

# A PROPOSAL FOR A BACHELOR OF SCIENCE IN COMPUTER SCIENCE: COMPUTER GAME DESIGN

*June 12, 2006*

## INTRODUCTION

The Computer Science Department proposes the establishment of a new interdisciplinary degree program focusing on the technical, artistic, and narrative underpinnings of interactive computer games. Assistant Professor Jim Whitehead and Professor Ira Pohl of the Department of Computer Science have developed this proposal. The degree will be hosted by the Computer Science Department.

From their beginning in the early 1960's, computer games have consistently stretched the limits of how realistic a virtual world can be represented within the computer. Today's games involve sophisticated modeling of terrain, water, and structures, with multiple objects interacting according to realistic simulations of their physical properties following classical Newtonian physics. Massively multiplayer online games (MMOs) have economic, social interaction, and governance structures that game designers must create, evolve, and manage. Issues of plot, character development, and storyline development are increasingly important in the development of long-lasting game brands that span multiple game releases.

Computer games are extremely sophisticated technical artifacts. Games require real-time programming to achieve smooth animation, involve sophisticated 2D and 3D graphics that drive the development of new graphics hardware, and have artificial intelligence that controls increasingly clever computer opponents. Online game playing against other human opponents involves many classical distributed computing algorithms to ensure that game state is accurately spread across multiple computers. Since games involve hundreds of thousands to low millions of lines of code, software engineering techniques are required to manage the development of game software, and ensure its quality.

Multiplayer online games have increasingly sophisticated socio-economic systems. Such games have experienced inflation and deflation, taxation, and multiple crises of their governance structures. Real-world marketplaces have sprung up around all successful online games, with people exchanging game money for real money, effectively setting an exchange rate that sometimes make game economies larger than some real-world national economies. Such games act as laboratories for the construction of new economic systems, providing the first controlled laboratories for the exploration of the design space of economies and government systems.

Games are aiming for the entertainment space currently occupied by television and movies, raising expectations for a more theatrical game playing experience. Games have interludes between game playing scenes where movie scenes are shown, acting to further develop the characters in the game. Thus, a game is both a virtual world, executed by a computer, as well as a theatrical experience aimed at creating an emotional bond with the player.

Today's computer games sit at the nexus of computer science, film, digital media, theater, art, literature, economics, and social science; increasingly complex technical and cultural artifacts developed by interdisciplinary teams. The rising complexity of games combined with their growing economic impact has led, in the span of 5-7 years, to games emerging from their marginalized position as curious novelties to items of growing academic interest. Game Studies is now a recognized academic discipline involving the critical analysis of games. Since the trend over time has been inexorably towards greater complexity and verisimilitude in game worlds, greater academic interest in these fascinating artifacts seems inevitable.

A recurring critique of computer games is that they are "just a fad." This was most evident in the early 1980's, when the first generation of programmable game consoles (Atari 2600, Intellivision, Odyssey 2) experienced spectacular growth, then declines in sales in America. However, since the introduction of the Nintendo NES in 1985, the computer games industry has experienced continual growth in sales and

console capabilities. The computer games industry, at least, is no longer viewed as a fad. Intellectually, there are many deep issues in computer games. Perhaps the greatest challenge is the creation of realistic non-player characters who have substantial freedom of action (as opposed to being scripted). The real-time graphics of the games also poses multiple challenges to achieve realism while maintaining performance. Understanding the subtle interactions between rules and gameplay, and how they contribute to a fun experience, are other issues that have attracted book-length academic treatments in the past few years. Most broadly, computer video games can be seen as an extension of people's multi-millennial fascination with games. We see substantial intellectual territory to explore in the realm of computer video games; no fad here either.

Computer games are also fun, an educational motivator. Steve Russell, developer of the original SpaceWar game, noted that, "I think the thing I take the most pride in about SpaceWar is that it got so many people hooked on computer programming. It caught a lot of eyes and got a lot of interesting people asking, 'How do you do that?'" (Joystick Nation, J.C. Herz, Chapter 1). This is still true today. The Computer Science Department is seeing an increasing number of students entering the field because they are motivated by computer games. Academic programs studying games can channel this inquisitive energy into the study of the most serious, non-trivial, technical aspects of computer science, computer engineering, digital media, film, economics, art and music. Games programs will graduate students with broad multidisciplinary backgrounds and interests.

There has also been a long-standing interest in games that perform a teaching role. In the ideal, a game can make learning fun, providing powerful motivation to learn complex subjects. One example is the classic game SimCity, where the game player takes the role of a city planner, whose decisions on zoning, taxation, and building of public works directly impact the evolution of a city. It portrays many of the complex interrelationships of city planning decisions in a more direct way that is possible using traditional classroom teaching. However, the potential for educational games has mostly not been reached, and the educational games industry has been shrinking. There are many open questions concerning how to structure games to teach more complex subjects such as essay writing, or advanced mathematics.

Academic game programs also address the growing need to provide highly trained personnel to develop the next generation of sophisticated games. California currently has a strong and growing game development industry. As the cinematic aspects of game development increase in importance, it seems reasonable to assume that proximity to the movie industry in California will be valuable, and hence growth of California's game industry seems likely—assuming there are enough skilled, creative people to give California-developed games a competitive edge. Additionally, a possible outcome is the coupling of these programs with a university industrial incubator program, so that motivated students can take their learning forward, and develop new game development companies that benefit UCSC and the Santa Cruz area.

## PURPOSE AND OBJECTIVES

*The goal of the BS in Computer Science: Computer Game Design is to provide a deep understanding of the technical aspects of computer game engineering, and a broad background in the artistic, narrative, and dramatic elements of game design.*

Today, organizations that develop first tier games for personal computers or gaming consoles—such as the Redwood City based Electronic Arts, which develops games for the PC, Xbox, Playstation, and Nintendo—specialize their game development staff into separate technical and art tracks. Engineers working in the technical track have strong software development backgrounds, with an emphasis on computer graphics, real time, algorithms, databases, and software engineering. A computer science or computer engineering degree is a typical credential, though it is an imperfect match for the needs of game development. Existing computer science degree programs have insufficient graphics content, and typically do not provide any training on computer gaming platforms (such as special purpose capabilities of graphics cards). Additionally, computer games have a unique and challenging requirement: they must be fun. A traditional computer science degree does not provide a deep opportunity to explore the overall design of video games, and understand the way rule systems, plot, graphics, and music can be combined to create a

fun experience. Computer science programs are just not sufficiently interdisciplinary to provide the strongest possible background for game engineers.

In contrast, the art track within game development organizations contains artists who create the many art assets within a game. Many computer games have large numbers of scenes, characters, and items, all of which require game-specific artwork. The necessary skill set here is a strong digital arts background, with experience in both 2D and 3D modeling, deep proficiency in the use of industry standard tools, and an understanding of technologies used to manage large numbers of art assets. People working in the art track have also done film work in the past, to provide film interludes between game scenes. Increasingly, however, these scenes are being completely computer generated, leading to a need for people skilled in creating entirely computer-generated movies, with no live actors.

Coordinating the members of the technical and art tracks is the game's director, which tends to be a very experienced game developer, from either a technical or non-technical background. The director sets the overall artistic tone of the game, and has broad discretion over the plot, choice of scenes, and rule system. Due to its high degree of artistic control over the entire gameplay experience, these tend to be coveted positions.

The focus of the BS in Computer Science: Computer Game Design is on providing the knowledge needed to become a strong member of the technical development staff of a game development organization, with a sufficiently broad background that they can eventually grow into the role of a director, or senior management. Hence, while Computer Game Design is inherently an interdisciplinary degree, the core content of the degree is a technically deep and rigorous sequence of courses from computer science. To this core is added material from computer engineering, physics, film & digital media, art, music, and economics.

An emphasis of the degree program is providing students with multiple opportunities to perform significant game design projects. Since students entering the major will be very motivated by the desire to create games, we have created a three-course freshman design sequence that allows students entering into the major to create games right away. We additionally provide a three-course capstone design sequence in the senior year, providing students the opportunity to create substantial games that can serve as the centerpiece of their portfolio of game design work.

Since there is substantial overlap between the knowledge necessary to create a computer game and the knowledge required to perform any significant software engineering activity, students completing the Computer Game Design program will have received a general purpose computer science education. As a result, while the degree is focused on training students to create computer games, the education they receive is not narrow, and has a wide variety of uses. Students will be able to create a wide range of simulations and perform information visualization by directly applying the techniques they learned in the degree program. Generally, students in the degree program will find that they are capable of excelling at a wide range of software engineering activities, and should be competitive in securing jobs or postgraduate student with other students from other institutions possessing a BS in Computer Science.

## STUDENT DEMAND

We are optimistic that there will be strong enrollments in our Computer Game Design program. There are several sources for this.

- Computer gaming is a common activity among high school students of both sexes, with game development viewed as being interesting and even somewhat glamorous.
- The US is going through its second great wave of cultural interest in Computer Gaming (the first was ignited by Pong and Space Invaders in the late 70's), with broad mainstream media coverage of gaming.
- The video game industry has grown and matured significantly over the past 5 years, with 2004 game software revenues (console games plus PC games) of appx. \$7.3 billion. Hence, a position in the gaming industry is widely viewed as a viable career path.

