Learning to Support the Instructor: Classroom Assessment Tools as Discussion Frameworks in CS 1

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ABSTRACT

In this paper we describe and evaluate Classroom Assessment Tools (CATs) designed to encourage interaction and student ownership in an introductory programming course (CS 1). Traditionally, Classroom Assessment Techniques allow instructors to collect feedback from students regarding their understanding of course material [2]. We developed and categorized over 60 specific CATs to facilitate discussion and learning in a CS 1 course. The Classroom Assessment Tools described in this paper highlight concepts from recorded lectures that are used in CS 1 distance courses employing the Tutored Video Instruction (TVI) model. We present a qualitative evaluation of Classroom Assessment Tools as discussion frameworks in a TVI course offering. Evidence from site observations, interviews with the instructor and students, and survey responses from the instructor and students indicate that the CATs created classroom interaction, improved students' attitudes in the course, and provided assessment opportunities for the instructor.

Categories and Subject Descriptors

K.3 [**Computing Milieux**]: Computers and Education

Keywords

Distance education, classroom assessment, tutored video instruction

1. INTRODUCTION

Learning to program is generally an active process; however, computer programming is often taught through lecture material, creating a passive environment [10, 8]. In any teaching model instructors encounter the challenge of presenting material while making the class feel personal to students. The lack of personal attention students feel in a distance learning environment is magnified. Our experiences with a distance learning course led us to develop assessment tools to give students local ownership of the course and provide support for the instructor. We designed a suite of Classroom Assessment Tools (CATs) to create active learning experiences for student ownership and to provide frameworks for discussion in a CS 1 course.

Bonwell and Eison assert active learning techniques are vital to student learning [3], engaging students in reading, writing, discussing, and solving problems. Using active learning techniques is among the seven principles for good practice in undergraduate education [4]. Additionally, good practice in undergraduate education includes giving prompt feedback for student assessment and respecting diverse ways of learning [4]. Students need frequent opportunities to receive feedback on their performance and need opportunities to learn in ways that work for them. In response to our experiences studying and creating a distance learning environment and keeping good practices in mind, we developed a set of Classroom Assessment Tools to scaffold student learning in introductory computer science.

We have distributed lecture materials for introductory programming courses to colleges employing the Tutored Video Instruction (TVI) teaching model. After assessing the students' and instructors' experiences using the TVI materials, we designed over 60 CATs to give students local ownership of the class. We distinguish our suite of assessment tools from the general techniques for classroom assessment [2] by referring to our set of tools as Classroom Assessment Tools, or CATs. These tools, implementing a variety of assessment techniques, are designed to enhance discussion among students and the instructor, provide concrete experiences in active learning, and generate feedback about students' conceptions about programming. We designed a wealth of tools covering a range of introductory topics in computer science to target various learning and teaching styles.

This paper provides a description of a Tutored Video Instruction classroom, conclusions made from our previous experiences with the TVI project, a general introduction to Classroom Assessment Techniques, our methodology in designing and evaluating Classroom Assessment Tools, and an evaluation of CATs in a TVI setting.

2. INTRODUCTION TO TUTORED VIDEO INSTRUCTION

Jim Gibbons and colleagues developed the teaching technique of Tutored Videotape Instruction[1] in the late 1970's

[1]Notice that we refer to Tutored Video*tape* Instruction in

ITiCSE'02 June 24-26, 2002, Aarhus, Denmark.

[6]. Their original proposal for TVI utilizes unrehearsed videotapes of classroom courses for viewing by a small number of students (3 to 10 students). An on-site tutor assists the students when they interrupt the tape to ask a question. Gibbons and his colleagues first employed the TVI model to allow participation in a course by a group of graduate engineering students at a remote site. In the study conducted by Gibbons et al. students using the TVI model out-performed the on-campus students by measure of GPA. Gibbons also found that having a tutor at the remote site is a key component to achieving success with the TVI model.

3. EXPERIENCES WITH TVI COURSES

Several motivations led to the development of Tutored Video Instruction materials for introductory computer science courses. By offering university course materials to community colleges, course credits are easily transferable. Additionally, community colleges face the challenge of hiring and retaining qualified faculty in computer science; community college instructors with limited experience in teaching or programming can facilitate courses using the TVI model. Our goal was to provide an alternative teaching model and course materials to community college instructors teaching CS 1 and CS 2.

