Carnegie Mellon's Entertainment Technology Center:
COMBINING THE LEFT AND RIGHT BRAIN

This professional master's degree program puts artists and technologists together on interdisciplinary teams to create interactive experiences.

By **RANDY PAUSCH** and **DON MARINELLI**

Carnegie Mellon University created its Entertainment Technology Center (ETC) in 1999 to grant a professional master's degree to prepare students for the video game and themed and digital entertainment industries. The goal is to prepare them to work in interdisciplinary teams that create content for video games, computer-generated movies, theme parks, and interactive museums. Carnegie Mellon has a long history of interdisciplinary research and teaching, but even by these standards, the ETC represents a broadly collaborative effort. Reflecting this explicitly interdisciplinary effort, one of us (Marinelli) was a professor of drama and arts management and the other (Pausch) a professor of computer science, human-computer interaction, and design. Each had prior experience merging art and technology: Pausch had spent a six-month sabbatical at Walt Disney

Hi-tech, themed entranceway to the Entertainment Technology Center, Pittsburgh, PA. (Created by the ETC's Location-Based Entertainment project group; photo by Charles Palmer, Carnegie Mellon ETC.)

Imagineering's Virtual Reality studio, evaluating the user interface on the virtual reality-based Aladdin attraction [8], and Marinelli had worked with computer scientists on the Synthetic Interview project, creating the illusion of an interactive conversation by retrieving appropriate video segments based on typed or spoken input [6].

Prompted in 1998 by an external School of Drama advisory board, Carnegie Mellon's president assigned a committee to explore technology-enabled entertainment and artistic expression. The committee found that the biggest risk in such a program would be that it would tilt one way or the other, becoming either about the art or about the technology. The president's solution was to have a co-directorship that negotiated four main ground rules with the provost:

Degree. The ETC would grant a two-year professional "master's of entertainment technology" degree, jointly conferred by the School of Computer Science and the College of Fine Arts;

Reporting. As co-directors, we would report directly to the provost rather than to dean(s);

Tuition. All students would pay full tuition; the provost's office would receive 20% of it to cover overhead; the rest would go to the program; and

Independence. We promised to make it financially self-sustaining or personally shut it down; in return, the provost agreed to give us total freedom in how we would run it.

Carnegie Mellon is agile. The committee did its research in late 1998 and early 1999, the provost brought the ETC into existence through a memo in March 1999, and in September 1999 we admitted our first pilot class of eight students, all graduating seniors.

The ETC has no tenure-track faculty other than the two co-directors. We had originally envisioned poaching time from existing tenure-track faculty but found that the emphasis on teaching rather than publishing made the ETC model a bad match for many faculty members' interests. Over time, the ETC devel-

oped a cadre of faculty hired on lecturer track with strong dedication to teaching in our novel environment. Treating them as full-fledged faculty, we hire slowly and carefully.

Before starting the program we visited potential employers and asked why they did not hire students right out of school. The unanimous answer was that students could not work effectively in interdisciplinary teams, so we focused the curriculum on that. We established a culture of left-brain, or concrete-oriented thinking, working with right-brain, or abstract-oriented thinking, embodied in the co-directors who shared a single office. The ETC philosophy is not to turn artists into engineers or vice versa but to teach students how to work in teams that utilize the disparate talents of their members. The ETC now has approximately 100 master's students (50 per class) and roughly 15 faculty and staff. Roughly 20% of the students come from outside the U.S.; roughly 25% are female.

The ETC is a professional master's program, like medical, law, or business school, judged by the jobs its graduates get. Many faculty on campus felt we should make it a one-year master's program to make it more attractive (and cheaper) to students. We resisted, feeling two years was the minimum for the degree and for students to complete semester-long projects with different teams. Attracting a large and talented pool of students willing to pay full tuition has not been difficult. Most take student loans, like their counterparts in medical, law, and MBA programs.

We prepare them for any environment where technologists and artists work closely on teams, including but not limited to theme parks, children's and science museums, Web sites, mobile computing, and, yes, video games. We prefer projects with a physical component (such as building a kiosk) because building something is tangibly satisfying. Practically no ETC project is just "a team of students building a video game"; having an external client and/or other creative constraint leads to better learning than building a game for one's own amusement.