- We are already seeing strong external interest by prospective students in the recently announced computer game design track of the BA in Computer Science. Internally, we have had strong interest in the new undergraduate introduction to game design course, CMPS 80K, Foundations of Interactive Game Design, which has attracted 174 enrollments in its first offering (Winter 2006).
- Enrollments in similar programs nationwide can serve as a yardstick for potential enrollments at UCSC. At Georgia Tech., the new Computational Media degree program started in Fall 2005, and has 120 students in the program. Rensselaer will launch a new degree program in Fall 2006, with enrollment capped at 25 students.

That said, it is always challenging to predict future demand for academic programs. This curriculum has been designed such that it can be launched with relatively few resource demands, and hence it has the ability to scale from low up to potentially large enrollments.

## CAREER OPPORTUNITIES

Graduates receiving a BS in Computer Science: Computer Game Design, will be well positioned to secure jobs within the computer games industry, as well as general software engineering jobs within a broad array of information technology companies. Students in the program will receive a solid and broad background in computer science, and hence are well positioned to continue on to graduate studies in computer science, digital media, or computer games. Since the degree explicitly has the name “Computer Science” in its title, students who decide to pursue traditional software engineering jobs after completing their degree will be at no disadvantage compared to those completing traditional computer science degree programs. In fact, we anticipate that their having completed a major capstone project may well be viewed as a significant plus factor when seeking jobs or postgraduate study.

Graduates in Computer Game Design will be competitive in securing development positions within the growing computer game industry. In the Fall 2005 Career Guide published by Game Developer Magazine (the 4<sup>th</sup> iteration of this guide), the average nationwide salary for game developers with less than three years experience is \$54,300, with salaries in the San Francisco Bay Area generally being higher than the average. Additionally, average additional compensation (bonus, profit sharing, stock options) was \$21,872 for all game developers. There is a large and growing computer gaming industry nationwide, with many companies concentrated in California, offering strong wages. The strong technical focus of the Computer Game Design program, combined with the ability for students to create solid demonstration games as part of their senior game design capstone sequence, should make UCSC graduates very competitive in the entry-level game design job market.

## TIMING AND ENROLLMENT

We hope that this program will be approved and in the campus catalog by the beginning of the 2006/7 academic year. We anticipate that the only students entering the program in the 2006/7 academic year will be existing students in the BA/BS Computer Science degree programs. It is likely that some students who applied to UC Santa Cruz because of the existing game development track within the BA Computer Science degree will want to switch over to the new degree program once it comes on line.

Predicting future enrollments is a notoriously difficult task. Ideally, we would like to have some number of current sophomore and junior Computer Science students (5) transferring into the program in the initial year of 2006/7, along with a small number of incoming freshmen (20). Incoming freshmen in Fall 2006 will not have had the opportunity to apply directly for the Computer Game Design major, but will have applied for enrollment in either the BA or BS in Computer Science degree, and will then transfer into the major. Enrollments in subsequent Computer Game Design classes will ramp up to the desired steady-state of 50 incoming students per year. Once the degree program has been approved, freshmen students will apply directly for the Computer Game Design major. The table below shows projected enrollments in the major.

The program curriculum has been designed such that community college transfer students can reasonably complete the program in two years after transfer, and hence the incoming students figures include transfer students. The breakdown of entering freshman vs. transfer students is indicated in parenthesis

(freshman/transfer). For the first year of the program, we also expect some students to transfer in from the existing BA/BS in Computer Science degree. Graduate numbers assume no attrition, and four-year completion rates for incoming freshman (two years for transfer students).

ACADEMIC YEAR	INCOMING STUDENTS (FRESHMAN/TRANSFER/SWITCH)	TOTAL STUDENTS	GRADUATES
2006/07	25 (20/0/5)	25	0
2007/08	35 (25/10/0)	60	0
2008/09	40 (25/15/0)	100	15
2009/10	50 (35/15/0)	135	35
2010/11	50 (35/15/0)	150	45

In order to increase awareness of this new major, we intend to include mention of the degree program in typical School of Engineering outreach materials, including a web site at UCSC providing an overview of the major. We also intend to work with UCSC admissions to improve outreach to prospective students, including targeted email messages, and inclusion of information about the program in typical admissions outreach publications. We would also like to perform outreach to high school guidance counselors to improve their awareness of the program, career opportunities in computer gaming, and to give a sense of the academic rigor of our offering. Towards this end, we have already met with Signe Coe, graduate counselor at the Pacific Collegiate School in Santa Cruz.

We would also like to target community college students in our outreach efforts. We have had preliminary discussions on this topic with Chuck Lindauer, Dean of Computers Technology and Information Systems at Foothill College. Foothill College would like to create a 2-year computer game development track, for many of the same reasons that motivate our proposal (increase enrollments, interest, and diversity). Foothill would like to advertise this program as a game-oriented pipeline preparing students for entry into the game degree program at UCSC, and possibly DigiPen. It is conceivable that other nearby community colleges would find this model attractive too.

Ideally, we want the Computer Game Design major to attract a diverse study body, especially women, into computer science, as we feel that computer game design may be more attractive to a broad array of students than traditional computer science. As a result, we anticipate outreach materials will include a diversity of students in photos and meetings, as well as tailoring specific messages about the degree program to attract a diverse student body.

Additionally, we note that there are currently no web sites dedicated to a discussion of computer gaming education, and hence web searches on relevant terms do not yield high quality information. We intend to create a web site providing an overview of all computer gaming education options (at, say, [gamingeducation.org](http://gamingeducation.org)), with the Computer Game Design program given prominent mention.

Since this proposal involves the creation of new courses in the Computer Science Dept., these courses need to be developed, and staff needs to be present to teach them. The Computer Science Dept. has successfully conducted a faculty search for an Assistant Professor focused on computer gaming in the 2005/6 academic year, hiring Michael Mateas. Prof. Mateas, in conjunction with existing computer science faculty, will be able to teach the new courses developed for this major. We anticipate that these new courses will be developed in the 2006/7 academic year, in time for their use by the first cohort of students. Several of the new courses are already under development in the 2005/6 academic year, and others involve a minor tailoring of the content of existing courses. As a result, the effort required to create these new courses is relatively minor, and is starting to be addressed.

A summary of the timing of events related to the launching of the degree program is shown below.

ACADEMIC YEAR	ACTIVITY
2005/6	<p>Development and campus approval of degree proposal (all year).</p> <p>Perform faculty search in Computer Science for computer gaming (W/S 06).</p> <p>Develop and teach new courses CMPS 128 (W 06) and AI for Computer Games (S 06). Development of new course CMPS 164 (S 06).</p> <p>Begin process of engaging corporations for equipment donations to game development laboratory (W/S 06).</p> <p>Develop outreach materials for prospective students (Summer 06).</p> <p>Catalog copy added to catalog (Spring/Summer 06)</p>
2006/7	<p>Launch degree program (F 06). First cohort of students transfer in from BA/BS Computer Science.</p> <p>Governance and committee structure of degree program begin, as outlined in Charter (F 06).</p> <p>Teach new course CMPS 164, and develop and teach new course Game Design Experience (S 07). Develop new courses Game Design Studio I-III (W/S 07)</p> <p>Develop articulation agreement for community college transfer students (F 06).</p> <p>Create game development laboratory (F 06/W 07)</p>
2007/8	<p>First cohort of students of freshman and community college students that have been directly admitted to the major (F 07).</p> <p>Perform faculty search in Computer Science for computer gaming (W/S 08).</p> <p>Teach new courses Game Design Studio I-III (all year)</p> <p>Preparation for accreditation of degree program by attending training workshops (all year).</p> <p>First students graduate from the program (S 08)</p>
2008/9	<p>Prepare for accreditation of degree program (all year).</p>
2009/10	<p>Perform accreditation of degree program.</p>

## RELATIONSHIP TO EXISTING CAMPUS PROGRAMS AND PLANS

There are two factors driving the creation of the Computer Game Design program at this time. First, the dramatic upswing of interest in computer gaming nationwide has led to a substantial interest in computer game design programs among college-bound students. Second, since the end of the dotcom era in Silicon Valley, enrollments in computer science programs nationwide have seen a significant downturn, at UCSC and elsewhere. We see there being a beneficial confluence of these events, as spare capacity in the existing computer science program at UCSC can be harnessed in the creation of an innovative degree program focused on computer gaming. Due to the current spare capacity within computer science, we do not foresee any adverse impacts on the existing BS or BA in Computer Science degree programs.

The nationwide decline in enrollments has led to substantial introspection among computer scientists on how to make computer science more attractive as a discipline, and more relevant to student interests. Our degree curriculum permits us to explore several innovations to the existing computer science degree programs, including an undergraduate project course (Game Design Experience), a year-long upper-division project experience (Game Design Studio I-III), and interdisciplinary course work in digital media.

The most closely related programs on campus are the digital media aspects of the Film and Digital Media major, which examines digital media from a narrative, social and artistic viewpoint, and the Digital Arts New Media (DANM) graduate program, which similarly explores the narrative and artistic elements of digital arts and digital media. Both of these programs have direct relevance for the proposed degree program, reflected in the inclusion of their courses under the Digital Media Electives category of our curriculum.

The DANM program is solely a graduate program, offering the MFA degree. DANM is offering a course on computer game design in Winter 2006, for the first time. We anticipate there being many possibilities for synergy with the DANM program, including Computer Game Design students potentially taking DANM courses, and DANM graduate students having close interactions with teams in the Game Design Studio sequence as they develop their video games.

The Dept. of History of Art and Visual Culture (HAVC) is also offering a new course on the history and critical analysis of video games during the Summer of 2006. If this course becomes permanent, we anticipate being able to integrate this new course, and others that may be offered across campus, as they are developed.

## COMPARISON WITH SIMILAR PROGRAMS IN UC AND ELSEWHERE

Nationwide, there is significant educational activity surrounding interactive computer games, though levels of engagement vary widely. Universities tend to fall into one of the following categories:

- 1-2 courses focused on computer games, with other courses involving computer game related projects  
*Local examples include Stanford, San Jose State University, and San Francisco State University*
- Deployed undergraduate degree programs in computer games  
*Technically focused programs exist at DigiPen, FullSail, DePaul, Champlain College, Univ. of Denver*
- Deployed graduate degree programs in computer games or computer simulation  
*University of Pennsylvania, Naval Postgraduate School, Southern Methodist University, Florida Interactive Entertainment Academy*
- Degree proposals in progress this year  
*Univ. of Southern California, Rensselaer*
- Minors or degree specializations, but no full degree programs  
*UCI: Studio Art specialization in Game Culture and Technology*  
*Univ. of Calgary: Computer Science with concentration in Game Design*  
*Michigan State University: minor in Game Design & Development*
- Research presence in computer game development, but no degree programs  
*California examples include UCI Game Culture and Technology Lab, UCSD Experimental Game Lab*

Existing and proposed degree programs tend to be:

- Art focused  
*Parsons School of Design, BFA in Game Design & Technology*
- Evenly split between art and technology  
*Georgia Tech: Computational Media*  
*Worcester Polytechnic Institute: Interactive Media and Game Development*
- Technology focused  
*USC, DigiPen, FullSail, DePaul, Champlain, Univ. of Denver*

Within the University of California system, *there are currently no degree programs* focused on either the artistic or technical aspects of computer games. This creates a substantial opportunity for UC Santa Cruz to attract the best students across the state interested in learning the technical aspects of computer game engineering.

Nationwide, there are only a handful of technically focused degree programs in computer game development. These programs are:

- DigiPen Institute of Technology, BS Real-Time Interactive Simulation  
<http://www.digipen.edu/programs/degrees/rtisbs.html>
- DePaul University, BS Computer Game Development  
<http://www.cs.depaul.edu/programs/2005/BachelorGAM2005.asp>
- University of Denver, BS Game Development  
<http://gamedev.cs.du.edu/>
- Champlain College, BS Electronic Game Programming  
<http://www.champlain.edu/majors/egame-prog/>
- Full Sail, BS Game Design and Development  
[http://www.fullsail.com/index.cfm/fa/degree.overview/dp\\_id/9/Game\\_Design\\_And\\_Development](http://www.fullsail.com/index.cfm/fa/degree.overview/dp_id/9/Game_Design_And_Development)

The University of Southern California is currently working to develop a new degree program, BS in Computer Science (Game Development), which is also technically focused (<http://gamepipe.isi.edu/BS-Game-Development/BS-Program.html>). This degree program has been approved by the Dept. of Computer Science at USC, and is now progressing to the rest of campus for approval.

Looking over the list of existing technically focused programs, we note that only one is offered by a Carnegie Research I university (USC). While other research I schools offer game-related degree programs (Georgia Tech, Rensselaer), they fall into the category of being evenly interdisciplinary, and hence are not directly comparable. With the launching of the USC and UCSC degree programs in Fall 2006, the set of technical gaming degree programs will be bifurcated into top-tier (UCSC, USC) and bottom-tier (all others). As one of only two top-tier technical programs nationwide, we expect UC Santa Cruz to be very competitive at attracting both top students within California, and also top students nationwide.

## PROGRAM EVALUATION

The program will be evaluated as part of the Computer Science Department.

We intend that this degree program will, within 3 years of its inception date, be accredited by ABET, the primary accreditation authority for computer science and engineering programs. We have designed the curriculum of the program such that it meets the existing accreditation requirements for computer science programs, the most relevant existing set of accreditation criteria. We feel that accreditation will be very helpful in outreach for this program, assuaging concerns about the rigor of the program. Additionally, the accreditation process is very helpful in developing multiple criteria for evaluating the program, and involves a site visit by external evaluators. Due to the demands of launching the new program, the need to have graduated some students prior to performing accreditation, as well as the time needed to satisfying accreditation requirements, we do not wish to commit to accreditation in the first two years after program inception, however a three year window for performing this activity seems adequate.

## CURRICULUM

The new curriculum is designed to train students to take on a technical role within a multidisciplinary team developing a computer game. To meet this goal, the program has a strong core in computer science, with additional strength in computer engineering and math. The degree is interdisciplinary, providing students with sufficient breadth in non-technical aspects of game design such that they have some skills and an appreciation for these subjects, and develop proficiency in discussing and analyzing the artistic and narrative elements of game design.

The core of the degree program is a strong grounding in computer science and computer engineering, preceded by a foundation in math and physics. Classes in ethics, as well as courses in art, film, music, theater arts, and economics provide breadth in topics of special relevance to computer game design. In their upper division courses, students gain depth by taking upper division electives in computer science and computer engineering. Two advanced courses in digital media give students the ability to view computer software from an artistic framework. A year-long capstone game design studio class allows students to develop substantial computer games, and integrate materials from the rest of the program.

The curriculum has 124-141 credits in 24-25 courses (depending on whether a student enters as a transfer student). 12 of the courses are upper division. Campus general education requirements are a maximum of 14 courses, up to 6 of which are covered in the major requirements.

Course requirements are divided into six conceptual areas:

- **Math and Physics:** (25-27 credits) Provides the mathematical and physics background necessary for students to work with computer graphics, and to appreciate how to model the physics of the interaction of objects within a game.
- **Computational Foundations:** (24-31 credits) Provides necessary background on how to program a computer, use and analyze common data structures, object-oriented programming, and assembly language. These courses are the prerequisites for most upper division computer science and computer engineering courses.
- **Game Design:** (20 credits) Provides an opportunity to work as a member of a team to create a computer game. The lower-division Game Design Experience allows students to develop a game early in their academic career, typically the freshman year, to gain an appreciation for the complexity of game design. The three-course Game Design Studio sequence is a senior-year activity where students can develop a detailed and sophisticated computer game that can be used as a student portfolio.
- **Computer Game Engineering Electives:** (25-33 credits) A broad range of courses in computer science and computer engineering that permit students to develop depth in the technologies used to construct computer games, such as computer graphics and artificial intelligence.
- **Digital Media Electives:** (10 credits) Courses that provide an artistic perspective on the use of computers to create artistic works, such as computer games. Also covered are narrative issues that can be applied to games. These courses develop student skills at conceptualizing and critiquing computer games as works of art, rather than purely technical artifacts.
- **Art and Social Foundations:** (20 credits) The ethics requirement gives students skills for reasoning about the role and impact of games within the broader society. The remaining three electives, chosen from five categories (Art, Film, Music, Economics, and Theater), target a student's choice of general education courses towards those classes that have particular merit for better understanding some aspect of game design. The Art elective focuses on providing drawing and spatial representation skills. The Film elective focuses on critical analysis of film, and the use of film techniques to achieve artistic goals. The Music elective gives an appreciation for music, assisting in the choice of music within computer games. The Economics elective provides students with an understanding of exchange systems, an important aspect of massively multiplayer online games. The Theater elective allows students to explore lighting, the design of visual scenes, costumes, character expression, animation, and humor.

An explicit design choice in this curriculum is its overall technical focus. Existing undergraduate computer gaming degree programs tend to fall in one of three camps. Art-focused programs have a heavy emphasis on developing artistic skills, and have a small exposure to the technical aspects of game development. These programs are typically offered by art/design colleges, and train students for the art track within game development organizations. Some programs are more evenly interdisciplinary, trying to provide some depth in both the technical and artistic aspects of game design. These programs tend to not achieve significant depth in either. We believe their students are at a disadvantage when seeking game-oriented jobs, since they are not as specialized as an artistically trained or technically trained graduate. The third camp, into which we fall, has programs that are technically focused, providing a strong technical core with a solid introduction to artistic aspects of game development. We believe that technically oriented programs provide

the best training for students wanting to join the “tech track” of game development organizations, since they receive deep training in computer science (with one more upper division computer science/engineering course than the existing BA in Computer Science), while also graduating with a substantial computer game in their portfolio, and enough exposure to artistic elements of game design to communicate with their non-technical peers.

# BS COMPUTER SCIENCE: COMPUTER GAME DESIGN PROPOSED CURRICULUM

*Draft, Not yet approved, May 18, 2006*

**MATH & PHYSICS**

MATH 19A	OR	MATH 20A
MATH 19B	OR	MATH 20B
MATH 21	OR	AMS 27/L
CMPE 16	OR	CMPE 16H
PHYS 5A/L	OR	PHYS 6A/L

25-27 Credits

**COMPUTATIONAL FOUNDATIONS**

CMPS 12A/L	OR	CMPS 13H/L
CMPS 12B/M		
CMPE 12/L		
CMPS 109		
CMPS 101		
Honors project lab (substitute for CS 12L/M)		

26-31 Credits

**ART AND SOCIAL FOUNDATIONS**

*Ethics Requirement AND 3 of the following electives*

Ethics Requirement

One of: CMPE 80E, PHIL 22, PHIL 24, PHIL 28, BME 80G

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Art Elective

One of: ART 10G, ART 10H, ART 80A, ART 80F

Film Elective

One of: Film 20A, Film 20C, Film 20P

Music Elective

One of: MUSC 11A, MUSC 11B, MUSC 11C, MUSC 11D, MUSC 80C, MUSC 80L, MUSC 80M, MUSC 80R

Economics Elective

One of: ECON 1, ECON 2, ECON 80H

Theater Elective

One of: THEA 10, THEA 18, THEA 19, THEA 20, THEA 30, THEA 40, THEA 80E, THEA 80L

20 Credits

**GAME DESIGN**

◇ CS 20: Game Design Experience (5 credits, lower division)

◇ CS 170: Game Design Studio I (upper division)

◇ CS 171: Game Design Studio II (upper division)

◇ CS172: Game Dsgn Studio III (upper division)

20 Credits

**GAME ENGINEERING ELECTIVES**

CGE Elective I

CGE Elective II

CGE Elective III

CGE Elective IV

CGE Elective V

CGE Electives: CMPS 160, CMPS 161/L, ◇ CMPS 164/L, CMPS 105, CMPS 111, CMPE 110, CMPS 128, CMPS 140, CMPS 146, CMPE 163/L, CMPS 180, CMPS 181, CMPS 183, CMPS 102, CMPS 130, CMPE 150, CMPE 152, CMPE 113, CMPE 118/L, CMPE 117/L, AMS 131, AMS147, AMS 162

25-33 Credits

**DIGITAL MEDIA ELECTIVES**

DM Elective I

DM Elective II

DM Electives: Film 170A, Film 177, Film 171D, any DANM course (requires approval of instructor), Art 118, THEA 157

10 Credits

## CURRICULUM DETAIL

### Math and Physics

Take all courses:

MATH 19A: Calculus for Science, Engineering, and Mathematics (*derivatives, limits*)

MATH 19B: Calculus for Science, Engineering, and Mathematics (*integrals, series*)

(*Students can alternately take Honors Calculus, MATH 20A/B.*)

MATH 21: Linear Algebra OR AMS 27/L Mathematical Methods for Engineers (*linear algebra, ODEs*)

CMPE 16: Applied Discrete Mathematics (*honors section also available*)

PHYS 5A/L: Introduction to Physics I (*mechanics, Newton's laws, work and energy, can also take honors*

*PHYS 6A/L*)

### Computational Foundations

Take all courses:

CMPS 12A/L: Introduction to Programming

CMPS 12B/M: Introduction to Data Structures

(*Students may substitute the new Honors Project Lab for 12L and 12M, featuring game development projects.*)

CMPE 12/L: Computer Systems and Assembly Language Laboratory

CMPS 109: Advanced Programming (*object-oriented programming and design*)

CMPS 101: Algorithms and Abstract Data Types (*includes complexity analysis of algorithms*)

### Game Design

Take all courses. Game Design Experience is waived as a requirement for transfer students entering with junior status, since the explicit goal of this course is to provide a game design experience in the lower division, and transfer students will be taking the intensive Game Design Studio sequence in their second year.

CMPS 20: Game Design Experience (*NEW in AY 06/07, lower division group-based game design project course, based on existing CMPS 80K*)

CMPS 170: Game Design Studio I (*NEW in AY 07/08, software engineering for game projects, group-based game design project, upper division*)

CMPS 171: Game Design Studio II (*NEW in AY 07/08, software and game design, group-based game design project, upper division*)

CMPS 172: Game Design Studio III (*NEW in AY 07/08, advanced game development technology, group-based game design project, upper div.*)

### Digital Media Electives

Pick two of the following:

FILM 170A: Introduction to Digital Media Production

FILM 177: Digital Media Workshop: Computer as a Medium

FILM 171D: Social Information Spaces

Any course offered in the Digital Arts New Media (DANM) curriculum (*requires approval of professor*)

ART 118: Computer Art: Theories, Methods, and Practices (*may require approval of instructor*)

THEA 157, Playwriting Workshop

### Computer Game Engineering Electives

Pick six of the following:

CMPS 160: Introduction to Computer Graphics

CMPS 161/L: Visualization and Computer Animation

CMPS 164: Graphic Elements for Computer Games (*NEW in 06/07 AY, developed by Prof. Pang using a new course fellowship in 2005/6*)

CMPE 163/L: Multimedia Processing and Applications

CMPS 140: Artificial Intelligence

CMPS 146: Game Artificial Intelligence  
CMPE 110: Computer Architecture  
CMPS 128: Distributed Systems: File Sharing, Online Gaming, and More  
CMPS 105: Systems Programming (*file i/o, processes, synchronization, signals, interprocess communication*)  
CMPS 111: Introduction to Operating Systems  
CMPE 150: Introduction to Computer Networks  
CMPE 152: Analysis and Design of Communication Protocols  
CMPE 113: Parallel and Concurrent Programming  
CMPS 180: Database Systems I  
CMPS 181: Database Systems II  
CMPS 183: Hypermedia and the Web  
CMPS 102: Introduction to Analysis of Algorithms  
CMPS 130: Computational Models  
CMPE 117/L: Embedded Software  
AMS 131: Introduction to Probability Theory  
AMS 147: Computational Methods and Applications  
AMS 162: Design and Analysis of Computer Simulation Experiments

#### **Art and Social Foundations**

Satisfy the Ethics Requirement, and then pick 3 of the following electives, which partially satisfy campus general education requirements:

#### **Ethics Requirement**

One of:

CMPE 80E: Engineering Ethics  
PHIL 22: Introduction to Ethical Theory  
PHIL 24: Introduction to Ethics: Contemporary Moral Issues  
PHIL 28: Environmental Ethics  
BME 80G: Bioethics in the Twenty-First Century: Science, Business, and Society (*cross listed as PHIL 80G*)

#### **Art Elective**

One of:

ART 10G: 2D Foundation (*introduction to two-dimensional art practice and history*)  
ART 10H: 3D Foundation (*introduction to three-dimensional sculpture, intermedia, performance art*)  
ART 80A: Introduction to Drawing  
ART 80F: Introduction to Issues in Digital Media

#### **Film Elective**

One of:

FILM 20A: The Film Experience (*intro. to basic elements of cinematic representation and expression*)  
FILM 20C: Introduction to Digital Media  
FILM 20P: Introduction to Production Technique

#### **Theater Elective**

One of:

THEA 10: Introduction to Theater Design and Technology  
THEA 17: Costume Construction  
THEA 18: Drafting for Theatrical Production  
THEA 19: Design Studio: Lighting Studio  
THEA 20: Introductory Studies in Acting  
THEA 30: Introduction to Modern Dance Theory and Technique  
THEA 40: Introduction to Directing

THEA 80E: Stand-Up Comedy  
THEA 80L: Muppet Magic: Jim Henson's Art  
THEA 80N: Walt Disney  
THEA 80X: The Performance of Story in Theater and Film

#### **Music Elective**

One of:

MUSC 11A: Introduction to Western Art Music (*study of selected masterworks in relation to their periods*)  
MUSC 11B: Introduction to Jazz  
MUSC 11C: Introduction to American Popular Music  
MUSC 11D: Introduction to World Music  
MUSC 80C: History, Literature, and Technology of Electronic Music  
MUSC 80L: Artificial Intelligence and Music  
MUSC 80M: Film Music  
MUSC 80R: Music and the World Wide Web

#### **Economics Elective**

One of:

ECON 1: Introductory Microeconomics: Resource Allocation and Market Structure  
ECON 2: Introductory Macroeconomics: Aggregate Economic Activity  
ECON 80H: Wall Street and the Money Game (*structure of financial markets*)

### **GRADUATION REQUIREMENTS**

To graduate with a BS in Computer Science: Computer Game Design, students must satisfy UCSC graduation requirements, as well as complete the course plan listed above. Receiving a passing grade in all three courses of the Game Design Studio sequence satisfies the comprehensive requirement. Since this sequence involves synthesis of materials learned in the curriculum as students create a substantial computer game, it meets capstone requirements.

### **GRADE REQUIREMENTS AND DISQUALIFICATION FROM THE MAJOR**

Consistent with other School of Engineering programs, we apply additional requirements for taking courses for a letter grade. We follow the Computer Science degree requirements that all courses required for the major must be taken for a letter grade. Two lower-division exceptions are allowed, though students are discouraged from using them for foundation courses (see Admission Requirements below), since a Pass translates to a C when computing GPA for admission to the major.

