SIGGRAPH as Textbook: Learning Skills for Undergraduates

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Abstract

This paper describes the design and implementation of a student-centered course in advanced undergraduate computer graphics. Instead of providing students with all necessary background before exposing them to recent research, students start with the latest SIGGRAPH proceedings and discover what topics they need to learn to understand them. The power of the group of students is exploited by having each student write a tutorial on one of the topics. Students then trade these written tutorials before being tested on the SIGGRAPH papers themselves. The course aims to nurture lifelong learning skills as well as an understanding of state of the art methods in computer graphics.

1 Introduction

The annual SIGGRAPH proceedings are a unique educational resource. Few other fields can boast such a compact collection of the most important papers of the year. As such, the SIGGRAPH proceedings are frequently a topic of study in advanced computer graphics seminar courses. However, the breadth and depth of background knowledge required for understanding papers in the SIGGRAPH proceedings pose a real challenge for educators. How can we give our students adequate preparation?

Simply expanding the range of prerequisite courses is not a viable option. Students have only so many electives to choose from and want to study cutting edge research as early as possible. Furthermore, the set of background topics required for the latest results in computer graphics is continually shifting.

This paper describes a student-centered approach to understanding the SIGGRAPH proceedings. Students start by choosing a set of the latest SIGGRAPH papers that the group will be responsible for. At first, they use the papers merely to identify gaps in their background knowledge. They then embark on individual research projects to fill those gaps. Each student works on filling only one gap, and then shares his or her newfound knowledge with the rest of the group. Ultimately, they are examined on the original set of SIGGRAPH papers.

This approach aims to increase confidence and to develop lifelong learning skills at the same time as it teaches computer graphics. It has elements of both peer assisted learning [Pigott et al. 1986; Wills et al. 1997; Donelan and Wallace 1998; Ploetzner et al. 1999] and problem-based learning. It was developed from earlier work in teaching computer vision [Novins and McCane 2001; Novins and Ming-Wong 2001].

2 Design and Implementation

The ideas outlined above were tested in a four-week unit of an undergraduate course in computer graphics at the University of Auckland. The earlier units of the course were taught in a traditional lecture-based format. Enrollment for the course was twenty fourth-year students with a half-semester third year course in computer graphics as a prerequisite. The stated goals for the student-centered unit of the course were:

- To identify active areas of computer graphics research.
- To develop research, writing and presentation skills.
- To work as a group to study one area of computer graphics research in depth.

The course had a scheduled group meeting three times a week for an hour. Each student's main task during the unit was to produce a written tutorial for use by the other students on an essential piece of background knowledge in computer graphics. However, there were a number of assessed activities leading up the submission of the written tutorial. The course design and implementation are described in the following subsections.

2.1 Week 1: Selection of SIGGRAPH Papers

Since the group could not study all 65 papers from SIGGRAPH 2001 in depth in just four weeks, it was necessary to select a subset of them. We chose two papers from each of two sessions of the conference. The selection process was performed by the students in conjunction with a group activity designed to give everyone a brief overview of all 65 papers.

Each student was randomly assigned a session from the SIGGRAPH conference. Their job was to skim each of the papers in that session and make a quick evaluation about how interesting it would be to study and how difficult it would be to study. They were then to make a poster summarizing their findings based on a given template. Posters were assessed and counted towards 10% of the mark for the unit.

The first session of the week was an introduction to the unit and the second session was an optional question-and-answer session regarding the poster work. This left the third meeting for the poster session and a vote on which papers to study.

Students were enthusiastic about the poster project and all students did a good job. The poster session was lively, with students "campaigning" for their personal favorites.

At the end of the hour, we had three secret ballots. First to determine a short list of potential SIGGRAPH sessions, next to choose two sessions to study, and finally to select two papers from within each of the winning sessions.

The papers chosen were from the Hands and Words [Baxter et al. 2001; Cassell et al. 2001] and Animation and Expression [Sun and Metaxas 2001; Noh and Neumann 2001] sessions. After the session, five students were assigned to each paper.

2.2 Week 2: Choice of Topic Areas

The first two formal sessions of the second week were cancelled. Instead, each student had a half-hour individual meeting with the instructor to choose the topic for their tutorial. Before the meeting, each student was responsible for making an initial reading of their assigned paper, noting any confusing sections or unfamiliar jargon. Preparation for the meeting was worth 5% of the unit mark.

Students were given a handout identifying four criteria for a good tutorial topic:

- *Relevance* – Your topic should be chosen so that your final tutorial will help the reader to understand the methods, results, or context of your assigned paper in greater depth than they would simply by reading the assigned paper. Your topic need not be part of computer graphics itself.

- *Value* – The topic should be chosen so that the final tutorial will be of value to your peers. That is, it shouldn't be about something that most of them know about already ... or could easily learn with a quick internet search.