Figure 1 indicates that our students achieve essen-
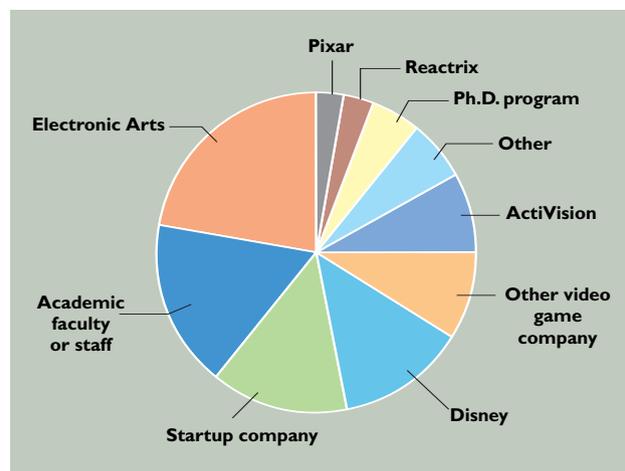
Figure 1. ETC recent graduate placement.

tially 100% placement. A number of companies have entered into written agreements with us, guaranteeing a minimum number of summer internships for our students. These internships often lead to jobs after graduation. Recent agreements have been with Electronic Arts (10 students/year), ActiVision (5), Rockstar Games (2), and Crystal Dynamics (2).

THE EXPERIENCE

Imagine trying to describe a unique entertainment experience like the Cirque du Soleil. Saying it's "like a circus" will drag you into a conversation about how many tigers, clowns, and trapezes it has. Similarly, the moment we say the ETC is a "master's program," people want to know how many and what kind of courses we offer. When designing the curriculum, we never asked "What courses shall we teach?" but rather "How do we create an experience in which students can learn?"

The ETC curriculum, like the Cirque du Soleil, is simply different. We have a project-based curriculum with almost no lecture-based coursework (see Figure 2); in each of the last three semesters, students take one free elective—anything taught at Carnegie Mellon—with the rest of their time in the project course, about as much work as a full-time job. All students do a summer internship in industry between their first and second years and can also co-op in industry (paying full tuition and receiving course credit) during semester three, semester four, or in unusual cases, semesters three and four.

Although the curriculum needed approval from both the College of Fine Arts and the School of Computer Science curriculum committees, the approval process took less than a month.

Project courses consist of a faculty-assigned interdisciplinary team of students sharing a dedicated project room for a semester. Each team has a faculty advisor who typically supervises up to three projects. Teams are required to build an artifact, often a prototype but that could also be a finished product ready for installation. Some teams have an external sponsor and/or client. Projects can originate with clients, from a faculty idea, or directly from students via a project pitch during the preceding semester.

By focusing on an artifact (as opposed to a paper), students address the trade-offs inherent in limited

First Year Fall
The Visual Story
Improv (Improvisational Acting)
Building Virtual Worlds (projects)
Fundamentals of Entertainment Technology

First Year Spring
Project Course
Elective

Industry Internship

Second Year Fall
Project Course
Elective

Second Year Spring
Project Course
Elective

Figure 2. Curriculum for the master's of entertainment technology program.

time, budget, and talent. Rather than pretend that projects matter, we make them matter, with real clients whenever possible. Only by working with a client can students appreciate how to manage a client relationship. Each team has a student producer responsible for schedule tracking, marshalling needed resources, and coordinating numerous project demos. The faculty advisor's role is unusual—partly to keep a project on track, partly to advise students about their team and work habits.

Projects have included:

Quasi. An interactive robot and associated show-control software (student initiated) (see Figure 3a);
Peacemaker. A simulation of what it is like to be the Israeli Prime Minister or Palestinian President (student initiated) (see Figure 3b);
Animateering. A digital puppeteering interface for Give Kids the World (www.gktw.org) (external client initiated) (see Figure 3c); and
Jam-O-Drum. A large shared projection surface/input device (initiated by faculty member Tina "Bean" Blaine) (see Figure 3d);

For a complete list see www.etc.cmu.edu.

Since all of our students already have undergraduate degrees, we focus on integrating talent and learning the related group dynamics, project management, client management, and problem-solving skills that are the difference between success and failure in the real world of commercial development and paying customers.

BUILDING VIRTUAL WORLDS

Project courses occur in semesters two, three, and four. In the first semester, students spend roughly 40 hours/week in a course called "Building Virtual Worlds," or BVW, which actually predates the ETC; it was first taught in spring 1998 when Pausch returned from his sabbatical at Disney Imagineering's Virtual Reality Studio and tried to replicate that culture in an academic environment. Students are assigned to teams of four, each with a specific skill (such as texture map painter, 3D modeler, programmer, and sound expert). The team is given 14 days to create an interactive, head-mounted-display-based virtual reality world. The teams are then reshuffled, and the process repeats for a total of five

Figure 3. ETC projects: (a) Quasi the robot (photo by Tom Altany); (b) Peacemaker simulation of being a leader in the Middle East; (c) Storybook Theme for animateering a virtual puppet show (photo by Tina Blaine); and (d) the Jam-O-Drum (photo by Lenny Larson).

rounds. The best pieces are performed live at the end of the semester before a 500-person live audience—a signature event at Carnegie Mellon.