We use a variation on the standard computer science policy for disqualification. Students who do not make adequate progress in the Computer Game Design major may be disqualified from the major. Adequate progress normally means passing a minimum of three courses required for the major over every three consecutive quarters. For part-time students, this means 1 course required for the major over every two consecutive quarters. Students who receive a total of three or more grades of D, F, or No Pass in the key courses, CMPS 12A/L, CMPS 12B/L, CMPS 13H, CMPS 101, CMPE 12, CMPE 16, CMPE 16H may, at the discretion of the Computer Science department, be disqualified from the major. We note that the Computer Science Department is currently considering revisions to its disqualification policy for the BA and BS degree; we intend to be consistent with the final form of this policy.

Additionally, the Computer Science Dept. may, at its sole discretion, disqualify from the major any student making two unsuccessful attempts in any one of the Math & Physics courses, Computational Foundations Courses, Computer Game Engineering, or Game Design elective courses. A grade of D, F, or No Pass counts as one unsuccessful attempt; each grade of W counts as one-half of an unsuccessful attempt.

## SAMPLE PROGRAM

### PLAN ONE – ENTER UCSC FRESHMAN YEAR

This plan is for a student entering UCSC in their freshman year who is prepared to go directly into MATH 19A/20A and CMPS 12A.

Year	Fall	Winter	Spring
1	Core MATH 19A or 20A CMPS 12A CMPS 12L or Honors Project Lab I	Composition (C, or gen ed) MATH 19B or 20B CMPS 12B CMPS 12M or Honors Project Lab II	Art/Social Elective I CMPE 12/L CMPS 20 (Game Design Experience)
2	PHYS 5A/L or 6A/L gen ed MATH 21 or AMS 27/L	Art/Social Elective II CMPS 109 CMPE 16	Art/Social Elective III Ethics Requirement CMPS 101
3	gen ed Game Engineering Elect. I Digital Media Elective I	gen ed Game Engineering Elect. II Game Engineering Elect. III	gen ed Game Engineering Elect. IV Digital Media Elective II
4	gen ed CMPS 170 (Game Design Studio I) Game Engineering Elect. V	gen ed gen ed CMPS 171 (Game Design Studio II)	gen ed CMPS 172 (Game Design Studio III)

### PLAN TWO – ENTER UCSC FRESHMAN YEAR, NEED MATH & CS PREPARATION CLASSES (MATH 3, CMPS 10)

This plan is for a student entering UCSC their freshman year who needs to take preparatory courses prior to Math 19A or CMPS 12A to ensure a successful outcome in those courses.

Year	Fall	Winter	Spring
1	Core MATH 3 CMPS 10	Writing (C, or gen ed) MATH 19A CMPS 12A/L	MATH 19B CMPS 12B/M Art/Social Elective I
2	Art/Social Elective II CMPE 12/L PHYS 6A/L	Art/Social Elective III CMPE 16 CMPS 109	MATH 21 or AMS 27/L Ethics Requirement CMPS 20 (Game Design Experience)
3	CMPS 101 Digital Media Elective I gen ed	Game Engineering Elect. I gen ed gen ed	gen ed Game Engineering Elect. II Digital Media Elective II
4	gen ed CMPS 170 (Game Design Studio I) Game Engineering Elect. III	gen ed CMPS 171 (Game Design Studio II) Game Engineering Elect. IV	gen ed CMPS 172 (Game Design Studio III) Game Engineering Elect. V

## PLAN THREE – TRANSFER STUDENT

We assume transfer students will have completed the equivalent of the following courses before entering UCSC: MATH 19A, MATH 19B, MATH 21, CMPE 16, PHYS 5A/L, CMPS 12A, CMPS 12B, as well as at least 40 credits worth of general education electives.

Dept. of Computer Science transfer students have, in recent years, frequently had the option of taking CMPS 101 in the summer before starting their first year> This improves their ability to complete degree requirements in two years by reducing the number of quarters in which they must take three technical courses at once. In the case of the Computer Game Design major, this would permit students to take CMPS 109 in the Fall Quarter, reducing the technical course load in Winter of year 1 to two courses (the same as all other quarters).

The undergraduate game design course requirement, Game Design Experience, is waived for transfer students.

Year	Fall	Winter	Spring
1	CMPS 101 CMPE 12/L Art/Social Elective I	CMPS 109 Game Engineering Elect. I Digital Media Elective I	Ethics Requirement Game Engineering Elect. II Digital Media Elective II
2	Art/Social Elective II Game Design Studio I Game Engineering Elect. III	Art/Social Elective III Game Design Studio II Game Engineering Elect. IV	gen ed Game Design Studio III Game Engineering Elect. V

## SATISFACTION OF GENERAL EDUCATION REQUIREMENTS

This section describes how the curriculum satisfies the campus core and general education requirements for students who complete all degree requirements at UCSC. By judicious choice of Art/Social Foundations classes, in combination with required computer science and math classes, students can satisfy up to 30 credits of general education.

Campus core – college core course

IH (10 credits): one IH course listed as an Art/Social Elective in Arts Division (Art Elective, Film Elective, Music Elective, or Theater Elective), one IH course from the Humanities Division

IN (10 credits): there are many ways to satisfy this requirement, one being CMPS 12A and MATH 19A

IS (10 credits): either the Art/Social Economics Elective (ECON 1 or ECON 2 only) or two IS courses outside the list of required courses for the curriculum

Topical Courses:

T3 (Social sciences): ECON 80H or a course from the T3 or T7 course lists outside the list of required courses for the curriculum

T4 (Humanities and arts): the Art/Social Music or Theater Arts Electives (choosing a course from the T4 list), or a T4 course not in the curriculum

T6 (Natural sciences or humanities and arts): Satisfied by CMPE 80E (Engineering Ethics)

## ADMISSION REQUIREMENTS

The Computer Game Design program will follow the existing admissions requirements for the BA and BS in Computer Science degree programs. In particular, this program will require incoming first year students to explicitly apply for direct acceptance into the program, and applicants will be granted direct acceptance

based on their high school grade point average, courses completed in mathematics and sciences, scores on standardized tests, and/or their personal statement.

Following existing School of Engineering policy, students who are not granted direct entrance into the program may still apply to declare the major once they have completed its foundation courses (these are distinct from the Computational Foundations and Art/Social Foundations courses) with a 2.8 or better GPA. The foundation courses for the Computer Game Design degree are the same as those for the existing Computer Science BA and BS: CMPS 12A and CMPS 12B (or CMPS 13H), CMPE 16 or CMPE 16H, MATH 19A, MATH 19B. Students below a 2.8 may be admitted at the discretion of the Computer Science Dept.

The School of Engineering's General Major Preparation recommendations apply to this program. These recommendations are to complete four years of mathematics (through advanced algebra and trigonometry), and three years of science. A more ideal high school preparation would include calculus, ensure physics was one of the science classes taken, and have an introduction to computer programming.

Transfer students from community colleges are encouraged to apply for entry into this program. Admission requirements are consistent with the rest of the School of Engineering, and involve students completing most of the foundation courses for the major. No articulation agreements with community colleges are currently in place specifically for the Computer Game Design major. However, students following existing articulation agreements for courses for the BA/BS in Computer Science will find it straightforward to transfer into this program. As well, many of the Art/Social Foundation courses likely already have existing articulation agreements, and these courses could be taken at community college as well. Existing articulation agreements can be used until Computer Game Design specific agreements are developed (as needed) during the 2006/7 academic year.

## **FACULTY**

The core of the degree program faculty is the membership of the Dept. of Computer Science. The department features research groups in computer graphics (Professor Suresh Lodha, Professor Alex Pang, Professor Allen van Gelder, Assistant Professor James Davis), artificial intelligence and machine learning (Professor Robert Levinson, Professor Manfred Warmuth, Professor David Helmbold, Professor Ira Pohl, Assistant Professor Dimitris Achlioptas), databases (Professor Phokion Kolaitis, Assistant Professor Wang-Chiew Tan, Assistant Professor Alkis Polyzotis), programming languages and software engineering (Professor Martin Abadi, Professor Charlie McDowell, Associate Professor Cormac Flanagan, Assistant Professor Jim Whitehead), and storage and real-time systems (Professor Darrell Long, Associate Professor Scott Brandt, Associate Professor Ethan Miller). This broad set of faculty provides a strong foundation for offering a technically rigorous degree program in Computer Game Design. Additionally, this large set of faculty permit broad flexibility in scheduling leaves of absence without adversely affecting ongoing degree programs.

Faculty in Film and Digital Media also contribute to the strength of the program. Associate Professor Sharon Daniel and Assistant Professor Warren Sack teach the majority of the digital media courses being used as digital media electives.

We note that the degree program draws upon courses from a wide array of departments, and hence their faculty will also be contributing to the development of students in the program.

## **RESOURCE REQUIREMENTS**

Resource requirements for the degree program fall primarily in the areas of faculty and lecturer projections and hiring, instructional laboratory creation, and program administration. These are covered in the sections below.

