Among the six teaching methods, the model was regarded as the best tool. Although the findings are only from a single experiment, this study does shed some light on the learning approaches of Hong Kong students, thereby helping all faculty members to prepare their teaching materials.

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REFERENCE

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Appendix I

Questionnaire/Survey

Session 1.1: Questionnaire on Diagram

1. The level of difficulty of this part of lecture material.

Not difficult				Average				Very difficult
1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. This teaching tool is able to illustrate the concept/theory clearly and help you to understand the lecture material.

Strongly disagree				Neutral				Strongly agree
1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. This teaching tool is able to stimulate your interest in learning the lecture material.

Strongly disagree				Neutral				Strongly agree
1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Technical Question.

The Streeter-Phelps oxygen-sag curve model is developed based on a few assumptions. Which of the following assumptions is NOT correct?

- (a) A continuous discharge of waste at a given location on the river.
- (b) Complete and instantaneous mixing.
- (c) The rate of deoxygenation at any point is proportional to the amount of waste in the river.
- (d) The rate of reoxygenation depends on the oxygen released from photosynthesis by aquatic plants.

5. The effectiveness of this teaching tool for classroom lecture.

Not effective				Average				Very effective
1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Appendix II

Additional question:

How would you rank the overall effectiveness of the following six teaching tools?

Teaching tool	Ranking	Definition of ranking
Diagram		1 = very effective
Model		2 =
Worked example		3 =
Short video clip		4 =
3D computer animation		5 =
Wrong example		6 = not so effective

Additional comments: