Advanced Digital Animation Curriculum Development: An Interdisciplinary Approach

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Technical Report No. UCB/EECS-2009-90
http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-90.html

June 5, 2009

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by

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B.A. (University of California, Berkeley) 2005

A thesis submitted in partial satisfaction of the

requirements for the degree of

Master of Science

in

Computer Science

in the

Graduate Division

of the

University of California, Berkeley

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Spring 2009

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Dedication

For Grandma Ruu,

who taught me how to love learning.

For Grandpa Bob,

who taught me, “red to red, black to black.”

For Grandma Mary,

who always believed in me, even when I did not.

For Mom and Dad,

who let me learn through my own (multiple) mistakes.

For all of my family and friends,

who have accompanied me as I have walked along this road.

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Abstract

Advanced Digital Animation Curriculum Development:

An Interdisciplinary Approach

by

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Master of Science in Computer Science

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Dr. Daniel D. Garcia, Lecturer SOE, Chair

Located in the heart of "Hollywood North"[1] in close proximity to Pixar Animation Studios, PDI/Dreamworks, Tippet Studios, and Lucasfilm Limited, the University of California, Berkeley (or "UC Berkeley") is in a unique position to collaborate with some of the best digital artists in the world. We were fortunate to have this opportunity to design a curriculum that draws from this pool of industry talent for guest lectures, technical demonstrations, and critiques of student work. During the 2005-2006 academic year, we developed a new course in Advanced Digital Animation as a collaborative effort between Pixar Animation Studios, the Center for New Media, and the departments of Electrical Engineering & Computer Science and Art Practice. It was offered during the 2006-07 academic year and subsequently in 2008-09. We hope to offer it every other year for the foreseeable future.

Our course simulated an environment similar to what students would encounter at an effects or animation studio upon graduation, focusing on different aspects of the production pipeline as the year progressed. This thesis aims to bring the knowledge

gained through our experience to the community at large and to share the insight gains from our interaction with the digital animation industry. The design choices, tradeoffs, and resulting curricula are relevant to any college or university interested in entering into the new and exciting arena of Digital Animation and New Media.

Motivation

New Media is an umbrella term that refers to the various new avenues of artistic expression that have blossomed over the past few decades. These arenas provide artistic minds with new outlets for their creativity through the synthesis of technology and art. Hypertext novels, podcasting, virtual worlds, interactive television, and computer games are all examples of such fusion, but possibly the most visible example of New Media in our society is at your local cinema.

The digital animation arena is flourishing with studios such as Pixar Animation Studios (Wall-E, Up, etc.), Dreamworks Animation (Shrek Series, Monsters vs. Aliens, etc.), Blue Sky Studios (Ice Age Series, Horton Hears a Who, etc), Castlerock Studios (Polar Express), and Sony Pictures Animation (Surf's Up and Open Season Series) producing feature length films with entirely digitally generated imagery. In addition to this revolution in film, many video game studios such as Blizzard (Warcraft, Starcraft, Diablo), SquareEnix (Final Fantasy Series, Dragon Quest Series, etc), and Electronic Arts (Mirror's Edge, Dead Space, etc.) make strong use of offline (pre-rendered) cinematics for their in-game cut-scenes and trailers. Many of these studios employ in-house production units that focus specifically on these short movies and operate in a similar way to their film industry counterparts.

In addition to these pre-rendered cinematics, some game studios have continued to push the boundary of what is possible with realtime rendering on modern gaming consoles and computers. id Software (Doom, Quake, Rage) and Valve (Half Life,

Portal) have primarily used realtime-rendered cutscenes in their games as a way to demonstrate the capabilities of their game engines. In 2005, SquareEnix surprised the industry and delighted fans of their best selling 1997 video game, Final Fantasy 7, when they demonstrated a remake of the game's introduction sequence[2] rendered entirely in realtime on the Sony Playstation 3. This realtime-rendered remake was vastly superior in image quality to the pre-rendered cinematic introduction in the game's release eight years earlier sparking fan outcry for a re-release of the game using Sony's new platform.

The Final Fantasy 7 technology demo revealed that the video game industry was serious about taking interactive storytelling to the next level with immersive environments and visual appeal that was previously only possible in movies. Many of the skills applicable to film production (modeling, animation, lighting, shading, and storytelling[3]) apply to these realtime cinematics as well.

As an undergraduate at UC Berkeley interested in digital animation, I graduated in 2005 feeling as though not enough was provided by the university to support and develop my passion. Other students with similar interests felt as I did, and we were left with no other option but to create informal learning communities to teach each other. When I returned as a graduate student, I made it a priority to develop a course for students to advance their interests, skills, and career in this field.

Existing Curricula

In 2005, students at UC Berkeley with an interest in digital animation and computer graphics had only a handful of courses to choose from: two upper-division (junior and senior level) courses in the department of Art Practice, one upper division course in Computer Science, and a student-led course which satisfied university general elective units but not any requirements within a major. Our course was designed to fit into this existing environment, so it is important to understand a bit about the lay of the land.

Art 172: CGI Animation Studies

Art 172 is the first of two courses available to students through the department of Art Practice. It requires no technical (computer science) background and serves to introduce Art students to the basics of computer-generated animation. Students gain experience with Maya, a popular animation software package, and begin to explore the realm of computer-generated imagery. This course typically has around twenty students enrolled and is offered once a year.

What follows is the course description from the UC Berkeley General Catalog of Courses:[4]

> *Motion is a ubiquitous element of human experience, yet attempts to explain it remain incomplete. The representation of motion with technical means is in continuous development, starting perhaps with sculptural representations of*

celestial movements in antiquity and leading to dynamic computer graphics simulations of molecular processes today. In this production-intensive studio course, we will study computer graphics for motion simulations, or animations. We will also probe these tools for their use in creative expression and analyze their impact on our own perception of motion. Software used: Maya. Each week will include relevant readings, class discussions, guest speakers, demonstration of examples, and studio time for training and working on student assignments.

Art 175: Advanced Computer Graphics Production

Art 175 is the second course offered through the department of Art Practice. This course primarily attracts Art and Film majors. Many students move on to take this course after completing Art 172. Students have been divided into small teams (four to five students) during some offerings and have other times worked as an entire class on a single production. This course focuses on story development and some of the more artistic aspects of production; technical experience is, again, not required and does not offer a structured approach to technical development. Enrollment in Art 175 is typically around twenty students, and the course is offered once a year.

What follows is the course description from the UC Berkeley General Catalog of Courses:[4]

Simulation of small, team-based CGI creative production environment based on skills developed in Art [172] or Film Studies Screenwriting. Completed projects will be presented at final PFA screening, and work will be available for student

animation reels. UCB will provide duplication services for all completed projects. Each week will include relevant readings, class discussions, guest speakers, demonstration of examples, and studio time for training and working on student assignments.

CS 184: Foundations of Computer Graphics

CS 184 is virtually the other side of the coin from Art 175. This course focuses on the fundamentals of Computer Graphics from a technical perspective. Students entering this course are expected to have completed the lower-division (freshman and sophomore) three-course computer science sequence as well as a course in introductory linear algebra and differential equations. The course is taught with a emphasis on theory and mathematics rather than its vocational applications, so tools commonly used in a production house (Maya, RenderMan, etc.) are not discussed. In essence, students learn the mathematics, theory, and algorithms behind such commercial products. Enrollment in CS 184 is typically around fifty students, and the course is offered every semester.

What follows is the course description from the UC Berkeley General Catalog of Courses:[4]

Techniques of modeling objects for the purpose of computer rendering: boundary representations, constructive solids geometry, hierarchical scene descriptions. Mathematical techniques for curve and surface representation. Basic elements of a computer graphics rendering pipeline; architecture of

modern graphics display devices. Geometrical transformations such as rotation, scaling, translation, and their matrix representations. Homogeneous coordinates, projective and perspective transformations. Algorithms for clipping, hidden surface removal, rasterization, and anti-aliasing. Scan-line based and ray-based rendering algorithms. Lighting models for reflection, refraction, transparency.

UCBUGG: Undergraduate Graphics Group

The UC Berkeley Undergraduate Graphics Group (UCBUGG)[5] was founded in Fall 2001 by Dr. Daniel D. Garcia. In 2005 it was transitioned to a DeCal[6] and since then has been offered every semester as a student-led course. DeCal (Democratic Education at UC Berkeley) is a student-initiated education program at UC Berkeley in which students are allowed to teach special interest courses under the guidance of a faculty advisor. Dr. Garcia was the faculty advisor for the original group and continues to serve as advisor for the DeCal.

The charter of UCBUGG was to bring together students from across campus to explore computer graphic imagery and animation. Initially, most students in the group were from technical fields. The group started by exploring fractal art in 2D, extended that to 3D, then transitioned into computer-animated short film production. Members were highly motivated and almost exclusively self-taught (with the aide of online and bundled tutorials) in the use of software packages for the animation pipeline such as

Photoshop, Maya, Shake, After Effects, Premiere, and Final Cut. The students shared what they learned and produced with each other at weekly meetings.

At first, students worked individually or in pairs. In 2002, the entire group worked on their first collaborative piece, The Play 3D[7], a digital re-enactment to celebrate the 20th anniversary of the famous final play of the 1982 football game between Cal and Stanford (The Big Game), known by fans of college football simply as "The Play."[8]

The experience producing The Play 3D served to highlight a few key points for those involved in UCBUGG. The amount of work needed to produce an animated short was far greater than any student expected. While there were a couple amateur artists and Art majors on the team, most had only technical backgrounds with little to no experience in the artistic aspects of story-boarding, layout, and lighting. That experience really highlighted the need to include more artists in the group and limit the scope of single-semester projects.

UCBUGG has achieved equity between artists and technical students in recent semesters, mostly by word of mouth. This increased presence of artistic talent in UCBUGG led to a richer environment with more collaboration and peer education, resulting in higher quality animations. It was this aspect of interdisciplinary collaboration and cross-education that we strived to include in our course.

Center for New Media

The Center for New Media (CNM) is an interdisciplinary initiative at UC Berkeley comprised of over thirty departments including Engineering, Art History, Art, Architecture, Music, Film Studies and many others. Their mission is "to critically analyze and help shape developments in new media from cross-disciplinary and global perspectives that emphasize humanities and the public interest."[9]

CNM has been involved with a number of upper-division and graduate-level courses that cross disciplinary boundaries. Some offerings from Spring 2009 included Virtual Communities/Social Media (Sociology 167), which studies the sociological effects of online communities like Facebook, Myspace, Twitter, Second Life, and WoW; Digital-Media: Story, Performance and Games (Rhetoric 189), which examines new media practices in story telling such as hypertext novels, interactive drama, video games, and artificial-intelligence-based story generation; and Advanced Topics in Computer Music (Music 209), which studies everything from digital signal processing to musical structure as it can be applied to digital music.

As our collaborator within the Art Department, Professor Greg Neimeyer was already involved with the Center for New Media when we approached him in 2005 about our new course. He was very excited to join our team to design this new course which would be a natural extension to his Art 172/175 sequence.

Similar Efforts

Over the past few decades, other universities have started initiatives similar to Berkeley's Center for New Media. Some of these initiatives have influenced us in our design process, either through interacting with their faculty, conversing with alumni, reading their published works, or perusing of their course websites.

MIT: The Media Lab

MIT's Media Lab was the first to start down the path of integrating art, media, and technology. While it has been influential in the field of New Media, MIT's course offerings do not show a sustained commitment to computer-generated animation. Nevertheless, it has spawned numerous initiatives that have helped to define the field. Here are some of its accomplishments since its founding in 1980:[10]

> *"In its first decade, the Lab pioneered much of the technology that enabled the "digital revolution," and enhanced human expression: innovative research ranging from cognition and learning, to electronic music, to holography.*
>
> *In its second decade, the Lab literally took computing out of the box, embedding the bits of the digital realm with the atoms of our physical world. This led to expanded research in wearable computing, wireless "viral" communications, machines with common sense, new forms of artistic expression, and innovative approaches to how children learn.*

Now in its third decade, the Lab is focusing on "human adaptability"–work ranging from initiatives to treat conditions such as Alzheimer's disease and depression, to sociable robots that can monitor the health of children or the elderly, to the development of smart prostheses that can mimic–or even exceed–the capabilities of our biological limbs."

Texas A&M: Visualization Laboratory

Texas A&M is one of a handful of universities that offers Masters- and Ph.D.-granting programs in the field of Visualization Science. Its Visualization Lab (or "VizLab")[11] was established in 1988 and was "created in response to clear indications that digital visualization was going to play a highly important role in digital communication. The program's core curriculum is designed to give all students a basic grasp of the artistic, scientific, cognitive, and technical foundations of the discipline."[12]

VizLab has arguably one of the strongest digital animation programs available, but they focus entirely on graduate-level education, with students in the program coming from a myriad of backgrounds. They prove that the cross-disciplinary model works, and our course extends this concept to the undergraduate level as well.

Virginia Tech: School of Visual Arts

The School of Visual Arts at Virginia Tech[13] offers four-year BFA degrees in Visual Communication Design/Graphic Design and Studio Arts. Students can elect to take concentrations in 3D animation or modeling within the Creative Technologies

program, which offers courses combining technology and the arts in modern computer labs. These courses are similar in scope to what our course offers, but due to their placement within the BFA program, the technical component is not as strong.

Georgia Tech: Interactive Technology Media Center

The Interactive Technology Media Center at Georgia Tech was founded in 1989 "to demonstrate how the multimedia computer could replace the long established architectural models that had been used to show what candidate Olympic facilities would look like if a city were chosen to host the games."[14] Since then, ITMC has grown into a center devoted to studying how interactive multimedia technology can be used in the arts, business, education, medicine, and sports.

University of Washington: Animation Research Labs

The Animation Research Labs (ARL) was founded in 1999 at the University of Washington as an interdisciplinary undertaking between the Department of Computer Science and Engineering, the School of Art, and the School of Architecture as part of the Advanced Technology Initiative.[15] It is a "place where computer scientists, animators, artists, musicians, architects, storywriters, and user-interface designers work together to create new algorithms, systems, and tools for computer animation -- and use these advances to create innovative and experimental animated productions, including interactive forms of animation such as web-based animation and games."[16]

Of the mentioned programs at other universities, ARL is closest in line to our goals in this curriculum development effort. They offer a series of courses that are available

to Art, Music, and Computer Science students interested in Computer Animation.[17] The first course in their sequence is Computer Animation (CSE458) which focuses on 3D character design to teach the students modeling, shading, lighting, and character animation. Students then take Pre-Production for Collaborative Animation (CSE459) which is devoted to pre-production aspects of concept art, story writing, character design, model sheets, storyboarding, story reels, animatics, and software training for Photoshop and Premiere. In their third quarter, students take Animation Capstone (CSE460) and focus on the remaining stages of the production pipeline and collaboratively produce a film.

UW's approach incorporates the interdisciplinary aspect that we strive for, but there are a few significant differences. Students start the UW sequence with no assumed experience in CGI or digital animation. They spend two quarters learning specific aspects of the pipeline, then spend a single quarter working on a short film. Our curricula, on the other hand, is targeted at students who already have experience with CGI or digital animation, and these students spend an entire academic year (two semesters versus a single quarter, three times as long) designing and producing an animated short film.

Course Planning

Pixar

By its very nature, UCBUGG has attracted students who aspire to work in digital effects or animation studios upon graduation, so it is not surprising that multiple UCBUGG graduates have landed positions at neighboring Pixar Animation Studios. In 2005, Pixar recruiter Lisa Forsell approached Dr. Garcia during a job fair at UC Berkeley and brought up the subject of its graduates. Her comments were full of praise, but she had a concern. She mentioned that UCBUGG was graduating great candidates who excelled at Pixar, but they often needed to provide extra training for our graduates than students from comparable universities. She said Pixar would be willing to remedy the problem by serving as the advisors for the creation of a new, advanced, interdisciplinary course taking cues from their own training program for new employees, Pixar University. At the exact same time, I was starting my graduate studies at UC Berkeley with the hope of putting together such a course, so the timing was absolutely perfect.

Initial Design

Process

Professor Neimeyer, Dr. Garcia, and I met on a weekly basis during the 2005-06 academic year to design the course that would eventually become Advanced Digital Animation (CNM 190). Randy Nelson, the Dean of Pixar University, and Michael

Fong, one of Pixar's Supervising Technical Directors, were highly supportive throughout the course development process, often hosting lunches to discuss the details of the course and coordinate appropriate guest speakers.

Integration with Existing Courses

From the beginning, our goal was to create a brand new course rather than revamp existing ones. We wanted students to come into this course with sufficient experience from the existing offerings. At the same time, we aimed to create an interdisciplinary experience; we did not want to be overly strict with our prerequisites by requiring students to take all of the existing courses. The average technical students have taken UCBUGG as well as CS 184. Similarly, the average art student has completed both Art 172 and Art 175. Some students may have taken courses from both departments, so we set the requirements at two semesters of UCBUGG, CS 184, Art 172, or Art 175 allowing students to enter from either track.

Due to these loose prerequisites, students could come into the course with entirely different backgrounds and skill-sets. We didn't see this as a problem, instead, we saw this as an opportunity. We wanted to encourage our students to learn as much from each other as from the material in the course. We were driven by the basic tenet that says students who teach concepts to other students gain a more thorough understanding of the material themselves.

Group Size

All students entering our course had experience working cooperatively on projects in groups of at least four to five students. Our course went beyond this to approximately ten students per group. Considering the demographics of interested students, this resulted in groups consisting of around four art students, four technical students, and two students from hybrid backgrounds. This allowed for better subdivision of labor amongst group members and resulted in more time being devoted to each piece during critiques because there were fewer pieces in production for the whole class. Given the complexity of a production, these were two big wins.

Length of Animation

Animation length was one point that was debated quite thoroughly during the planning process. Suggestions varied between thirty seconds and five minutes in length, with strictness of these times also varying between just suggestions and hard limits.

If the total running time (TRT) were only a suggestion, students would have the benefit of more control over their production. However, experience has shown that students tend to grow their piece with new ideas and avoid cutting shots because they do not want their previous work to be "wasted." Having a fixed time limit placed the students in an environment similar to a production house in which they had an exact number of frames that could not be exceeded. This forced students to get comfortable with sending shots to the cutting room floor and carefully considering how many

frames they wanted to allocate to each shot. Our course implemented strict time limits to benefit from these advantages.

While we did not choose this route, it is worth noting that a hybrid of these two ideas could work as well. One could give students a suggested length that they have flexibility with during the early stages of production, but once storyboards and blocking has been completed, the team would settle on a strict length for the piece and stick with it throughout the remaining production. While this has some resemblance to production studio environments, it is possible that too much undesirable "fat" could be added to the piece in early production. Trimming the story down back to its optimal length would then become a more onerous task. To address this, another possible variant could involve putting strict upper limits on the length of individual shots as they are after the initial blocking animation is completed, but this doesn't allow students to understand the zero-sum game of shot length; i.e., growing one shot requires cutting another shot.

While the shorts produced by students in UCBUGG and Art 175 have often been three to five minutes in length, our collaborators in industry were in strong favor of thirty-second pieces. A thirty-second limit would force students to trim their story down to the bare essentials leaving absolutely no fat. Television commercials have repeatedly demonstrated that thirty seconds is sufficient to convey a story to the audience.

In the end, we decided to have each group produce three thirty-second shorts.

Theme

Given the interdisciplinary aspect of the course, it seemed appropriate to theme the course around the differences between traditional (i.e., “hand done") and procedural approaches to digital animation. Since each team was going to produce three shorts, we decided that one of these shorts would use only models, animation, textures, etc. that were created “by hand”; one of the shorts would use only procedurally-generated assets and animation; and the other could combine both procedural and manual approaches. This would force students to appreciate the strengths and weaknesses of manual and procedural methods.

Guest Speakers

While our course was co-taught by faculty from Art and Computer Science experienced with digital animation, experts from industry provided a unique perspective. We were very fortunate to be in a position to bring in guest speakers from Pixar, PDI/Dreamworks, Lucasfilm, and EA Games, all within commute distance of our campus. Approximately a third of our lectures involved visitors giving talks and demonstrations.

Technical Resources

We wanted to design the course to teach students about the environment that they would encounter if they worked in this industry after graduation, so we endeavored to provide a first-class hardware and software lab. Students in our course had access to

Maya[18] for modeling and animation, RenderMan Studio[19] for shading and rendering, Shake[20] for compositing, and Final Cut Studio[21] for non-linear video editing.

Schedule

Since the students would be working on a production during the course, it seemed natural that the topics be presented in the same order that they would appear in a production pipeline (making lecture topics relevant to what they should be working on during any given week). The first semester of our course focused on story development, storyboarding, character design, modeling, rigging, and animation, and the second semester covered shading, lighting, compositing, foley, and editing.

In contrast to the daily schedule of a production studio, we designed our class to meet two hours per day, twice a week. One day per week was allocated to lectures, demos, and guest speakers. The other day was split between a one-hour critique and a one-hour lab session. Very early on, it was clear that one hour per week was insufficient for effective critique of the students' work, so the lab session was canceled and the critique grew to take up the entire two hours.

Critique

A very important aspect of life in a digital production house is showing off one's work for comments and critique. Studios usually have screenings where directors will review new work and offer feedback on a daily basis, hence the name "dailies." We designed the critique sessions in our course to provide time for the entire class to see

other students' work and get a more thorough understanding of how their contributions fit into the final production.

In critiques, we wanted to provide students with valuable feedback from instructors and their fellow classmates. We had each team prepare an updated story reel integrating their latest work. This reel would start out as just frames from their storyboard, and over the year evolve into their final piece. In addition to this group reel, each student would prepare turntables, renders, and other imagery to show off their individual contributions. This would allow students to show their current work in progress to get feedback on technical problems as well as artistic direction. For example, students could prepare a matrix of possible "looks" for a shot and show them all during the critique to get feedback on what works best.

Assignments

Creating assignments for a course like this is not trivial. In most courses, students turn in their homework assignment and move on to the next one without revisiting. In contrast, we wanted to have students revise their work as they progressed. If a student turned in a modeling assignment that needed revision, the student should not simply move on to the next assignment. They would need to revisit their model and finish it given the feedback received during the critique.

To allow for this revisiting, we designed a very loose assignment structure. Assignments were laid out according to lecture topic as a way to pace students, but the only two firm deadlines were at the conclusion of the fall and spring semesters.

Students were not required to hand in individual assignments on each topic. Instead, students were asked to prepare web pages showcasing their individual contributions to the group.

Grading

Due to the qualitative nature of this course, grading was quite a bit more subjective than pure technical courses and resembled Art courses more than Computer Science ones (something that the Art students might be comfortable with but with which the technical students might be unfamiliar). The addition of the rather large group component made grading challenging. Our grading system used three equally weighted categories: homework (determined by examining the students' websites), participation (as gauged during the critique sessions), and peer evaluation (through a group survey filled out at the end of the course).

First Offering

First Semester, Fall 2006

Advanced Digital Animation (CNM 190) was first offered during the 2006-2007 academic year. The Fall 2006 semester was taught by Dr. Garcia (Computer Science), Jeremy Huddleston (Computer Science), and Professor Neimeyer (Art).

Pitches (Weeks 1-2)

We were concerned that students would feel limited by the thirty-second time-frame we were restricting them to, so we started off by demonstrating what was

possible in thirty seconds by showing them a selection of commercials. Randy Nelson visited the class on the first day to discuss the art of story telling and give an overview of the film production process at Pixar.

Their first homework assignment was to write three story pitches that they could deliver in thirty seconds. This exercise allowed them to realize that thirty seconds was enough to convey a story while also making them focus on timing and brevity. Each student delivered two of their three pitches to the rest of the class.

Grouping (Week 2)

At the start of the course, we surveyed all the students to get a sense of their backgrounds. We then did our best to divide the class into two groups with roughly the same number of art and technical students. One group was "Gold Team," and the other was "Blue Team" (our two school colors). During the second week, each group chose ten of the original sixty pitches and further developed each story.

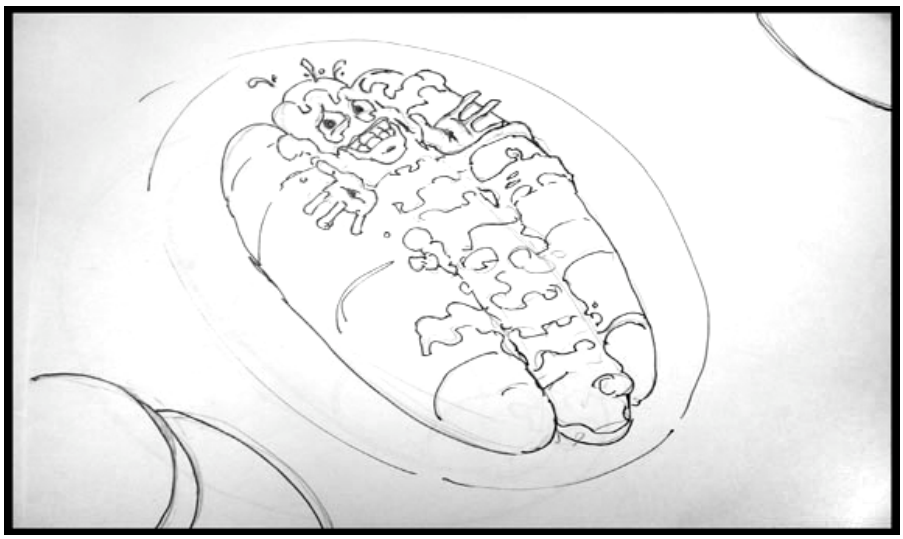
Blue Team

Gold Team

Storyboarding (Weeks 3-4)

From the ten stories that each group had been developing in Week 2, they chose three finalists to produce over the coming year. During the third week, every team member individually picked one of their stories and created a storyboard for it. Each student interpreted the story slightly differently, and this exercise allowed the groups to visualize these various interpretations. This activity introduced them to the inherent subjectivity of storytelling, making them more conscious of ambiguity in their artistic vision.

The following week, the teams resolved the differences between their individual storyboards and collaboratively made story reels for their three pieces. Story reels are videos using the storyboard elements and a rudimentary audio track to give a sense of timing for the shots in the piece; the "camera" pans and zooms across the cell of the storyboard to give a sense of camera motion.



Sample storyboard panel

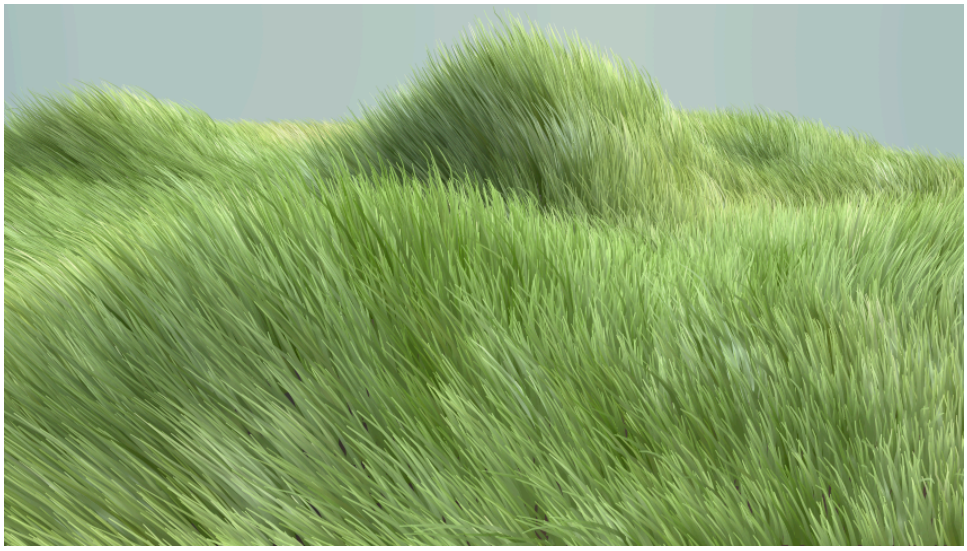
Physical Modeling/Sculpture (Week 5)

Students then transitioned into physical modeling of the major assets in their three films. We did not restrict them to any particular medium, but most students chose to work with clay. In this first offering of the course, we did not have the students design character sheets before physical modeling, so the students were trying to hit key poses from their storyboards (rather than character sheets) in their physical models. Each student was responsible for individually producing at least one model in their productions.

Physical Models

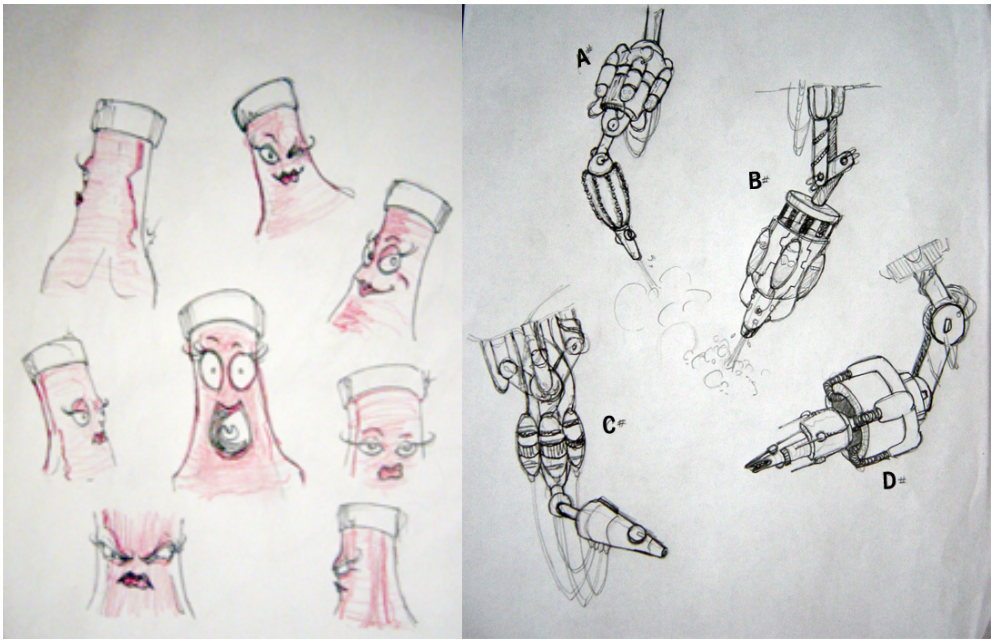
Digital Modeling (Weeks 6-8)

Up until this point in the course, students had been doing everything by hand, so we wanted their first computer modeling experience to contrast this manual approach as much as possible. In Week 6, students were exposed to procedural modeling and learned how to leverage their scripting and programming experience. We catered our discussion this week to topics that were pertinent to their productions: procedurally generated urban environments (city building), grass, and procedural set design.



Procedurally Modeled Grass

In the following week, we transitioned away from procedural modeling into manual modeling of digital assets and followed that up with rigging. The rigging process involves inserting a virtual skeleton into a computer-generated model which allows an animator to manipulate it into poses. To start rigging, students created character sheets for all their heros. These character sheets were artistic drawings of their characters in extreme poses, and it was the job of the rigger to ensure that the rigged models could achieve those poses.



Character Sheets

The topic of rigging was a natural transition from modeling into animation as it made the students consider how their models would move and how they would behave in their environment. Additionally, the students needed to make decisions about which aspects of the characters' animations would be controlled by the animator and which should be done as procedural secondary animation.

In the character sheet on the right above, there are many hinges and wires on this mechanical model. Hand animating such a complex model would take an enormous amount of effort to give a sense of realism. Instead of taking this manual approach, the students learned how to write scripts to control secondary motion for these wires. They designed intelligent rigs using inverse-kinematics to determine the configuration of joint angles for all the hinges allowing an animator to just focus on the high-level orientation of the model without worrying about such complex details.

Cinematography (Week 9)

Before starting animation, we took a week to discuss classical and procedural techniques in cinematography. We covered concepts such as shot distance, framing, and camera angles and gave specific attention to the effects that these could have on the emotion and mood of a shot. We discussed how to maintain good continuity through editing, including eye-line matching, the 180° rule, match-cutting, and cross-cutting.

Animation (Weeks 10-15)

The final six weeks of the first semester were dedicated entirely to animation. We started off discussing the basics of interpolation and the many problems that one can run into. Interpolating between Euler angles often gives horrible results in animation, so we introduced the students to quaternions and interpolation between quaternion representations for orientation (slerping). We then bounced back and forth between technically heavy and more artistic concepts as we covered crowd simulation, physical simulation (cloth, hair, fluids), cause and effect, and walk cycles. Apurva Shah (Pixar) gave a Maya demo on particle simulation that showed the techniques he used in Finding Nemo. Apurva was the first visitor to incorporate a demo into his talk. This resonated very well with the students highlighting the importance of demos from our guest speakers rather than just high level discussion.

Mid-Year Evaluations and Revisions

By the end of the first semester, each team had solidly completed animation on at least two of their three films. Each team had been struggling with one piece through the production process. This was probably more a product of the course design than a fault of the students. It was quite clear from our experience (as well as from student feedback) that we did not have enough time allocated to produce three pieces per team. We had only two hours allocated each week for critique, and taking into consideration startup time (we started ten minutes after the hour) and transition time between pieces, the best we could hope for was around seventeen minutes per piece per week. It was very common for one or two pieces to be skipped and go two weeks between critique because we ran out of time.

The three films being produced by each team were divided such that one was "by hand," one was "procedural," and one was "mixed" in all aspects of production. Through our experience in the first semester, it was quite clear that "all procedural" was not a feasible goal. We believe it would be possible to do an "all procedural" short, but careful consideration needs to be given to this piece up front to ensure that it can really be done without any manual tools.

Furthermore, having each team produce three films was not having the desired effect. We wanted all team members to work on all of the pieces. In practice, each of the teams subdivided themselves with most members working on one or two of their team's three pieces.

As a result, we revised this policy at the start of the second semester. Each group chose one of their three pieces to complete and the other two were abandoned. A lot of work and pride had gone into the cut pieces over the previous semester, so we were a bit concerned that this might demoralize some of the group members or cause friction and infighting as they decided which one would be selected. Luckily, our fears were not realized. Gold team had a fairly easy choice. One of their three pieces was not fully developed, and one was being spearheaded by a student who was leaving the course to work at Pixar, so their choice was easy. They kept Savannah, a short about an octopus trapped in a lake in the savannah that tries to befriend an elephant. Blue team, however, had two strong pieces to choose from, but the decision was made quite peacefully without damaging their group, so we were lucky for that. They decided to keep Top Dog, a short about a hot dog caught in a love triangle as Ketchup and Mustard fought over him only to be horrified when he came back with a bite taken out of him.

A common desire expressed on the student evaluations was an extension to the thirty-second time limit. The students had been fighting this timing in all of their pieces during the first semester. We saw some shots get cut which were fairly important to the story, so we allowed their film to grow to forty-five seconds. In addition to satisfying the students' desire for more time, this presented an opportunity for the team members who may not have worked on the chosen film to contribute new modeling and animation work.

Second Semester, Spring 2007

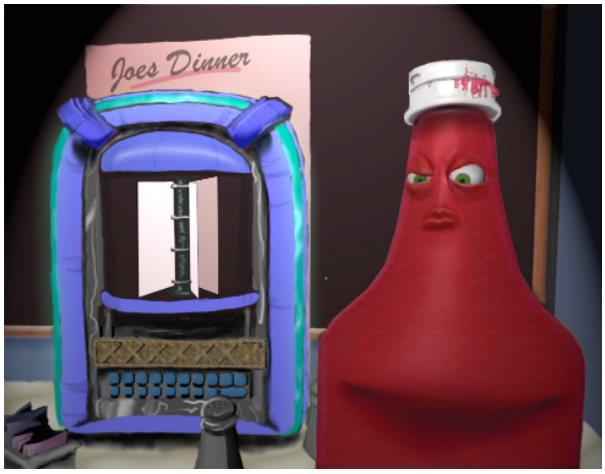
Professor Brian A. Barsky (Computer Science) and Ashley Eden (Computer Science) joined Dr. Garcia, Jeremy Huddleston, and Professor Neimeyer to teach the spring 2007 semester.

Color Palette Look and Feel (Weeks 1-2)

Most studios spend a great deal of time working on color, look, and feel before and during the story-boarding stage of production, but we did not discuss color until the beginning of the second semester. Our goal was to spend the entire first semester working on story and animation and the entire second semester focusing on look. This is probably the sharpest contrast between our pipeline and ones found in industry.

We started off the second semester by discussing color choice and how it effects the mood and feel of a movie. Shannon Jeffries and Marilyn Friedman (PDI/ Dreamworks) visited to give feedback on the look of the students' work and give a talk about the artistic process at PDI.

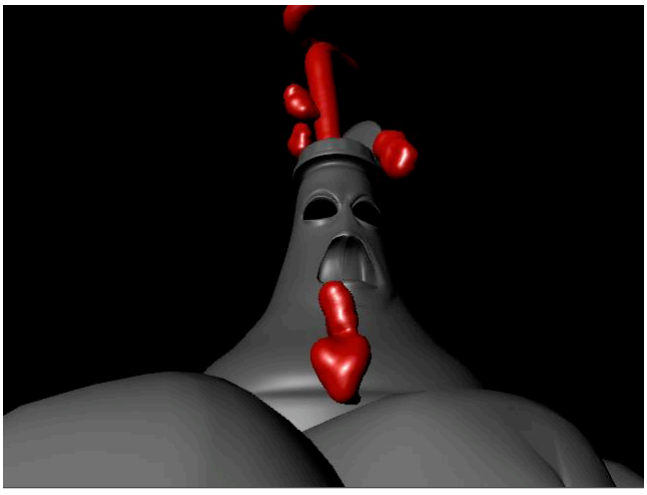
As an exercise, the students took frames from their greyscale animation and colored them using any method they wanted. Some traced printouts and then added color with markers, paint, or pastels; others stayed purely digital and used Photoshop. This exercise was done individually to allow the students to experiment with color choice on their own and get a chance to explore the options presented by the rest of their team.



Colored frame

Visual Effects & Particle Simulation (Weeks 3-4)

During the next two weeks, Keith Klohn and Michael O'Brien (Pixar) visited the class for our sections on visual effects and particle simulation. The main simulation in Top Dog was the squirt from Ketchup and Mustard as they screamed in horror to see their mutual love interest come back decapitated. Similarly, Savannah used a particle simulation for the splash of water as the octopus was thrown back into the lake.



Ketchup Particle Simulation

Rendering (Weeks 5-7)

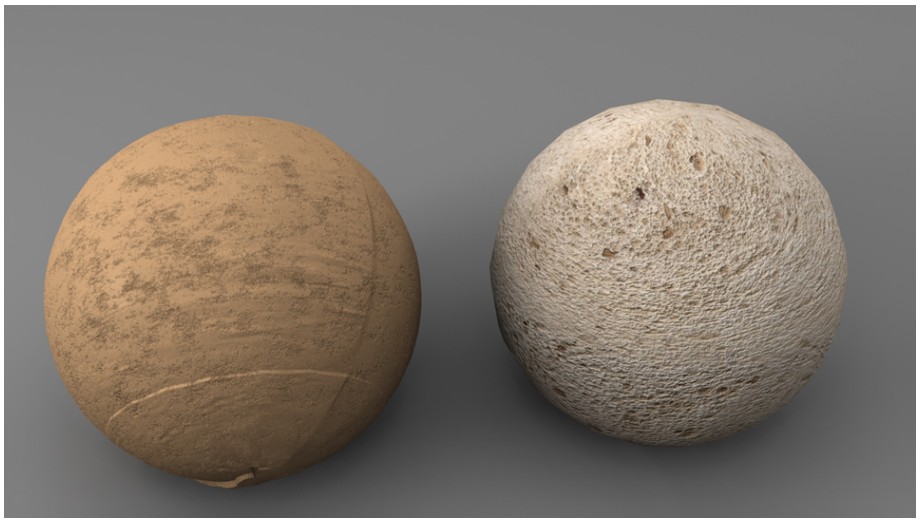
During weeks 5 through 7, we discussed the details of rendering. This series of lectures was highly technical, but that added a nice balance to the previous section which was more artistic in nature. Tony Apodaca (Pixar) visited the class to talk about ways to optimize scenes and shaders for efficient rendering. Additionally, most of the students were not familiar with RenderMan, so we gave a demo utilizing Maya and the MtoR (Maya to RenderMan) plugin to introduce them to RIBs (RenderMan Interface Bytestreams, RenderMan's geometry format), SL (the RenderMan Shading Language[22]), and how to integrate RenderMan into their existing pipeline.

Textures & Shading (Weeks 8-10)

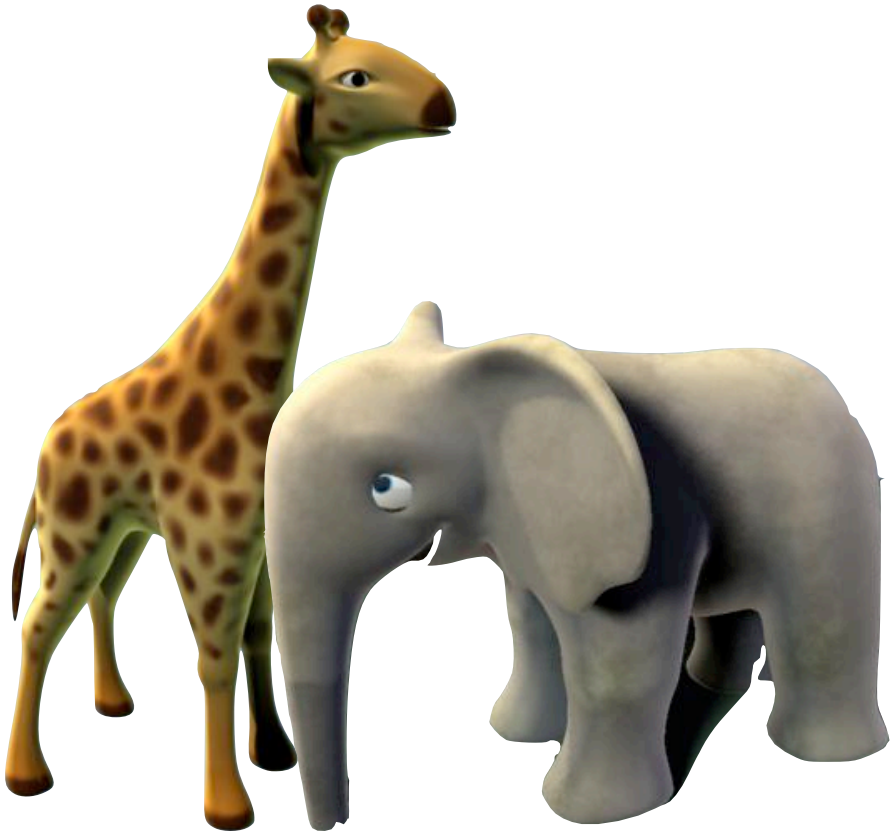
We devoted the next three weeks to shading. We started out by asking the students to find examples of what they considered good and bad textures and evaluated their selections in class. Good textures have detail at multiple frequencies and reveal history, age, and character. We discussed how the "good" textures contained all of these features or showed how the "bad" textures often lacked one or more of these elements. This was a very effective exercise; we had a great discussion, and the students seemed to develop good eyes for texture quality.