## **FACULTY AND LECTURER PROJECTIONS**

As the Computer Game Design program ramps up to its estimated steady-state enrollment of 100 students per class, there is a need to hire new faculty members and lecturers to cover these enrollments. Additionally,

we expect many additional computer game design degree programs to be launched nationwide over the coming 5 years, leading to a need for broader course offerings to maintain UCSC's early lead and competitiveness in this space.

In the 2005/06 academic year, Computer Science has hired a junior tenure-track faculty member in computer games, Michael Mateas. Prof. Mateas is a widely recognized researcher in the area of interactive drama, and richly interactive non-player characters, and will bring considerable strength and visibility to the program.

In the long term, we will build up a research group of 3 faculty with research interests in computer gaming (hired in 2005/6, 2007/8, and 2010/11). This will provide sufficient critical mass in this area to have an effective research group in computer gaming, as well as provide flexibility and depth in computer game course offerings. We expect that, to remain competitive with other computer game design programs over the coming years, we will need to expand course offerings in computer games beyond the core classes listed in this proposal. The new faculty will be able to cover existing course offerings, as well as create new courses in their area of specialty. Additionally, three total faculty make it possible to easily cover leaves of absence. As these faculty build up their research programs, they will additionally be training graduate students and creating research laboratories in computer gaming, which will have positive effects on the degree program. Our hiring of faculty in computer gaming is consistent with current Computer Science hiring plans, part of the School of Engineering's divisional five-year plan.

Can the degree program be launched with only one faculty hire with interests in computer gaming? Absolutely. The Computer Science Dept. currently has sufficient depth of personnel that it can successfully offer the proposed degree. Computer Science has four existing faculty in Artificial Intelligence and Machine Learning (Levinson, Warmuth, Helmbold, and Achlioptas), and three faculty in Computer Graphics (Pang, Lodha, Davis). The three Computer Systems faculty (Long, Miller, Brandt) are able to cover distributed systems issues in computer games, such as in CMPS 128 (Distributed Systems: File Sharing, Online Gaming, and More), taught by Prof. Miller. Prof. Whitehead is currently teaching course CMPS 80K (Foundations of Interactive Game Design) on game design. As a result, Computer Science has the capacity to teach the four new required courses being introduced as part of this degree program.

ACADEMIC YEAR	FACULTY HIRES	LECTURER HIRES
2005/06	1 Computer Gaming (Assistant Professor, CS)	None
2006/07		1 quarter (CS, games course)
2007/08	1 Computer Gaming (Assistant Professor, CS)	1 quarter (CS, games course)
2008/09		1 quarter (FILM, Digital Media course)
2009/10		2 quarters (FILM, Digital Media courses)
2010/11	1 Computer Gaming (Assistant Professor, CS)	

Hiring of lecturers is designed to enhance current course offerings in computer gaming, as well as to address enrollments of students in the upper division Film and Digital Media Dept. courses that comprise the Digital Media electives component of the degree. At present, Film and Digital Media can only accommodate appx. 15-20 additional students in their upper division digital media courses before they become impacted. We request support for lecturers in Film & Digital Media to forward-fund additional

course offerings to accommodate computer gaming students. The need for these additional lecturers begins once student enrollments start increasing in the upper division, starting in the 2008/9 academic year. Once these additional course sections have been offered once or twice, we anticipate that the enrollments generated by these courses will generate sufficient funding for future offerings.

We also include 1 quarter of lecturer per year in computer science to increase course offering in computer gaming as we hire additional computer gaming faculty. In particular, in the 2006/7 academic year, we hope to continue a new course being offered in Spring 2006, AI for Computer Games, being offered by John Funge, a local expert in artificial intelligence for computer gaming. John Funge is an example of the kind of local talent that exists in the Santa Cruz and Silicon Valley area that we can draw upon to immediately improve course offerings in computer gaming as we ramp up the program. We note that John Funge is teaching AI for Computer Games this year pro-bono, though there is no guarantee that will continue.

## INSTRUCTIONAL GAME DEVELOPMENT LABORATORY

The gaming degree program will require the creation of an instructional laboratory for use by gaming classes, and the senior design sequence. We propose to create a teaching laboratory stocked with game console development kits (e.g., Xbox 360, Playstation 3, Nintendo Revolution) for the purpose of instruction in game design, parallel programming, and graphics. Instruction using actual game consoles is one way that universities can provide a valuable educational role, since the cost of these development kits is beyond the resources of most individuals. Especially with the next generation of game consoles, their hardware capabilities are substantially different from stock PCs, and hence experience developing for these platforms is a plus. Providing instruction on these consoles will also be very attractive to prospective students.

Initially, we would like to construct a 10 station laboratory, where each station includes a current generation development kit, high definition-capable screen (next generation consoles are designed to drive high definition displays), and development workstation (with its own dedicated screen). We estimate that each station will have a cost of \$4.3k (\$2k HD screen, \$2k for dev. workstation and screen, \$300 for security cables/monitoring), assuming we can secure donations of the development kits. We are currently in discussion with Microsoft on getting donations of Xbox 360 development kits.

We anticipate being able to secure donations of at least one complete set of development kits for one of the consoles (such as the Xbox 360). We also hope to have smaller numbers of development kits for other consoles, to support projects on these platforms. We anticipate also having 2 stations for use in critical analysis of games. These stations will have stock versions of each console, along with a high-definition display and headphones, mounted on a moveable cart for use in classroom teaching as well. Each such station is estimated to cost \$4.3k per station: \$2k HD screen, \$500 per game console x 3 consoles, \$400 for a wheeled cart, \$100 for headphones, \$300 for security cables). If we are unable to obtain donations of games, we will also need \$1000 (total) for purchase of games for these consoles.

The total cost of equipment for the laboratory, assuming donation of development kits, is estimated to be \$52.6k. We assume that much existing furniture can be used for this lab, though additional required furniture may add up to \$15k in costs.

The location of the game development laboratory is expected to be in Engineering 2, most likely on the third floor in existing Computer Science laboratory space (E2 397 and E2 392 are two possibilities here). Use of E2 5<sup>th</sup> floor space is another possibility.

This laboratory setup is very similar to the existing GamePipe instructional laboratory currently in use at USC. We believe the creation of an instructional game development laboratory at UC Santa Cruz is critical for the success of the program, and for attracting top students.

The game development laboratory will be created during the 2006/7 academic year. We believe it is important to create this laboratory quickly, so UCSC can develop experience in operating such a laboratory, as well as using it for a recruitment tool. The Dean of Engineering has agreed to the development of this laboratory.

As enrollments in the degree program reach their steady-state level, we anticipate the need to increase the size of the game development laboratory to accommodate more student teams and larger class sizes. Due to the rapid obsolescence of computer hardware, we anticipate replacing all of the original computers (but not the development kits), and doubling the size of the laboratory in the 2009/10 academic year.

We expect that administration of the laboratory will be performed by the Baskin Engineering Lab Support (BELS), and not Instructional Computing within ITS. We believe BELS is the best choice for lab administration, since the laboratory is for specific use by a small set of courses within the degree program. Instructional Computing typically administers labs that have general use by a wide range of classes, and serves a broad range of departments and degree programs. Since the goal of this laboratory is to specifically support Computer Game Engineering courses, especially the senior year capstone game design sequence, this laboratory is much more focused than the typical lab administered by Instructional Computing. We also anticipate advantages in coordination concerning the laboratory due to the close physical proximity and long-established working relationships with BELS staff.

Ongoing maintenance requirements of the game development laboratory are expected to be modest. Machines will need ongoing security patches and operating system upgrades, and new software will need to be installed on the machines, as needed. Broken machines will need to be sent for repair on a timely basis. We anticipate that managing this laboratory will require 0.25-0.50 of one full time person, once the initial lab setup has been completed. The Dean of the School of Engineering is supportive of this level of lab management.

## **PROGRAM ADMINISTRATION**

The program will primarily be administered by the Computer Science Department, in cooperation with the School of Engineering Undergraduate Advising Office, and the Engineering Business Office, as appropriate.

The Faculty Chair of the Computer Game Design degree will be directly responsible for oversight of the degree. The Faculty Chair is expected (but not limited) to be the Chair of the Dept. of Computer Science. The Faculty Chair is the lead administrative officer for the degree program.

The Faculty of the Computer Game Design program are selected by the Dean of the School of Engineering. This faculty is expected to typically consist of the faculty of Computer Science, along with participating faculty from Film and Digital Media. As the degree program evolves, the set of program faculty is expected to grow as more gaming courses are introduced across campus.

The Chair and Program Faculty shall be responsible for short-range and long-range planning, curriculum development, evaluation of the program, outreach activities, undergraduate advising, and all other aspects of maintaining an active undergraduate degree program.

Program Faculty are responsible for teaching program courses, and for serving on standing and ad-hoc committees.

The Chair shall execute the policies of the Program Faculty in the day-to-day running of the program.