Kors, Postner and Shelton conducted observations of local community college instructors teaching CS 1 and CS 2 with the TVI materials [7, 11]. Student and instructor interaction was less frequent than the experiences described by Gibbons [6]. In the observed sessions, the instructor often initiated the discussions by pausing the video. Each discussion lasted, on average, under two minutes [7]. Some community college students taking CS 1 in the TVI model had negative experiences in the course since a live instructor did not deliver the lectures [1]. The students had difficulty identifying with the "University of Washington" instructor and felt that the TVI course was a "University of Washington" course not designed for them. In another study of 25 community college students conducted by Lowell and Clelland-Dunham, they found that 62% of students taking CS 1 in the TVI format did not enjoy the course and 64% would not recommend the course to a friend [9]. These observations, interviews with the instructors, and student survey responses provide evidence that teaching introductory computer science in the TVI format needs support to encourage student-student and student-instructor interaction, providing local ownership in the course.

3.1 CATs in the Context of TVI

We responded to the issue of students not feeling locally involved in the course by developing and classifying a repository of Classroom Assessment Tools to supplement each lecture video. Classroom Assessment Techniques can provide scaffolding for student discussion in addition to giving students concrete examples and evidence of their own (mis)understanding. Our repository of Classroom Assessment Tools provides an additional instructional mode to support students who learn best in an active environment. Our hypothesis is that CATs encourage local interaction, improving students' attitudes in a TVI course.

this section. Our technology no longer uses tapes; instead, we use streaming video.

4. CLASSROOM ASSESSMENT TECHNIQUES

Classroom Assessment Techniques are learner-centered activities that are ungraded and usually submitted anonymously by students. This type of activity encourages students to be honest in what they do and do not understand in a course. Instructors, after evaluating the responses submitted by students, can address student concerns and questions in a timely manner.

Angelo and Cross promote the use of Classroom Assessment Techniques to collect feedback from students about what and how they are learning the material [2]. With frequent use of these techniques, instructors can monitor student progress throughout the course. These techniques provide a continual feedback loop for the instructor and could potentially prepare students better for exams and programming projects. By using a variety of Classroom Assessment Techniques and instructional methods, instructors can learn how students respond to various teaching approaches. Some students learn material in a lecture/video environment while others need concrete activities; providing lecture material combined with Classroom Assessment Techniques targets both learning styles. We created a suite of Classroom Assessment Tools for assessment purposes in addition to our objective of creating student ownership and discussion. CATs are a novel solution for eliminating the "distant" feeling of a TVI course.

In a study conducted by Steadman, she found that students' attitudes improved when using Classroom Assessment Techniques [12]. Students feel that they have more control and voice in the classroom. The techniques also encourage students to be involved in their own learning by monitoring their progress in a course. Steadman's findings suggest that Classroom Assessment Techniques may improve student learning and attitudes in an introductory programming course taught in the TVI model. Giving students more control and ownership in the course might encourage them to participate and initiate discussions with other students and the instructor during and after lecture presentation.

5. METHODS

Angelo and Cross provide a teaching goals survey to direct professors in developing appropriate Classroom Assessment Techniques to achieve their goals [2]. We administered this survey to four college instructors to discover their goals when teaching introductory programming courses. These four instructors included people who have previously taught in the TVI format and those who would be using the TVI materials in the future. Table 1 shows the number of times each goal scored in the top three of the six goals in the four surveys. One survey had three goals that tied for the third position, accounting for the total of 14 in Table 1.

We used the results of these surveys to create a set of appropriate Classroom Assessment Tools targeting the goals listed in Table 1 for CS 1 lectures. The CATs we developed are content specific, testing knowledge related to the main concepts in each lecture. There are a variety of activities ranging from role-playing activities to code-writing exercises. We provide a variety of CATs for each lecture so that instructors can choose CATs appropriate in content and style for their students. Table 2 gives a listing of types of specific CATs in the repository associated with three lec-

Inventory Goals Results

Goal	Number Times
I. Higher Order Thinking Skills	4
II. Basic Academic Success Skills	1
III. Discipline-Specific Knowledge and Skills	4
IV. Liberal Arts and Academic Values	1
V. Work and Career Preparation	3
VI. Personal Development	1

Table 1: The number of times each goal is among the top three in teaching goal inventory survey results from four introductory computer science instructors.