Having five projects means students are free to fail; a botched project (where the real learning occurs) takes only two weeks, not a semester. Students need a structure where failure is tolerated as part of a risky process. From a social standpoint, two-week projects also allow students to work in groups that disband before members have time to get fed up with one another. BVW (or other mechanisms with short-term projects in the first semester) must precede semester-long project teams. Faculty critique each project at the end of the first week (halfway through) and again after it is finished. We find that having a critique from only one or two faculty members, rather than a larger panel, is the most effective format in the first semester.

From 1997 to 2003 students created content through the locally developed Alice system (www.alice.org), programming in the Python language and creating 3D objects in 3D Studio Max and/or Maya [2] (see Kelleher's and Pausch's article in this special section). In 2003 we switched to the Python/C++ Panda3D toolkit [4], a joint project of the ETC and the Walt Disney Virtual Reality Studio (www.panda3d.org). BVW originally had all assignments done for the head-mounted display; more recently we expanded it to the Jam-O-Drum [1], the locally created Quasi robot [5], the shadow-detecting wall-projected Playmotion system (www.playmotion.com), the Sony AIBO robotic dog, now discontinued as a commercial product (www.sony.net/Products/aibo), and the Mitsubishi Electric Research Laboratories DiamondTouch four-user touch-screen

parade of individual faculty members all make the same subjective critique, the left-brain students (and some stubborn right-brain ones) realize that subjective does not mean random. The feedback is given informally and does not affect student grades, but the student producer is required to take extensive notes during the session.

A major challenge in teaching with teams is finding the grading balance between individual and group efforts. The semester project grade is divided into product (50%) and process (50%). The product grade is assigned by the entire faculty after mid-semester and final review based on short presentations and a hands-on examination of the artifact. All students on the same team get the same product grade. The process grade is given by the individual faculty member on the project, delivered in one-on-

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[3]. Having to use unusual platforms forces students to think like designers. Thinking about the strengths and weaknesses of unusual platforms keeps them from just regurgitating games they previously played. The only content restriction we impose in BVW is "no shooting, violence, or pornography."

BVW has few formal lectures; most class time is spent on group meetings, review of work, and critique. There is no textbook, but Pausch's *Tips for Working in Groups* is a helpful handout (www.randypausch.com).

CRITIQUE, GRADING, FEEDBACK

One of our biggest challenges has always been providing critique that students accept, especially computer scientists with no experience with subjective critique. The first project course critique is given a quarter of the way into the semester, when each group makes a brief presentation to all faculty and students, with no Q&A. We then immediately send the student groups back to their project rooms where faculty individually visit the student teams, rotating among rooms. Being in their own project room (home turf), with everyone seated and no audience for the critique, reduces potential social tension. We stress that faculty begin visiting without conferring with other faculty members. Therefore, when a

one meetings at one-third, two-thirds, and end-mark of the semester. We find it useful to have process evaluations out of phase with product grading. Process meetings are often painful, but that's why we built a culture where most students realize they are part of the core value of their education. We give 10-years' worth of feedback in two years, since industrial managers in the real world don't focus on personal development the way faculty can.

We stress the ability to make public presentations. While there is no formal grade for public speaking, each member of the project team is required to speak either at the one-quarter, halfway, or end-of-semester presentations; public speaking is critiqued as part of the feedback. We have also moved to shorter and shorter presentation formats. Being able to describe a project in 10 minutes is much more valuable than describing it in 30 minutes. Similarly, while we do not provide explicit leadership training, most students have at least one opportunity to be a producer on a project, helping them learn leadership skills.

Two weeks before final projects are due, we have what we call "Soft Opening," a term taken from the theme park community. Roughly analogous to previews on Broadway or beta release in software, this is the point where the artifact should be done but probably still needs time to work out the kinks. Faculty members visit each project individually, play with the artifact, then meet as a group and give email feedback to each team with an informal "if I had to give it a grade today" and detailed list of needed improvements. This is highly motivating, especially to teams that are in trouble.

More Traditional Courses

We also offer more traditional courses. Many students take a game design course as their second semester elective, currently taught by Jesse Schell,

spend several days on a cruise ship, in a historical re-enactment, or in some other immersive setting; when they return, they are responsible for creating an ungraded original artistic response. These trips allow for more individual creative expression to counterbalance the group work and provide social bonding, along with an opportunity to destress between BVW assignments.

In our first few years, we included a mandatory cross-training course in the first semester, where students with more artistic backgrounds took a Java programming course, and students with more technological backgrounds took a drawing course. We stopped because we found that students who wanted to cross-train would do so via electives or informal learning and that forcing master's students who were not interested in cross-training was a waste of time.