We then moved on to the more finer points of shader writing. Thomas Jordan (Pixar) visited and talked about his experience as a shading technical director on Cars. Cars was an extremely challenging production for shading primarily because of all the

reflective surfaces in the film, so he passed along tips to the students about creating efficient shaders.



Bread crust and interior shader samples



Shaded Elephant and Giraffe

Lighting & Compositing (Weeks 11-14)

We concluded with four weeks on lighting and compositing followed by two weeks dedicated to just critiquing the students' work. Stefan Gronsky (Pixar) visited the class to talk about his experience as a Lighting TD. Stefan was an alumni of UCBUGG, so his return as a guest lecture was a great experience for the students. We started out helping the students develop an eye for what constitutes a well-lit shot and how to use lighting to convey a particular mood. We talked about standard three-point lighting (key, bounce, fill, and rim), discussed other less common lighting styles employed in film and theatre, and explained how to create similar effects using lighting rigs in Maya. We covered topics such as the physical aspects of light, high dynamic range, and global illumination models (plus ways of approximating it).

An important consideration when lighting is deciding what to do in the renderer and what to do in compositing. Compositing software offers very effective tools for 2D image manipulation, and with enough planning, most of a scene's lighting can be effectively tweaked in the compositor. Many camera effects (such as depth of field, 2D motion blur, and depth haze) can also be effectively implemented in the compositor rather than as a lens shader. Putting these effects in the lap of a compositor means that each tweak iteration takes seconds to process which is orders of magnitude better than the ten minutes it can take for a frame to render. This leads to a resources dilemma as students contemplate a trade-off between computational resources (for renders) and manpower (for compositors).

To demonstrate the power of compositing, we gave a demonstration using Shake. In this demo, we showed the students how to divide their scene into sets of geometry that render separately. This process allows them to increase the efficiency of their render by cutting down on memory usage in each layer. We showed the students how to further their savings using these layers by creating sets for background and stationary geometry that only needs to be rendered once per shot (depending on the camera motion).

Next, the students learned how to write RenderMan shaders that would allow them to render a set of geometry once but get diffuse and specular lighting values from each light group in separate files in addition to their final beauty render, which combines all the lighting values into a single image. Finally, we showed them how to combine all these different renders using Shake to produce their final lit scene. To demonstrate the quick turnaround time in compositing, we showed how easy it is to change the color of the lens filter, tweak the color or intensity of specific lights, or add simple color bleed to fake global illumination.

Final Frame

Studio Showcase

During "Dead Week," a period of three days between the end of instruction and the start of finals, we took the students to show their films at PDI and Pixar. This was a great opportunity for the students to go on tours of those production houses and get more industry exposure. The guests who had visited our class during the previous nine months were able to see the final pieces, and the students were able to interact directly with the Technical Directors, Artists, and Human Resources Representatives that also attended the show.

Final Course Evaluations

As with any initial offering of a course, there were hiccups along the way. The main points that were brought up by students in their feedback matched what we experienced as faculty and staff running the course.

One of the more frustrating issues was topic overlap. We had a lot of guest speakers come in cold, not sure what had already been covered, so they would repeat what was covered the previous week. Students would see some topics multiple times yet not get exposed to other concepts. When we asked speakers to visit, we just gave them a topic, and they started from ground zero. We learned that when giving a course that is highly dependent on guest lectures, it is important to prime the speaker as much as possible, so they know where to start and what topics were already covered.

Furthermore, some guest speakers would come in and give a presentation from a very high level. They would discuss "how they made fur" or "how they made water." Their presentation would rely heavily on powerpoint slides and did not show the meat of the process. The students preferred live demonstrations given by the guests using tools like Maya, Shake, and RenderMan.

The second semester progressed much better with one film per team rather than three. We had more time to devote to each piece in the critiques, but time was still tight. This was certainly evidence that three pieces per team would have been a disaster if we had continued that through the second semester. This raised the question of how much time was right for critique. Surely increased time devoted to critique would result in better feedback. Having a three-hour block set aside for critique would have been better. That way we would not have been as rushed during the critiques and would have had more opportunity for demos and technical support if we happened to run out of material to review.

We had two deadlines (one at the end of each semester), but it was difficult to set solid deadlines and assignments during the semester. Unlike other classes where students hand in a homework assignment, get a grade for it, then move on to the next assignment, we wanted students to revisit their earlier work to polish it and make improvements. Additionally, their later work depended heavily on their earlier work. This made it very difficult to abide by deadlines and inevitably led to slipping and end-of-semester crunch. It was clear that something needed to change to provide solid deadlines for pacing while not penalizing students for revising as they moved along.

Second Offering

This course was offered for the second time during the 2008-2009 academic year. Professor Barsky, Dr. Garcia, and Jeremy Huddleston co-taught both semesters.

Key Changes

In our second offering of this course, we attempted to address the main concerns we had after our first offering. We gave guest speakers better priming to limit topic overlap and asked them to provide demos rather than powerpoint slides if it was feasible. Additionally, we stuck with our earlier decision and had each team work on a single thirty-second piece.

While we did not change the time allotted for critique, we did emphasize that the students were in control of the critique. Part of the problem with the critique sessions in the first offering was that we were driving the discussion rather than the students.

By making sure the students felt in control, it was our hope that they would get more out of the critique by focusing attention where they needed.

Pacing was a very big problem during our first offering, so we created weekly homework assignments. These assignments started off very specific and individual. As the course progressed, they became group assignments and eventually more open-ended. Later assignments just required students to submit a text file explaining what they did that week and a .zip file containing images and movies of their progress.

First Semester, Fall 2008

During the first offering, the story development process was too rushed, so we decided to place a stronger emphasis on story telling and character development. The entire story development and team-picking process was changed to accommodate this. We started off by having each student write three thirty-second pitches and deliver two of them to the class. The following week, the students paired up, and each pair chose two of their four pitches to revise and storyboard. The next week, the two pairs combined to form groups of four, and each group created a story reel for two of their four storyboards and again revised the story pitch. This gave us ten story reels to choose from. Everyone in the room voted for their top three films, and after a few rounds of voting and elimination, we had narrowed down the list to the top two films with twelve students on one film, and nine on the other. One student switched teams giving us a good division amongst our two groups.

Another key change was the introduction of character sheets earlier on. When we first offered this course, students created character sheets after physical modeling and before rigging. In industry, character sheets are created during the early visualization stages and used to create the physical models. With our increased focus on story development and pre-visualization in our second offering, it felt natural to move character sheets earlier in the curriculum. This change made the character development process much smoother and better mirrored industry.

Second Semester, Spring 2009

Our second semester revisions were less drastic. The main revision was in the color and look exercise at the beginning of the semester. We had three lectures on color instead of just two, and the single group assignment was broken up into two assignments. The first color assignment, done as a group, was to decide on a color palette for their film. The groups decided on a look for each of their characters, major assets, lights, etc. The second assignment was very similar to the assignment in the first offering; each student added color to frames from their film independent of the other group members. The difference with this assignment was that the students had already agreed on a color palette. The teams divided frames amongst the group members to limit overlap, and the teams presented an updated story reel using these colored frames instead of the original storyboard or animation elements. Each student colored at least three frames (all from different shots), which resulted in about 1-1.5 frames per second. Having the students decide the color palette and combine the

frames into a new reel was a big win. This highlighted how different people can interpret qualitative (or even quantitative) descriptions of color differently. Two consecutive frames in the reel would have slightly different looks even though both artists were working from the same palette. The reel also allowed the students to easily visualize how the look of their film changed over time.