CATs Associated with Three Example Lectures

Lecture Content:	Variables Values, Types	Arithmetic Expressions	Input & Output
CATs:	Focused Listing	Problem Recognition Tasks	Concept Maps
	Categorizing Grid	Expression Exercises	Categorizing Grid
	Programming Activity	Documented Problems Solutions	

Table 2: Example CATs developed for three lectures of the TVI introductory programming course curriculum. Each CAT covers a specific concept from the associated lecture.

tures. The types of CATs are described in *Classroom Assessment Techniques* by Angelo and Cross [2]. Many CATs encourage small group collaboration while some are individual exercises or whole class activities.

The complete set of CATs and classifications developed for the CS 1 Tutored Video Instruction (TVI) lectures can be found on the course web site.[2] Instructors can easily choose a CAT for their needs since they are organized by lecture topic. Each CAT comes with a list of goals associated with the tool, the content tested, the activity as the instructor would give it to the students, possible solutions to the activity, and a list of suggestions for extending and adapting the CAT.

We studied the use of CATs in a classroom using TVI materials. We discussed the objectives for using CATs in the classroom with the instructor prior to the start of the academic term. In order to assess the CATs we conducted a site observation to see how students use the tools, collected survey data from the instructor about specific CATs, interviewed students in the TVI course, interviewed the instructor, and collected survey data from the students. We followed Erickson's qualitative methods to guide analysis of the data [5].

[2]www.cs.washington.edu/education/online/cse142/

6. EXAMPLES OF CATS

We provide two exemplary CATs from our repository in this section. The first example illustrates the organization of the material we provide to college instructors. The first example CAT uses the technique of approximate analogies to encourage students to think about how programming relates to a different domain. The second example (activity description only) uses the technique of concept mapping to provide a way for students to organize their thoughts about a particular topic.

Example 1: (From Spring 2001 offering[3])
Lecture 2: Problems, Algorithms, and Programs
Content Tested: Syntax and Semantic Errors
Lecture Content:

- Problems, Algorithms, Programs
- Problem Solving
- Compiling and Running a C Program
- Errors and Debugging

Goals:

- Ability to synthesize and integrate information
- Learn concepts and theories
- Develop capacity to think for oneself
- Improve memory skills
- Develop ability to think creatively

Assessment Technique: Approximate Analogies
Purpose: To allow instructors to find out if students understand the differences between a syntax error and a semantic error and to discover relationships between these concepts in another domain.
Activity: Write the following on the blackboard, overhead, or a piece of paper:

Imagine a game or sport you like to play. (Or, if you're a musician, use musical scores for this analogy). Now, in that new domain (games, sports, or music) describe what the difference between a syntax error and a semantic error would be. Give concrete examples of a syntax error and a semantic error.

Sample Responses:

Let's look at a sport. Syntax errors in a sport would be violations of the rules of the game. For example, if the sport is soccer then the players (other than the goalie) catching the ball with their hands would be a syntax error. A semantic error would be poor execution of a play or a poor strategy to win the game. For example, the soccer team might have a play to kick the ball to a certain person to score and a semantic error would be the team failing to get this person the ball at the appropriate location.

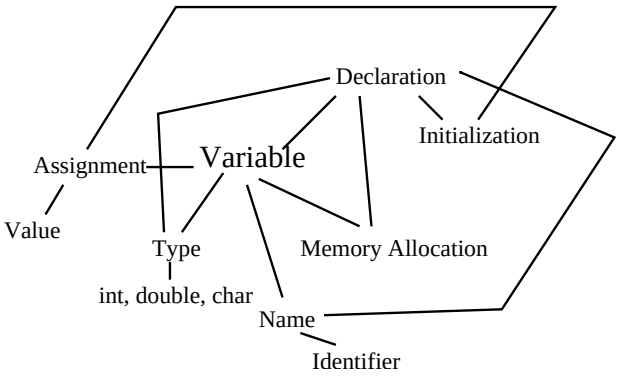
Let's look at music. If a musician is composing a piece, a syntax error would be an error in writing down the appropriate notes or dynamics. A semantic error would correspond to someone playing the wrong notes according to the written music.