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including design fundamentals by having students create traditional card and board games. Required courses are only in the first semester, including: BVW; Improvisational Acting (Improv); The Visual Story; and Fundamentals of Entertainment Technology. Improv is probably the most important course in a program stressing teamwork. Brenda Harger, who teaches it, says it is about serving the narrative and emphasizing one's partner rather than oneself. Students learn it's easy to put their own ideas first but leave their teammates no way to continue; much more difficult is saying "yes" to each other's ideas and building on each other's strengths without premature judgment. Socially, Improv allows new students to become comfortable with their peers in a creative, playful setting. Improv is graded solely on attendance. The Visual Story, taught by Ralph Vituccio, is a distilled "film school"-type course emphasizing how to set up a shot in both linear and interactive media. Students work in teams and are graded on linear and nonlinear audio/video-based projects.

The first semester also includes a fairly traditional overview course called "Fundamentals of Entertainment Technology." Another aspect of the first semester is that the entire first-year class goes on several overnight field trips coordinated to occur when the other courses shut down for a week. Students might

Eating and Traveling Club

We often quip that ETC really stands for "The Eating and Traveling Club." We spend lots of money on free food, believing it builds social fabric and a strong sense that the faculty cares about students in a visceral way. The food is simply the most tangible measure of a strong sense of community that continues even after students have graduated. Our alumni routinely come back to visit and/or host current students in their new locations, building an impressive in-industry network.

As for traveling, Pittsburgh may not yet be the center of the interactive entertainment universe, though the current rate of ETC spin-offs may well change that status. Since most of the companies we deal with are far away, we dedicate budget for sending students to experience the industry they are preparing themselves for, as well as to conferences. Each January, we take the entire class of 50 first-year students on a week-long West Coast tour, everything paid for by the ETC. Stops have included: BRC Imagination Arts, Dreamworks, Electronic Arts, Exploratorium, Industrial Light and Magic, Iwerks, Jim Henson Creature Shop, LucasArts, Naughty Dog, Pandemic, Pixar Animation Studios, Reactrix, Rhythm & Hues Studios, Rockstar Studios, Shaba Games, Sony Online, Thinkwell Design, TreyArch, Walt Disney Imagineering, Zeum, and Z-Axis Games.

We have also embarked on a new phase we call "ETC Global" involving campuses worldwide, starting with Adelaide, Australia, in 2006 and Seoul, South Korea, in 2007. Rather than being franchises, they will be parts of a distributed whole; students will be free to shift from location to location on a semester-by-semester, project-by-project basis to complete their two-year degree. We will also experiment with distributed project teams. In a globalizing world economy, it will prepare our students for the jobs of the future, where teams distributed over multiple continents will be commonplace.

CONCLUSION

It strikes us as risky to create a video game degree without selective admissions; the industry is extremely competitive, and students not intrinsically strong run the risk of ending up with a narrow education they cannot use for other professions. With that caveat, we offer a number of specific lessons learned and advice for others contemplating their own degree programs in this area:

Know the metric for success. The ETC began with an explicit goal of being a professional master's program, judged by where our students got jobs, making it easy to evaluate how we were doing;

Establish industrial relationships early. If a program is placement-based, these relationships must be established, asking lots of questions about what people in industry consider valuable for students and their future employees to know;

Let students learn by doing. Take a project-based approach, where the projects are done by interdisciplinary teams; students shouldn't be allowed to pick the other members of their teams; it doesn't happen in the real world;

Demand students try ambitious things. Find ways to allow students to fail and learn from their mistakes; the ETC believes "Experience is what you get when didn't get what you wanted";

Be willing to change. We swore we'd make a million mistakes but never the same one twice. When things don't work, we change fast, which the students appreciate;

Get dedicated space for projects. We found it critical to have dedicated space for project teams to live in, giving them a sense of ownership and control over their work, along with myriad practical advantages;

Get a good program coordinator. This is the nonfaculty staff member—a crucial position—students can confide in;

Teach students to focus on what the team needs to make, not on what pleases them individually. An artist who cares only about personal expression or a technologist who cares only about a clever technical solution will derail a team trying to build something; and

Avoid bureaucratic oversight at all costs. This was easy at Carnegie Mellon and a blessing.

The ETC's special culture brings out the best in its students. The whole is more than the sum of the parts if you can find a way to get students to work across disciplines. Rather than focus on particular facts or skills, the ETC focuses on students tackling real projects and learning to interact with groups. All this occurs in a supportive environment that constantly challenges them while providing personalized feedback on their performance. **C**

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