# A Distributed Expertise Model for Teaching Computing Across Disciplines and Institutions

**Thomas Way [1], Lillian Cassel[1], Kim Pearson[2], Ursula Wolz[3], Deborah Tatar[4], and Steve Harrison[4]**
[1] Department of Computing Sciences, Villanova University, Villanova, PA 19085, USA
[2] English and Interactive Multimedia Departments, The College of New Jersey, Ewing, NJ 08534, USA
[3] Computer Science and Interactive Multimedia Depts., The College of New Jersey, Ewing, NJ 08534, USA
[4] Department of Computer Science, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, USA

**Abstract -** *Computing education has permeated virtually all disciplines, expanding learning with new technology and an updated definition of literacy that includes computational thinking. As opportunities for multi-disciplinary courses that include computing increase, so do the challenges placed on faculty to develop such courses and the required computing expertise needed to teach them. This paper defines an approach for leveraging the distributed expertise of faculty across disciplines and institutions in a variety of ways to facilitate cross-institutional and multi-disciplinary education where computing is among the disciplines. Two prototype courses that use this approach are described and evaluated, lessons learned are discussed, and potential future course collaborations are presented.*

**Keywords:** Distributed expertise, multi-disciplinary courses, cross-institutional collaboration.

## 1 Introduction

The age of ubiquitous computing clearly has arrived, and computational thinking has become a valued and necessary intellectual commodity if one is to be literate in the 21st Century [11]. Computer Science educators are uniquely positioned to facilitate multi-disciplinary courses that include computing [2], providing a foundational expertise that informs computational thinking across a wide range of subjects.

Distance learning and the use of rich multimedia communication technology, including desktop sharing, video conferencing, and instant messaging, among many others, means that traditional classroom boundaries have expanded beyond a physical location. The decoupling of geographic location and education means that faculty expertise can be shared in ways that were very difficult in the past. Where institutions lack the enrollment, faculty, or specialized expertise to offer a new course, it is possible now to import that expertise electronically. With the increasing prevalence of multi-disciplinary topics that involve elements of computing, computer science educators now have the means to collaborate and teach from a distance.

This paper explores the challenge of connecting instructors who cross-disciplinary and geographic boundaries to share and benefit from subject matter expertise that is similarly distributed. An approach to computing education that relies on distributed expertise is defined within the context of multi-disciplinary and cross-institutional course collaboration is presented.

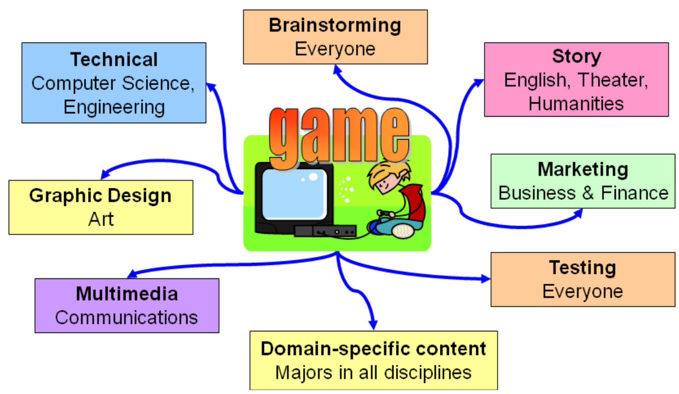


**Figure 1**. Model for team-based game design course involving students in a variety of major disciplines, described in Section 3.1.

Two examples of this approach that involves faculty at geographically separated universities are analyzed. The first collaboration is between Computer Science, English and Interactive Multimedia faculty who co-taught a game design course (Figure 1), and the second describes the experiences of Computer Science faculty with differing levels expertise and cultural backgrounds who co-taught a computer ethics course. For computer science educators who wish to participate in such collaborations, a number of lessons learned are discussed and ideas for future multi-disciplinary courses containing significant computing content are introduced.

## 2 Distributed Expertise

A *distributed expertise* approach involves the collaborative teaching of a course by two or more faculty at two or more locations. These faculty potentially come from differing fields or with differing levels of expertise. As a result, the development of this distributed approach resembles many aspects of team teaching and distance learning techniques, and benefits from the vast body of research and experience in these areas.

## 2.1 Background

While much has been written about team teaching and distance learning, little has been written about a distributed approach. In one case, a cross-institutional, geographically distributed, faculty collaboration on the design of an undergraduate engineering course that was taught in state-of-the-art distance learning classrooms demonstrated that following an iterative design-implement-evaluate-refine cycle was important [10]. This project differs from our approach in that the faculty members had the same level of expertise in the same subject area, while in our approach, faculty expertise typically will be complementary, providing an opportunity for mentoring.