- *Research Potential* – The topic should lead you to research other sources besides your assigned paper. You'll need to find both library and Internet resources.

- *Uniqueness* – Your topic should be distinct from the topics of others in the class.

Discussion at the meetings focused on choosing a background area that met the criteria and identifying starting points for learning about that topic. It usually wasn't difficult to avoid overlapping topics, since different students had different backgrounds and interests. In a few cases, negotiation was necessary.

For the third session of the week, each student met with the others who were researching background knowledge for the same paper. This allowed them an opportunity to share insights on the paper and to plan a group paper presentation in the following week.

2.3 Week 3: Paper Presentations

During the third week, the formal sessions were devoted to short presentations of the papers by the students writing tutorials for them. These could not be comprehensive. They were meant to give all students an overview of the papers that they would be responsible for on the final exam. Students were encouraged to plan their talk around the following focus questions:

- What is the problem that the paper is trying to solve?

- What solutions are the authors proposing? How well do they work?

- How are the solutions different from existing solutions to the problem?

- What parts of the paper are most difficult to understand?

- How good are the results? Do they match the authors' claims?

- What are the limitations of the system?

- Are there any limitations that the authors don't report?

Each group was also responsible for asking questions of other groups after their presentations. They had to divide the tasks of formal presentation, question answering and question asking among themselves to spread the workload. Group performance was worth 10% of the unit mark.

The group presentation and associated activities helped to develop a healthy "team spirit" among those studying the same paper. The restriction of formal presentation to just fifteen minutes and the requirement that every group ask at least one question of each of the other groups led to interesting discussion sessions. It encouraged broad understanding of the papers and critical analysis; however the sessions were light on technical details.

Another activity during the third week was a second individual half-hour meeting with the instructor. Students were expected to have made substantial progress on their tutorial research by this time and were asked to bring an outline and a list of references that they had uncovered in their research. Preparation for the second meeting counted for 5% of the unit mark.

2.4 Week 4: Peer Review

Students were required to write a complete draft of their tutorial and to bring two copies of it to the sessions in the fourth week. These drafts were distributed and each student read and reviewed as many drafts as possible. The review form contained the following instructions: "As reviewer, your task is to give the author of the tutorial constructive feedback about the content and clarity of the draft tutorial. Focus your comments on how the tutorial affects your learning. Be as specific as possible, and be sure to include both positive and negative feedback. Suggest ways that the tutorial could be improved." The draft tutorial and peer reviews counted for 20% of the unit mark.

Students took the draft tutorials and peer reviews seriously. It was an early chance for students to share knowledge and it enabled them to see how others were going about explaining complex material.

It also was an opportunity for students to discover whether they had pitched their tutorials to the right levels. While this succeeded in some cases where students had assumed too high a level of mathematical sophistication, most student reviewers were shy about giving negative feedback and about admitting that they didn't understand things. Many comments related to grammar, spelling and format rather than tutorial content. In retrospect, student reviewers should have been given clearer guidelines, perhaps including some sample reviews.

2.5 Final Tutorials

Final written tutorials were due at the end of the fourth week and were worth 50% of the unit mark. They were marked on both technical content and clarity. Students were told to use their SIGGRAPH paper as a general guide to length and format. Formal writing was not a requirement. Students were reminded that their audience was their peers and that they should avoid jargon.

As soon as they were received, final tutorials were put on the course web page so that other students could refer to them while studying for the final exam.

It was disappointing to discover that four of the twenty students engaged in plagiarism of published sources in their final tutorials. Three of those students were international students who may have had misconceptions about what was acceptable in addition to difficulties with written expression in English.

For the other students, final tutorials were of good quality, with a tighter spread of grades than the students' incoming grade point averages. This was perhaps due to the fact that they exchanged drafts as part of the peer review process and were able to increase or decrease their subsequent work in response to how they felt they were doing relative to the rest of the class. Weaker students performed better than they had in other courses and many of the top students performed worse.

2.6 Final Exam

A third of the closed-book two-hour final exam was devoted to the SIGGRAPH-oriented unit. Students were responsible for all four papers on the final exam. On the exam itself, students were given a choice of answering one of two essay questions. They were to support their answers using materials from at least three out of the four papers that were studied.

Performance on the exam correlated with performance in the unit assignments; however the overall quality was lower. This may indicate that the students did not find their peers' tutorials as useful as expected. However, there were several complicating factors including time pressure from other parts of the final exam, a short gap between handing in the tutorials and the final exam, and time pressure from other courses. More research is necessary.

3 Feedback

A student survey was performed just before the final tutorials were due. Fourteen out of the twenty students participated. They were asked to respond to the statements in Appendix A by rating their agreement as one of five steps on a scale from 0 (strongly disagree) to 4 (strongly agree). A mark of 2 is neutral. Average scores, standard deviations and departmental averages are given in Table 1. Departmental averages are across all undergraduate Computer Science courses.