In our first offering, we had a small thirty-minute RenderMan demo in Week 6 and a more in depth RenderMan/Shake demo during Week 14. Having this detailed demo so late in the course was problematic. The students really needed to know how to use Shake much earlier than Week 14, so we decided to combine these two into a single demo given during Week 12. In retrospect, this was still too late in the semester. By the time we had given the demo, students had been shading for three weeks. They were getting thoroughly frustrated with RenderMan and various bugs fitting it into their pipeline. This frustration caused them to abandon RenderMan in favor of Mental Ray (the renderer built into Maya) before the demo was given. Students had also been battling the integration of effects into their shots since they started working on effects during Week 6. While having this demo during Week 12 was certainly better than having it in Week 14, it was abundantly clear that it needed to be moved even earlier.

At the tail end of our second offering, Will Files (Skywalker Sound) visited the class to talk about foley and sound mixing. This was the first time in either offering that we had a lecture focusing on audio. In our first offering, and for most of the second offering, we talked about sound during critique, but we did not have a lecture

dedicated to the topic. For Will's visit, we setup a 5.1 speaker sound system in our room, and Will used this to demonstrate the different stages of sound mixing. The students showed him their work and got feedback on how to create different sound effects for their films. The information was well received and helped the students make many improvements to their audio. Unfortunately, the students were feeling pressure from rendering and did not have the time necessary to develop their audio tracks in great depth. This lecture could have had a bigger impact on their pieces if it had occurred earlier in the production.

Future Revisions

Overall, the second offering of this course felt more mature and went much smoother. The major problems from the first offering had been ironed out, but less prominent issues still required revision.

The weekly assignments helped keep a better production pace throughout the year, but the students still lagged behind schedule. To combat this, we gave the students a final deadline that was a week before their visit day and told them that they might not be able to make changes to their piece after this date. This was partially true since we were sending the submitted pieces to Pixar and PDI to test in their screening rooms, but we knew that they would be able to make changes to their piece as long as we could bring the updated movie in the exact same format that the studios had tested. In some sense, this mirrors industry deadlines as well. Most production houses set deadlines well in advance knowing that there will be slippage along the way.

Unfortunately, like industry, the students still slipped well past their early deadline. Their pieces were finally ready less than an hour before the first showing at PDI/ Dreamworks. A stricter deadline policy with grade penalty will hopefully help mitigate this problem in the future.

Another lingering issue was the amount of time allocated for critique. Giving the students more control over the weekly critique session made the two hours much more effective, but it was still insufficient. Increasing from a single two hour critique to a three hour critique is not reasonable. Three hours is a long time to ask anybody to sit in one room at a time, and it does not solve the frequency problem. Instead, the class would benefit more from two 1.5 hour critiques each week. This would allow the students to get quicker iteration on feedback and also help with the homework revision problem. For example, students could show work in progress during their Friday critique and submit polished work for grading during the Monday critique.

The students responded well to demos that showed off the pipeline. There are many quirks and problems that advanced users know how to work around, and students could benefit from early exposure to these workarounds in order to limit their frustration and focus their attention on the important aspects of production. It was clear in both offerings that the RenderMan/Shake demo needed to be earlier to help students break up their rendering layers and integrate effects into their shots. We moved it from Week 14 to Week 12 in the second offering, but it should really appear around Week 6 or 7 (after effects). If the course is changed from two days per week to

three days per week to accommodate a higher critique frequency, it would be possible to give demos in lieu of critique early in the semesters when the critique load is lighter and these demos are most needed.

The major difference between the ordering of the production pipeline in a studio and our course was when we addressed Color/Look. We divided our course to focus entirely on Color/Look during the second semester, but the look of a film is very important during early pre-visualization, storyboarding, and character development. Additionally, we only taught Sound during the last week of production when the students were stressed about rendering, shading, and lighting and did not have many cycles to devote to their soundtracks. Moving Camera, Sound, and Color/Look into the first semester would allow the students more time to focus on these artistic aspects. This would also more closely match a production environment. Color could be placed after Storyboarding and before Character Sheets. We could keep the Walk Cycle Animation lecture after Rigging and follow that up with Camera and Sound to close out the first semester. This would allow students to spend more time developing their animation rigs and walk cycles before using them in shots at the start of the second semester.

Students Respond

There are different metrics that could be employed to gauge the success of a program such as this. First, we could look at the quality of the students work to see whether or not they gained technical proficiency. The four pieces that came out of the

first two offerings of this course were phenomenal. The students overcame difficult technical problems to present rich and developed stories. While the work students created in our course has helped many of them acquire jobs in the Animation and Digital Effects industry, an even more signifigant metric for the success of this course is direct student evaluation. This course was designed to help students reach the next level in unlocking their creative potential. To gauge whether or not we were successful in this, we asked our students for feedback on the course. Here are two of their responses:

> *"I just wanted to say thank you for an amazing year in CNM 190! This was definitely one of the most valuable courses I've taken at UC Berkeley. I learned so much from my group members, and had quite the bonding experience with them. I'll never forget those all-nighters spent with maya ncloth - [names removed], and I had lots of fun with that! ... It is because of what I learned in this class that I received the Pixar Technical Undergraduate Program Internship for Summer 2009, which I am so excited about!"*

> *"This course has shown me what it takes to make it in this industry. Seeing the leaders in my group work as hard as they possibly can, the all-nighter sessions, and seeing what we have produced together as a team has been one of the coolest things I've been able to experience in college. This has probably been, without a doubt, the hardest I've had to work for any single class, but well worth it."*

The students taking this course gave it their all. It was their drive, determination, strength, and passion made this course a success. By fostering teamwork and providing practical industry knowledge, this course created an environment that cultivated our students' talents. This program was a success because we let our students shine and reach their potential without getting in their way.

Starting Fresh

Curricula

We were fortunate to be teaching in a location that allowed us to integrate guest lectures by industry talent. These visitors were a great asset for our course, but they were certainly not a required component. Our curricula can easily find its way into any college where dedicated students are interested in this material. Location should not be a barrier for any school that wants to start a program like ours.

There are really two critical ideas to keep in mind when developing a program in digital animation. The first is that no single individual is an expert in every aspect of production. The second is that the students are the keys to the success of this type of program. These two ideas interact well with each other. Students can not and do not expect that the instructors are experts in all stages of production, and it is not the role of instructors to be that expert. Instead, it is the instructor's job to help the students reach their potential and hopefully become experts themselves.

As a starting point for any school interested in developing a program like ours, we recommend first creating an undergraduate graphics group like our UCBUGG. In doing so, make sure that you reach out to other departments. Build bridges and attract students from Architecture, Art, Computer Science, English, Film, and Theatre. Start out with simple assignments and discussions that center around the aspects of computer graphics that you as an instructor are comfortable with and build from there. These assignments do not need to relate directly to a traditional production pipeline. For example, the original assignments from UCBUGG involved animation of fractal art using the scheme programming language.[23]

After a couple of semesters, you should have a core group of students. Find out what they are interested in, and let them have some ownership by allowing them to pick the direction that the group will go. Let the students work on projects that grab their attention. As an instructor, you should find out what they are interested in and provide the guidance and tools necessary to help the students reach their goal. Along the way, you will learn a lot about the process that will help in developing more advanced curricula.

After three to five years, students coming out of the undergraduate group should be ready to move on to a more structured course. Some of these students may already be very proficient with some of the production tools. Keep in mind that it is not the role of the instructor to be the ultimate expert. Learn to leverage the students' abilities in a way that benefits the rest of the class. You could have every student sign up for a

week and give demonstrations on different topics that they learn through independent study. One of the common requests that we have seen in our evaluations has been for more demonstrations. Delegating this back to the students is a great way to harness the power of peer education.

Software

Many of the software packages that we used during this course are industry tools that are quite expensive, especially when purchased in volume to fill a lab. Such a steep price tag should not be a barrier in creating a course like Advanced Digital Animation. While it is certainly advantageous to use the same applications as industry, it is important to know that there are free and open-source solutions available.

Audacity

For example, Audacity is free and open-source "software for recording and editing sounds. It is available for Mac OS X, Microsoft Windows, GNU/Linux, and other operating systems."[24] Audacity is a great application for foley work as it has support for many audio formats and an intuitive user interface for layering and editing sounds.