Possible Uses of Activity:

[3]www.cs.washington.edu/education/courses/cse142/01sp/

- Have students write responses individually and submit these to the instructor anonymously. The instructor reads the responses and the class discusses why the analogies fit or don't fit.
- Break students into small groups (2-4 people) and have each group create two or more responses. Have each group explain why their responses fit or don't fit the analogy.

Example 2:
Lecture 5: Input and Output
Assessment Technique: Concept Map
Activity:
In groups, have students create a concept map about the concept "Input". Additionally, the students should create a concept map about the concept "Output". In order to guide the students, give them the following concept map of "Variable".



A concept map is a map with concepts and arcs. If two concepts go together in the model, then place an arc between them. Design a concept map for "Input" and a separate concept map for "Output". When labeling edges in your group, discuss why the concepts are related.

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7. EVALUATION OF CATS IN A TVI SETTING

7.1 Background on the Institution and Students

We studied the effectiveness of using our repository of Classroom Assessment Tools in a TVI course taught at a small, rural, liberal arts college with an ethnically diverse set of students. The course had a total enrollment of 12 students, 8 females and 4 males. The instructor has a Ph.D. in mathematics and taught introductory programming in the C language using the TVI materials for the first time. Most of the students in the course were majoring in the sciences including computer science, math, physics and biochemistry.

7.2 Classroom Interaction

Our instructor survey data and field observation data provide evidence that students engage in interactive activities while completing the CATs. During the 85-minute class session we observed, the instructor showed the lecture video for 28 minutes and students worked on a Classroom Assessment Tool for 18 minutes. The instructor gave an introduction to the details about turning in homework for 15 minutes and discussed the answers to the CAT for 24 minutes. During the playing of the video, no questions were asked of the instructor even though the instructor stopped the video five times to reinforce points made by the lecturer in the video. When handing out the Classroom Assessment Tool, the instructor gave the students the option of working with a partner or working alone. Seven of twelve students worked with another person to find a solution and/or check their solution. Five of the seven students who worked with another person told us in an interview at a separate time that they did not work with other people in the course. These five students were not aware of their own levels of interaction in the course.

When asked if the CAT helped facilitate classroom instruction, the instructor had the following comment about the CAT listed as Example 1 in this paper: "I think it complimented the lecture material and helped with classroom instruction. It was a nice change of pace and allowed for additional student interaction and active learning." When giving the the CAT listed as Example 2, the instructor gave them the option of working alone or together and a majority of the students worked with at least one other student.

Evidence gathered through surveys, observations, and interviews indicate that students entered into an active learning environment by discussing concepts with their classmates.

7.3 Student Attitudes of the Teaching Style

To gauge the feeling of local ownership and attitudes of the teaching style, we interviewed five (4 female, 1 male) of the twelve students in the course. All the students said they were excited about the TVI format and would take another class in a similar format. They had differing opinions about the video. All five thought the video was informative, but two of the five students did not think that the video was engaging. One responded that the video is "a little bit boring, but very helpful." Four of the five students that we interviewed liked the balance of "hands-on" activities and the lecture video. We asked two students if they thought watching the video at home would be an equal substitute for attending class. Both students responded that the video alone could not equal being in class. These students feel local ownership in the course by making attendance in class a priority.

We asked the students to complete a survey about their experiences in the course. Nine (5 female, 4 male) students completed the survey. We asked them to rate on a 5-point scale (Strongly Agree = 5, Somewhat Agree = 4, Neutral = 3, Somewhat Disagree = 2, Strongly Disagree = 1) their thoughts about various components in the course helping them learn how to program. We computed the average score response for each category with the results as follows: Homework (4.55), CATs (4.11), Lecture Videos (4.00), Quizzes (3.89), Textbook (3.89), Exams (3.67). Overall, the students' perception of the usefulness of the resources is positive.

We asked the students in survey questions "Do you enjoy the teaching format of this course? Why or why not?" and "Would you recommend this course to a friend? Why or why not?". The responses, separated by gender, are shown in Table 3. The results give evidence that most students

Student Attitudes by Gender

	Response	Male	Female
Enjoy	yes	4	3
	no	0	1
	indifferent	0	1
Recommend	yes	4	3
	no	0	1
	depends	0	1

Table 3: Results of students by gender about their enjoyment of the course and if they would recommend the course to a friend.

in the course we studied had positive experiences in the TVI course. These results, although not significantly significant due to the small number of students in our study, are different than the set of 25 students (at three different community colleges) who took the course in the TVI format previous to the development of the CATs. In this set, 38% of the students did not enjoy the course and 36% would not recommend the course to a friend [9].