In Questions 10 and 13, students rated the amount learned and the overall effectiveness of the teaching higher than the departmental average. In Question 1, all students agreed or strongly agreed with the statement "Material was presented in an interesting manner." In Question 12, just over three quarters of respondents agreed or strongly agreed with the statement "I would like more teaching in this format."

Students were also asked for written comments about the best and worst aspects of the course. In terms of the best aspects of the course, students cited the course content, individual choice of topic and accessibility of the instructor. One student commented: "[I] really enjoyed the change of style, and getting to study some of the newest developments in graphics. [It] was good to give students input into what was studied as it ultimately must increase interest. Often at university we take subjects thinking they should be really interesting and they focus on the boring stuff!" The aspect most cited as needing improvement was the workload. Although most students reported that the workload was fair, a substantial minority thought more time should have been given for researching and writing the final tutorial. One student noted that "consistent work [was] required ... [causing] strain on other assignments."

Statement	Mean	Std. Dev.	Dept. Mean
1. Presentation Interesting	3.50	0.50	2.51
2. Assignments Effective	3.14	0.52	2.76
3. Workload Fair	2.50	0.82	2.54
4. Lecturer Responsive	3.50	0.50	2.78
5. Lecturer Attitude	3.71	0.45	3.00
6. Lecturer Available	3.36	0.89	2.60
7. Diverse Backgrounds	3.00	0.82	N/A
8. Lecturer Enthusiasm	3.86	0.35	2.93
9. Lecturer Organized	3.00	0.38	2.79
10. Amount Learned	3.00	0.53	2.61
11. Interest Increased	3.00	0.78	N/A
12. Like Format	3.00	0.85	N/A
13. Overall Effectiveness	3.15	0.53	2.64

Table 1: Results of the student survey. The numbers indicate average level of agreement with the statements, which are reproduced in full in Appendix A.

4 Conclusions and Future Work

This paper presented the design of a student centered advanced undergraduate computer graphics course. Students start by selecting papers from the latest SIGGRAPH proceedings that they want to study, and work backwards through the literature to gain the background knowledge that they require. Through the use of shared written tutorials, each student is able to benefit from their peers' research, enabling them to achieve more in a limited period of time than they could on their own.

The course design was largely a success in the small study outlined here. Students were enthusiastic participants and developed computer graphics research skills at the same time that they learned about the latest techniques. They were pleased with the outcome.

The design is not without its flaws, however. An open question is how well the students were able to learn from each other's tutorials. This is an important area for future research. In the implementation outlined here, time pressure affected most of the students, probably reducing their ability to explore others' work. In the next incarnation of the course, the unit will be expanded to six weeks.

Time pressure affects the instructor as well. One-on-one meetings with students are an important part of the design, and require a large number of contact hours. This is balanced somewhat by a reduced load of lecture preparation. For larger classes, additional teaching assistants would surely be necessary.

Deep understanding and original tutorial content can be increased as a result of requiring a computer implementation as well as research and writing. This appears to be true even if the programming project is relatively small [Novins and McCane 2001; Novins and Ming-Wong 2001]. An interesting challenge will be to introduce implementation work into the problem.

Further work in this area seems well justified. As the joint IEEE/ACM task force on the Year 2001 Model Curricula for Computing (CC2001) states:

> An essential requirement of any computer science degree is that it should enable graduates to cope with – and even benefit from – the rapid change that is a continuing feature of the computing field. But how does one achieve this goal in practice? At one level, the pace of change represents a challenge to academic staff who must continually update courses and equipment. At another level, however, it suggests a shift in pedagogy away from the transmission of specific material, which will quickly become dated, toward modes of instruction that encourage students to acquire knowledge and skills on their own.
>
> Fundamentally, teaching students to cope with change requires instilling in those students an attitude of mind that promotes continued study throughout a career. [CC2001 2001].

This work is hopefully a step in the right direction.

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A Student Survey Statements

Student levels of agreement with these statements are given in Table 1.

1. Material was presented in an interesting manner.
2. Assignments, tests, etc. were effective aids to learning.
3. Workload was fair.
4. Lecturer responded to students' questions in a constructive way.
5. Lecturer had a positive attitude toward students.
6. Lecturer was available to students outside class times.
7. Lecturer worked well with students from diverse backgrounds.
8. Lecturer showed enthusiasm for the subject.
9. Lecturer was well organized.
10. Amount learned overall (0=nothing, 4 = a lot).
11. My interest in the subject has increased as a consequence of this paper.
12. I would like more teaching in this format.
13. Overall effectiveness of teaching (0=very poor, 2=average, 4=very good).