One concern that has surfaced multiple times is how to monitor and handle potentially large enrollments in the courses of participating departments. The program's Curriculum Committee is specifically charged with performing a yearly assessment of the enrollment impact of the degree program on each participating department. The Chair, in cooperating with the Dean of Engineering, is responsible for negotiating for additional resources, as needed, to cover the impact of high enrollments.

Other details concerning the administration and governance structure of the program can be found in the Charter for the Computer Game Engineering Degree (enclosed).

## **ADDITIONAL RESOURCES**

There are a few additional resource implications for this program.

While the Science and Engineering library already has a strong collection of materials on computer graphics and computer gaming, we anticipate these would need to be augmented with some additional computer gaming specific materials. We expect that the library funds allocated as part of the startup packages of the three computer gaming faculty hires will be more than sufficient to purchase necessary books. Existing subscriptions to academic digital libraries (ACM, IEEE) cover the most relevant sources of information on the computer science of computer games. The library also possesses many electronic versions of books on graphics and game programming.

The new courses in computer gaming will need associated TA resources. We anticipate that each new course will require at least a single TA. In the event of large enrollments for the Game Design Experience or Game Design Studio courses, multiple TAs would be needed per quarter. This is a modest increase over current TA needs for the entire Computer Science Department, and hence we expect that TA resources will come out of the normal yearly Computer Science TA allocation. We recognize that, like all classes at UCSC, that TA allocations will depend on the level of undergraduate enrollment in these classes, and the overall enrollment on campus which generates the funds from which TAs are drawn. We note that, in the unlikely event of very low enrollments in computer gaming specific courses, the need for TAs will be substantially reduced, and in the case of very low enrollments, TAs may not be necessary at all. We anticipate TA allocations being evaluated on a per-year and per-offering basis to make the most efficient use of TA resources.

Funds are included for accreditation of the degree program once it has graduated its first students. This includes \$5k in 2007/8 to pay for attendance at ABET training workshops, and \$15k in 2008/9 to cover costs of the site visit for accreditors, as well as a course relief for the faculty member leading the accreditation activity.

## **FEEDBACK OR QUESTIONS ON THE PROPOSAL**

Questions concerning this proposal may be directed to Ira Pohl, [pohl@cs.ucsc.edu](mailto:pohl@cs.ucsc.edu), or Jim Whitehead, [ejw@cs.ucsc.edu](mailto:ejw@cs.ucsc.edu), 831-459-1227.

## SUMMARY OF RESOURCE REQUIREMENTS

We show a summary of anticipated resource requirements by year in the table below. Expected total enrollments per year are indicated under the year.

ACADEMIC YEAR	RESOURCES
2005/06 (0)	Faculty hire #1 (Assistant Professor) Startup package for computer gaming faculty hire #1 (\$125-\$150k, includes library funds)
2006/07 (25)	Game development laboratory (\$52.6k-\$67.6k) Hire game development laboratory manager (0.1 FTE) 2 teaching assistants for Game Design Experience & CMPS 164 Graphic Elements for Computer Games. Lecturer in Computer Games (\$8k-\$10k)
2007/08 (60)	Faculty hire #2 (Assistant Professor) Startup package for computer gaming faculty hire #2 (\$150-\$175k, includes library funds) Accreditation expenses (\$5k) Computer game purchases for critical analysis (\$1k) 5 teaching assistants for Game Design Experience & CMPS 164 (Graphic Elements for Computer Games) & Game Design Studio I-III Lecturer in Computer Games (\$9k-\$11k)
2008/09 (100)	Accreditation expenses (\$15k) Computer game purchases (\$1k) 5 teaching assistants for Game Design Experience & CMPS 164 & Game Design Studio I-III Lecturer in Digital Media (\$10k-\$11k)
2009/10 (135)	Update and potentially increase size of game development laboratory (\$50k-\$100k) Accreditation expenses (\$10k, shared with other programs undergoing re-accreditation at this time, including Computer Engineering and Electrical Engineering) Computer game purchases (\$1k) 5 teaching assistants for Game Design Experience & CMPS 164 & Game Design Studio I-III 2 lecturers in Digital Media (\$20k-\$21k)
2010/11 (150)	Faculty hire #3 (Assistant Professor) Startup package for computer gaming faculty hire #3 (\$175-\$200k, includes library funds) Computer game purchases (\$1k) 5 teaching assistants for Game Design Experience & CMPS 164 & Game Design Studio I-III

## CATALOG COPY

The following section describes changes to the UCSC General Catalog that will need to be made once the BS Computer Science: Computer Game Design degree program has been approved. Section headings and page numbers are from the printed version of the 2004-06 edition. Text changes are with respect to the updated (online, electronic) version of the catalog at <http://reg.ucsc.edu/catalog/> (access date: May 8, 2006). New text is represented in **bold**, deleted text has a strikethrough ~~line~~.

## FIELDS OF STUDY

Page 8.

Add a new line under Computer Science, labeled “Computer game design”. A bullet will be placed in the “B.S.” column.

## ENGINEERING

Page 190.

Under the heading “Undergraduate Study”

The School of Engineering offers ~~1413~~ undergraduate degree programs. Students may choose from the following options:

Bioinformatics B.S. or combined B.S./Graduate

Bioinformatics minor

Computer engineering B.S. or combined B.S./M.S.

Computer engineering minor

Computer science B.A. and B.S.

**Computer science: computer game design B.S.**

Computer science minor

Computer technology minor

Electrical engineering B.S.

Information systems management B.S.

Statistics minor

Immediately after the Computer Science program description (page 191), add the following paragraph:

**Computer Science: Computer Game Design.** The computer game design curriculum is a four-year interdisciplinary program that focuses on the technical, dramatic, and artistic elements of computer games. The program provides a rigorous education in computer science, in concert with a broad introduction to those aspects of art, music, narrative, digital media, and computer engineering most relevant to games. An intensive year-long game design studio sequence permits students to create substantial video games as part of a multi-student team. Students receive proficiency in many aspects of computer science, a good academic foundation for careers in the computer game industry or information technology industry, or for the pursuit of graduate studies in computer science, or computer game design.

## FOUNDATION COURSES

Page 192.

After the section describing Computer Science foundation courses, add the following section (these are the same requirements for the existing Computer Science BA and BS degrees, and are listed separately from these for clarity):

**Computer Game Design:** Computer science 12A and 12B, Computer Engineering 16 or Mathematics 19A-B.

## LETTER GRADE POLICY

Page 192.

After the section describing Computer science major and minor, add the following section (these are the same requirements for the existing Computer Science BA and BS degrees, and are listed separately from these for clarity):

**Computer game design:** All courses required for the major and minor must be taken for letter grades. Two lower-division exceptions are allowed.

## PROGRAM DESCRIPTION

Page 209.

This is the program description section underneath the Computer Science department heading.

Computer science is the study of the theoretical and practical aspects of computer technology and computer usage. The Computer Science Department offers courses on a wide range of topics, many of which include a mathematical component, and offers **undergraduate** both the bachelor of arts and bachelor of science degrees **in computer science, a bachelor of science in computer science: computer game design**, as well as the master of science and doctor of philosophy degrees. Besides offering instructional courses, the department engages in a substantial research program in which both advanced undergraduates and graduate students participate.

The bachelor of arts program at UC Santa Cruz is designed to give students a solid grounding in both theoretical and practical topics in computer science, computer engineering, and mathematics while leaving flexibility for a broad program of study, including many courses outside of the sciences, or even for a double major in another discipline. The bachelor of science program is appropriate for students desiring a somewhat stronger concentration in the sciences, with more courses in computer science and computer engineering, as well as courses in physics or chemistry; this program also allows for electives outside of the sciences. **The bachelor of science in computer game design builds on a rigorous core program of study in computer science, adding interdisciplinary study on the artistic, dramatic, and narrative elements of computer game design; a year-long game design project acts as a capstone learning experience.** Because many courses in ~~both~~ **all three** programs have prerequisites, students leaning toward ~~either program~~ **many of these programs** will enjoy greater scheduling flexibility if they begin some preparatory courses in their first year. The specific course requirements for each undergraduate degree are given below.

Applications of computer science are found in many other areas of study, from art and music to business and science. Thus, interdisciplinary activities are encouraged. For those students whose primary interest is in another area, a minor in computer science is offered.

## MAJOR REQUIREMENTS

Page 211.

Immediately after the end of the “B.S. Major Requirements” section, add the following section that describes the requirements for the BS Computer Science: Computer Game Design.

## *B.S. Computer Science: Computer Game Design Major Requirements*

The goal of this degree is to provide students a deep understanding of the technical aspects of computer game engineering, and a broad background in the artistic, narrative, and dramatic elements of game design. The core of the degree program is a strong grounding in computer science and computer engineering, preceded by a foundation in math and physics. Classes in ethics, as well as courses in art, film, music, theater arts, and economics provide breadth in topics of special relevance to computer game design. In their upper division courses, students gain depth by taking upper division electives in computer science and computer engineering. Two advanced courses in digital media give students the ability to view computer software from an artistic framework. A year-long capstone game design studio class allows students to develop substantial computer games, and integrate materials from the rest of the program.