7.4 Assessing Student Learning

As mentioned previously, CATs have the additional benefit of giving instructors the ability to assess student understanding about concepts. When asked if the CAT listed as Example 1 helped in assessing the students' levels of understanding, the instructor replied, "The CAT was helpful in identifying students that were still having trouble distinguishing between the two (syntax vs. semantic) error types." Describing the CAT listed as Example 2, the instructor commented, "It was a catalyst for questions regarding syntax (use of &, etc.) and issues related to the concepts of input and output."

We asked four of the five students that we interviewed if they had completed any in-class activities. All four remembered they did an activity about sports and error types. One of the students responded that "A syntax error would be running with the ball in soccer and a semantic error would be missing your kick." A second student followed on by saying that a semantic error is "a mistake that doesn't break the rules."

Our data suggest that the CATs given to students in a TVI course help the instructor assess the students' levels of understanding. The tools also provide concrete activities as frameworks for students' questions.

8. CONCLUSIONS

We developed a repository of Classroom Assessment Tools to give students local ownership and to facilitate interaction in a course taught in a Tutored Video Instruction format. Our experiences with the TVI course in previous settings informed our design and development of Classroom Assessment Tools. We have and will continue to assess our intervention of CATs in a TVI classroom. Our results suggest that the instructor and students benefit from having concrete activities supporting lecture material to foster interaction in the classroom.

Acknowledgments

This study was funded by the Program for Educational Transformation through Technology, a university initiative fund at the University of Washington. We would like to express our thanks to the college instructors and students who are using and providing feedback on the Classroom Assessment Tools. We thank Lori Postner for proofreading the CATs and for helping with data collection. We also thank Jennifer Turns, Steve Wolfman, Sarah Schwarm and Lori Postner for many helpful comments on drafts of this paper.

9. REFERENCES

[1] R. Anderson, M. Dickey, and H. Perkins. Experiences with Tutored Video Instruction for Introductory Programming Courses. *SIGCSE Proceedings*, 33(1):347–351, March 2001.

[2] T. A. Angelo and K. P. Cross. *Classroom Assessment Techniques: A Handbook for College Teachers.* Jossey-Bass, 1993.

[3] C. C. Bonwell and J. A. Eison. Active Learning: Creating Excitement in the Classrooom. eric digest. *ASHE-ERIC Higher Education Reports, The George Washington University*, 1991.

[4] A. W. Chickering and Z. F. Gamson. Seven Principles for Good Practice. *AAHE Bulletin*, 39:3–7, March 1987.

[5] F. Erickson. *Handbook of Research on Teaching.* MacMillan, New York, 1986.

[6] J. F. Gibbons, W. R. Kincheloe, and K. S. Down. Tutored Videotape Instruction: A New Use of Electronics Media in Education. *Science*, pages 1139–1146, March 1977.

[7] K. Kors. Redesigning Tutored Video Instruction: Recommendations for Higher Education Programs Using TVI. Technical report, Program for Educational Transformation through Technology, University of Washington, 2001. http://depts.washington.edu/pettt/papers/.

[8] G. Lewandowski and A. Morehead. Computer Science Through the Eyes of Dead Monkeys. *SIGCSE Proceedings*, pages 312–316, 1998.

[9] N. Lowell and Z. Clelland-Dunham. Student course evaluations and grades in cse 142 and 143: Winter and Spring 2000. Technical report, Program for Educational Transformation through Technology, University of Washington, 2000. http://depts.washington.edu/pettt/papers/.

[10] J. J. McConnell. Active learning and its use in Computer Science. *ITiCSE Proceedings*, pages 52–54, 1996.

[11] B. E. Shelton and L. Postner. Tutored Video Instruction: A Preliminary Qualitative Evaluation of Computer Science at the University of Washington. Technical report, Program for Educational Transformation through Technology, University of Washington, 2000. http://depts.washington.edu/pettt/papers/.

[12] M. Steadman. Using Classroom Assessment to Change Both Teaching and Learning. *New Directions for Teaching and Learning*, (75):23–35, 1998.