Pixie

Pixie[25] is a free and open-source RenderMan renderer that was originally developed by Okan Arikan when he was a graduate student here at UC Berkeley. Pixie implements many of the features found in commercial RenderMan renderers

(such as Pixar's RenderMan) including programmable shading (using the RenderMan Shading Language), high dynamic range, network parallel rendering, multithreaded rendering, and AOVs (arbitrary output values).

POVRay

The Persistince of Vision Raytracer ("PovRAY")[26] is another open-source renderer available for Windows, Mac OS X, and Linux. POVRay is great for Constructive Solid Geometry ("CSG") objects and has a large community of fans who create images and movies directly within POVRay using CSG. PovRAY has an extensive online support network of forums, wikis, and newsgroups making it easy for students to get support, share their work, or become involved in the development process.

Wings 3D

Wings 3D[27] is an open-source subdivision modeler. Its trimmed down user interface makes it less daunting than other feature-rich applications. Wings 3D can import and export model formats that are commonly found online such as 3D Studio and Wavefront (Maya). It also has support for outputting models in the POVRay format making it a great way to introduce students to modeling after they have become comfortable using CSG directly in POVRay.

Blender

Blender[28] is an outstanding software package for anyone trying to do 3D art. It is a free and open-source package with support for modeling, shading, animation,

rendering, compositing, and non-linear editing. In addition to its own renderer, Blender can be configured to use pixie, POVRay, and many other free and open-source rendering packages that are available. It can import models developed by Wings 3D, Maya, or 3D Studio and has support for a wide array of image formats throughout the package including the shading engine and node based compositor. Blender's extensive user-base have created an online community providing user-to-user support through forums, tutorials, and videos, most of which are freely available. These resources are invaluable to students as they take on the daunting task of learning such a complex software package.

The Blender community continually raises money to develop animated short films using only open-source solutions. This money is used to fund around five artists and two developers who push the capabilities of Blender during their production (typically lasting around six months). The developers respond to the needs of the artists and contribute all of their code back to the community to help not just the team involved with that production but the entire Blender user-base. The Blender community has developed two short films, Elephant's Dream[29] and Big Buck Bunny,[30] and they are in the planning stages for their third production, code-named The Durian Project,[31] set to begin production in September 2009. These shorts provide a proof of concept for anyone interested in open source digital art.

Appendix A: Calendars

Fall 2006:

Week	Day	Lecture Topic	Assignment Due
1	Mon	Course Overview, Story Writing	
	Wed	More Story Writing, Asset Management, Systems	
2	Mon	NO CLASS: HOLIDAY	
	Wed	Critique	Story Pitch
3	Mon	Camera 1 : A Camera with a Feeling	
	Wed	Critique	Storyboard
4	Mon	Procedural Tendencies: The Cultural Agenda Behind Algorithmic Thinking	
	Wed	Critique	Animated Storyboard
5	Mon	Modeling 1 : Procedural Modeling Basics	
	Wed	Critique	Physical Models
6	Mon	Modeling 2 : Sets, Characters, Hair, Fur, and Advanced Procedural Modeling	
	Wed	Critique	Procedurally Generated Models
7	Mon	Modeling 3 : Skeletons & Rigging	
	Wed	Critique	Hand Generated Models
8	Mon	Camera 2 : Procedural Techniques of Cinematography	
	Wed	Critique	Character Sheets, Set Drawings, Hero Rigs with Pose Sheets
9	Mon	Animation 1 : Basics, Motion, Sound, Data	
	Wed	Critique	Layout Animation, Shot Sheets, Secondary Models

10	Mon	Animation 2 : Inverse Kinematics, Automating Animation, Physics Simulation	
	Wed	Critique	Final Layout Animation, Final Models & Sets
11	Mon	Animation 3 : Cause and Effect, Primary and Secondary, Procedural Style	
	Wed	Critique	Animation Progress
12	Mon	Animation 4 : Walk Cycles & Autonomous Motion	
	Wed	Critique	Animation Progress
13	Mon	Animation 5 : Particle Simulations, Crowds, Cloth, Hair	
	Wed	Critique	Animation Progress
14	Mon	Animation 6 : The Shiver of Affection	
	Wed	Critique	Animation Progress
15	Mon	Critique	
	Wed	Critique	Animation Progress

Spring 2007:

Week	Date	Lecture Topic	Assignment Due
1	Mon	NO CLASS	
	Wed	Course Overview - Review work done over break	
2	Mon	Look & Feel: From Pastels To Pixels	
	Wed	Critique	
3	Mon	Effects 1: Basics, Fluids and Particles	
	Wed	Critique	
4	Mon	Effects 2	
	Wed	Critique	

5	Mon	Rendering	
	Wed	Critique/RenderMan Intro	
6	Mon	NO CLASS: HOLIDAY	
	Wed	Critique	
7	Mon	Render Optimization	
	Wed	Critique	
8	Mon	Shading 1: Texture Mapping	
	Wed	Critique	
9	Mon	Shading 2: Procedural Shading	
	Wed	Critique	
10	Mon	Shading 3: Advanced Procedural Shading	
	Wed	Critique	
SprBr	Mon	NO CLASS: SPRING BREAK	
	Wed	NO CLASS: SPRING BREAK	
11	Mon	Lighting 1	
	Wed	Critique	
12	Mon	Lighting 2	
	Wed	Critique	
13	Mon	Lighting 3/Compositing 1	
	Wed	Critique	
14	Mon	RenderMan, Shake, and Compositing	
	Wed	Critique	
15	Mon	Critique	
	Wed	Critique	
16	Mon	Critique	
	Wed	Pixar & PDI/Showcase	

Fall 2008:

Week	Date	Lecture Topic	Assignment Due
1	Tue	No Class	
	Thu	Course Overview	
2	Tue	Storytelling	
	Thu	Critique	Story Pitches
3	Tue	Storyboarding & Camera 1	
	Thu	Critique	Storyboard
4	Tue	Critique	
	Thu	Story Reels and 2D Animatics	
5	Tue	Critique	Story Reel
	Thu	Character Design	
6	Tue	Critique	Character Sheets
	Thu	Clay Modeling	
7	Tue	Critique	Clay Hero Models
	Thu	Computer Modeling	
8	Tue	Critique	Unrigged Models and Sets
	Thu	Skeleton & Rigging	
9	Tue	Critique	Updated Models and Sets
	Thu	Procedural Modeling & Set Dressing	
10	Tue	Critique	Rigged Models
	Thu	Camera 2: Cinematic Techniques and Procedural Cameras	
11	Tue	Critique	Dressed Sets with Camera Paths

	Thu	Animation 1: Primary Hero Animation & Inverse Kinematics	
12	Tue	NO CLASS: HOLIDAY	
	Thu	Sets: Set Dressing	Animatic/Revised camera
13	Tue	Critique	Low Frequency Animation
	Thu	Animation 2 : Walk Cycles and Autonomous Motion	
14	Tue	Critique	Detailed Hero Animation 1
	Thu	NO CLASS: HOLIDAY	
15	Tue	Data-driven Maya (demo) + Crit	Detailed Hero Animation 2
	Thu	Critique	Background Animation
16	Tue	Critique	

Spring 2009:

Week	Date	Lecture Topic	Assignment Due
1	Mon	NO CLASS	
	Wed	Review work done over break	
2	Mon	Pastel to Pixels	
	Wed	Color: Physics and Science of Color	Color Pallette Ideas
3	Mon	Color 2	
	Wed	Effects 1/Mini Crit	Colored Frames
4	Mon	Effects 2	
	Wed	Critique Effects	Coloring & Effects
5	Mon	NO CLASS: HOLIDAY	
	Wed	Rendering/Mini Crit	

6	Mon	Critique	More Effects
	Wed	Rendering Optimization	
7	Mon	Critique	Even More Effects
	Wed	Shading 1: Texture Maps	
8	Mon	Shading 2: Procedural Shading	
	Wed	Shading 3: Advanced Procedural Shading	
9	Mon	Lighting 1	
	Wed	Critique	Shading
SprBr	Mon	NO CLASS: SPRING BREAK	
	Wed	NO CLASS: SPRING BREAK	
10	Mon	Critique	Lighting/Shading
	Wed	Lighting 2	
11	Mon	Critique	Lighting
	Wed	Lighting 3	
12	Mon	Critique	Lighting
	Wed	Compositing 1	
13	Mon	Critique	Compositing
	Wed	Compositing 2	
14	Mon	Critique	Sound
	Wed	Foley	
15	Mon	Critique	
	Wed	Critique	
16	Mon	Critique	
	Wed	Studio Visit Day	

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