The curriculum has 124-141 credits in 24-25 courses (depending on whether a student enters as a transfer student). 12 of the courses are upper division. Students interested in the major should pay special attention to the overlap between general education requirements and major requirements, as the major covers up to six general education requirements.

### **Lower- and Upper-Division Requirements**

Course requirements are divided into six conceptual areas:

#### Mathematics and Physics

Complete all of the following courses:

Mathematics 19A-B: *Calculus for Science, Engineering, and Mathematics*

(Students can alternately take Honors Calculus, Mathematics 20A-B. Credit for one or both Math 19A-B may be granted with adequate performance on the CEEB calculus AB or BC Advanced Placement exam.)

Mathematics 21: *Linear Algebra* OR Applied Mathematics and Statistics 27/L *Mathematical Methods for Engineers*

Computer Engineering 16 (or 16H): *Applied Discrete Mathematics*

Physics 5A/L (or 6A/L): *Introduction to Physics I*

#### Computational Foundations

Complete all of the following courses:

Computer Science 12A/L: *Introduction to Programming*

Computer Science 12B/M: *Introduction to Data Structures*

Computer Engineering 12/L: *Computer Systems and Assembly Language Laboratory*

Computer Science 109: *Advanced Programming*

Computer Science 101: *Algorithms and Abstract Data Types*

#### Game Design

Complete all of the following courses. The course *Game Design Experience* is waived for transfer students.

Computer Science 20: *Game Design Experience (pending)*

Computer Science 170: *Game Design Studio I (pending)*

Computer Science 171: *Game Design Studio II (pending)*

Computer Science 172: *Game Design Studio III (pending)*

#### Computer Game Engineering

Complete six courses from the following list:

Computer Science 160: *Introduction to Computer Graphics*

Computer Science 161/L: *Visualization and Computer Animation*

Computer Science 164: *Graphic Elements for Computer Games*

Computer Engineering 163/L: *Multimedia Processing and Applications*

Computer Science 140: *Artificial Intelligence*

Computer Science 146: *Game Artificial Intelligence*

Computer Engineering 110: *Computer Architecture*

Computer Science 128: *Distributed Systems: File Sharing, Online Gaming, and More*

Computer Science 105: *Systems Programming*  
Computer Science 111: *Introduction to Operating Systems*  
Computer Engineering 150: *Introduction to Computer Networks*  
Computer Engineering 152: *Analysis and Design of Communication Protocols*  
Computer Engineering 113: *Parallel and Concurrent Programming*  
Computer Science 180: *Database Systems I*  
Computer Science 181: *Database Systems II*  
Computer Science 183: *Hypermedia and the Web*  
Computer Science 102: *Introduction to Analysis of Algorithms*  
Computer Science 130: *Computational Models*  
Computer Engineering 117/L: *Embedded Software*  
Applied Mathematics and Statistics 131: *Introduction to Probability Theory*  
Applied Mathematics and Statistics 147: *Computational Methods and Applications*  
Applied Mathematics and Statistics 162: *Design and Analysis of Computer Simulation Experiments*

#### Digital Media

Complete two courses from the following list:

Film and Digital Media 170A: *Introduction to Digital Media Production*  
Film and Digital Media 177: *Digital Media Workshop: Computer as a Medium*  
Film and Digital Media 171D: *Social Information Spaces*  
Any course offered in the Digital Arts New Media (DANM) curriculum (*requires approval of professor*)  
Art 118: *Computer Art: Theories, Methods, and Practices (may require approval of instructor)*  
Theater Arts 157: *Playwriting Workshop*

#### Art and Social Foundations

Complete the ethics requirement and three of the following electives.

##### Ethics Requirement

One of:

Computer Engineering 80E: *Engineering Ethics*  
Philosophy 22: *Introduction to Ethical Theory*  
Philosophy 24: *Introduction to Ethics: Contemporary Moral Issues*  
Philosophy 28: *Environmental Ethics*  
Biomolecular Engineering 80G: *Bioethics in the Twenty-First Century: Science, Business, and Society*  
(*cross listed as PHIL 80G*)

##### Art Elective

One of:

Art 10G: *2D Foundation*  
Art 10H: *3D Foundation*  
Art 80A: *Introduction to Drawing*  
Art 80F: *Introduction to Issues in Digital Media*

##### Film Elective

One of:

Film and Digital Media 20A: *The Film Experience*  
Film and Digital Media 20C: *Introduction to Digital Media*  
Film and Digital Media 20P: *Introduction to Production Technique*

##### Theater Elective

One of:

Theater Arts 10: *Introduction to Theater Design and Technology*  
Theater Arts 18: *Drafting for Theatrical Production*  
Theater Arts 19: *Design Studio: Lighting Studio*  
Theater Arts 20: *Introductory Studies in Acting*

Theater Arts 30: *Introduction to Modern Dance Theory and Technique*  
 Theater Arts 40: *Introduction to Directing*  
 Theater Arts 80E: *Stand-Up Comedy*  
 Theater Arts 80L: *Muppet Magic: Jim Henson's Art*

Music Elective

One of:

Music 11A: *Introduction to Western Art Music*  
 Music 11B: *Introduction to Jazz*  
 Music 11C: *Introduction to American Popular Music*  
 Music 11D: *Introduction to World Music*  
 Music 80C: *History, Literature, and Technology of Electronic Music*  
 Music 80L: *Artificial Intelligence and Music*  
 Music 80M: *Film Music*  
 Music 80R: *Music and the World Wide Web*

Economics Elective

One of:

Economics 1: *Introductory Microeconomics: Resource Allocation and Market Structure*  
 Economics 2: *Introductory Macroeconomics: Aggregate Economic Activity*  
 Economics 80H: *Wall Street and the Money Game*

*Comprehensive Requirement*

Students satisfy the senior comprehensive requirement by either receiving a passing grade in all three courses of the Game Design Studio sequence or performing a senior thesis.

*Computer Science: Computer Game Design Major Planners*

The following are three sample academic plans that students can to plan their sequence of courses in the major. Plans One and Two are suggested guidelines for students who begin their studies in their freshman year. Such students, if they plan carefully will have several openings free to take other breadth courses they find interesting. Plan One is for a student entering UCSC in their freshman year who is prepared to go directly into Mathematics 19A/20A and Computer Science 12A. Plan Two is for a student entering UCSC their freshman year who needs to take preparatory courses prior to Mathematics 19A or Computer Science 12A to ensure a successful outcome in those courses. Plan Three is for students that transfer to campus at the beginning of their junior year.

**PLAN ONE – ENTER UCSC FRESHMAN YEAR**

<b>Year</b>	<b>Fall</b>	<b>Winter</b>	<b>Spring</b>
<b>1</b>	Core MATH 19A or 20A CMPS 12A CMPS 12L or Honors Project Lab I	Composition (C, or gen ed) MATH 19B or 20B CMPS 12B CMPS 12M or Honors Project Lab II	Art/Social Elective I CMPE 12/L CMPS 20 (Game Design Experience)
<b>2</b>	PHYS 5A/L or 6A/L gen ed MATH 21 or AMS 27/L	Art/Social Elective II CMPS 109 CMPE 16	Art/Social Elective III Ethics Requirement CMPS 101
<b>3</b>	gen ed Game Engineering Elect. I Digital Media Elective I	gen ed Game Engineering Elect. II Game Engineering Elect. III	gen ed Game Engineering Elect. IV Digital Media Elective II

4	gen ed CMPS 170 (Game Design Studio I) Game Engineering Elect. V	gen ed gen ed CMPS 171 (Game Design Studio II)	gen ed CMPS 172 (Game Design Studio III)
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**PLAN TWO – ENTER UCSC FRESHMAN YEAR, NEED MATH & CS PREPARATION CLASSES (MATH 3, CMPS 10)**

Year	Fall	Winter	Spring
1	Core MATH 3 CMPS 10	Writing (C, or gen ed) MATH 19A CMPS 12A/L	MATH 19B CMPS 12B/M Art/Social Elective I
2	Art/Social Elective II CMPE 12/L PHYS 6A/L	Art/Social Elective III CMPE 16 CMPS 109	MATH 21 or AMS 27/L Ethics Requirement CMPS 20 (Game Design Experience)
3	CMPS 101 Digital Media Elective I gen ed	Game Engineering Elect. I gen ed gen ed	gen ed Game Engineering Elect. II Digital Media Elective II
4	gen ed CMPS 170 (Game Design Studio I) Game Engineering Elect. III	gen ed CMPS 171 (Game Design Studio II) Game Engineering Elect. IV	gen ed CMPS 172 (Game Design Studio III) Game Engineering Elect. V

**PLAN THREE – TRANSFER STUDENT**

Year	Fall	Winter	Spring
1	CMPS 101 CMPE 12/L Art/Social Elective I	CMPS 109 Game Engineering Elect. I Digital Media Elective I	Ethics Requirement Game Engineering Elect. II Digital Media Elective II
2	Art/Social Elective II CMPS 170 (Game Design Studio I) Game Engineering Elect. III	Art/Social Elective III CMPS 171 (Game Design Studio II) Game Engineering Elect. IV	gen ed CMPS 172 (Game Design Studio III) Game Engineering Elect. V