An early use of collaborative, real-time, interactive, distance learning techniques to provide training of rural special education instructors found benefits to both students and faculty that will inform our approach. Among the identified benefits are that distributed team teaching encourages the sharing of a diversity of student and instructor perspectives, exposes students to a variety of instructional techniques and points of view, and enables faculty to benefit from the sharing of expertise and workload with collaborators. [5]

A study of multinational faculty collaboration notes that, although cooperative projects among faculty at the college level are increasing, there is a lack of research on the challenges involved in these multi-institution collaborations. Our research fills this need. [1]

Hains reports on the successful use of a collaborative, distributed training seminar for early childhood educators that met once per week for 3 hours at multiple sites, with the first 20 minutes consisting of videoconferencing linking all sites. Faculty brought different skill levels and expertise to the process, and the course implementation resembles our proposed models. To prepare, collaborating faculty communicated via email, telephone, teleconferences and in face-to-face meetings, with key factors for successful implementation identified as developing collegial partnerships and faculty incentives. [8]

Another study showed that when faculty are assigned to teach material outside their own areas of expertise, they focus on familiar parts of the subject matter and tend to avoid the more challenging aspects of the subject [3]. This is more common in smaller departments where there may be limited numbers of faculty who may lack the breadth of expertise that is desirable to teach all core computing subjects. The same problem may arise when a new topic emerges and the department wants to stay up-to-date. Someone becomes the person to make the first offering of the subject. The faculty member works hard, but has no real expertise in the area and may not have someone to call on when things become difficult.

## 2.2 Models of Collaboration

In defining an approach to distributed expertise, we identified three models for collaboration that fall on a continuum (Figure 2): Remote Expert with Local Facilitator (RE), the Cooperative Experts (CE) and the Special Resource (SR) models. In the Remote Expert with Local Facilitator (RE) model, a desired expertise in a subject resides at a distant institution, in the form of a remote expert. Much as surgery being performed in a remote location (e.g., rainforest in Ecuador) can draw on remotely available expertise of a physician specialist in a geographically distant research hospital (e.g., Richmond, Virginia) via digital communication [6], a distant instructor with an expertise needed by the local institution can collaboratively teach to that specialty with a local instructor serving as facilitator.

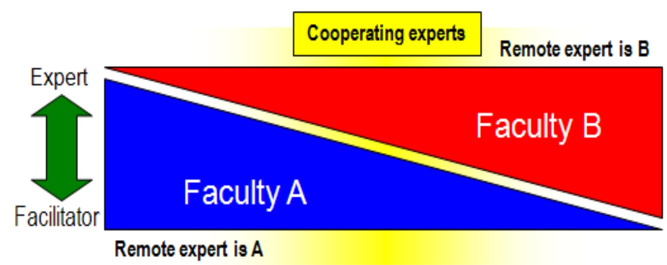


**Figure 2**. Digital distributed classroom expert-facilitator model continuum.

The local facilitator is generally a faculty member who possesses only limited knowledge of the expert's specialty. The expert benefits from instructing a larger class of students, while the local facilitator benefits from exposure to this expertise in order to increase understanding of the material. Eventually, the facilitator may gain sufficient understanding of the expert's material to teach the material alone. The connection to the expertise remains a benefit, possibly leading to fruitful discussions that benefit students at both locations.

Within a computer science curriculum, it is not uncommon for a department at a given institution to have one or more areas in which there is no faculty member who is considered an "expert." In such situations, the ability to collaborate with other institutions in offering a team-taught course in a distributed digital classroom can benefit students with access to expert instruction and faculty with a chance to enhance their knowledge and improve their future course offerings.

In the Cooperative Expert Facilitators (CE) model, collaborative faculty each has an area of expertise and participate equally in instruction and facilitation. The remote and local faculty complement each other by providing expertise in different aspects of the course and take turns at serving as an expert or facilitator. This team-teaching approach has recognized benefits for learning, with students gaining exposure to high quality course content, and to concepts of collaborative relationship negotiation that can benefit them beyond the classroom and particular subject matter [7].

The Remote Expert with Local Facilitator approach defines one endpoint of the continuum of collaborative instruction. If one of a pair of collaborating faculty is designated A and the other B, this model is one where A is an expert and B is a facilitator. The other endpoint is the identical model, the only difference being that the roles of A and B are reversed; B is the expert and A is the facilitator. The Cooperative Expert Facilitators model represents the median, with A and B providing complementary areas of expertise while serving as facilitators at other times.

This continuum will be fluid, changing as facilitators gain expertise with the help of experts. Over time, a collaboration that begins as a Remote Expert model will evolve into a Cooperating Expert model. During a semester, it is likely that various points on the continuum will be encountered as the strengths of each faculty member are explored. Naturally, some faculty will possess stronger background in some material at some time during the semester, while at other times the other faculty member will be better equipped to instruct. For common areas of expertise, the duties of expert and facilitator will be shared.

In the Special Resource (SR) model, an expert is "on call" to provide a fill-in lecture on a particular topic in a course otherwise conducted normally. There is no continuing connection between the expert and the course. The resource may consist of recorded lectures or examples that can be inserted into the course where they are needed.

# 3 Prototype Courses

To explore the distributed expertise approach, five workshops were held with the result that a number of faculty participants formed partnerships to team-teach two prototype courses using a multi-disciplinary and cross-institutional model. In the first, a version of the RE model was used, while in the second a more balanced CE model was followed.

## 3.1 Game Design

During the Spring of 2009, three faculty members at The College of New Jersey (TCNJ) and Villanova University collaborated on the design and teaching of a course in computer game design. TCNJ developed significant expertise over four years teaching game design, architecture and project management with multi-disciplinary faculty, and has published pedagogical innovations [9,12,13]. Two TCNJ faculty with backgrounds in computer science and journalism, respectively, served as the Remote Experts in the area of game design, taking the lead in overall course design. The Villanova faculty member was a computer science professor, but lacked experience in teaching game design.

The TCNJ upper division class, cross-listed in Computer Science and Interactive Multimedia, is open to students campus-wide by permission of instructor. The fall course focuses on game design, while the spring course is a project management course in game implementation. Seventeen students were enrolled in Spring 2009, with approximately half each from computer science and interactive multimedia, including a double major, as well as a journalism and psychology major. Approximately two thirds were continuing from the fall semester offering and thus served as "managers" in the software development process.

At Villanova, the course was a new offering, created to explore the distributed expertise approach [4]. As at TCNJ, enrollment was open to students in any major. Twenty-five students enrolled with 15 from computer science or computer engineering and the remainder from arts/humanities (1), business (4), economics (2), electrical engineering (1), physical sciences (1), and social sciences (1). Each institution had only one woman enrolling in the class.

The courses were not identical, and had different expected outcomes and student assessments. However, students at each institution had assignments that transcended the partnership. The classes from both institutions did directly interact on Tuesdays for real time video conferencing. Typically, in these sessions, the students talked about their work and the professors served as guides. Students also communicated between campuses via other internet modalities including chat, Facebook, and email to complete assignments. The faculty also held planning sessions via Skype.

The TCNJ course agenda was dependent upon design and prototype work completed in the fall design course, while the Villanova course was a single semester offering. TCNJ students were focused on projects that had been under development for the previous semester, while Villanova students spent considerable time "getting up to speed" by working on their own smaller game design projects as individuals and in small groups. Villanova students were assigned the role of consultants, working in small groups with a TCNJ small group and taking their task cues from their TCNJ counterparts. TCNJ students likened this to their being the "main corporation" and Villanova the "outsource company" in an attempt to model a common real life project scenario.

We had mixed results with the outsourcing model, which, given industry analysis of outsource was perhaps to be expected. The TCNJ students, who were barely in control of their own code were reluctant to relinquish control to Villanova. It was a real learning experience for a number of graduating seniors in computer science at TCNJ fully to appreciate the need for explicit modular design in order to "outsource" coding. Once personal communication was established between individuals at the two institutions, tangible contributions to the TCNJ game engine, and example games were made by Villanova students. They were able to

(a) track down system configuration problems, (b) critique design logic, (c) debug code, (d) offer critique of game play and engine design and implementation.

Our perspective as instructors is that the formal model of "outsourcing" needs to include development of soft skills in remote communication. Encouraging our students to engage in active communication as part of an assignment gets them outside their typical comfort zone as passive classroom learners who do individual homework. Wolz, Pearson and their colleague S.M. Pulimood promote the notion of “problem solving in community.” Distributed expertise requires explicitly addressing how to promote one-to-one and small-group to small-group interaction between campuses.

## 3.2 Computer Ethics

During the same Spring 2009 semester, two faculty at Virginia Tech collaborated with one at the University of Limerick in Limerick, Ireland to teach course with significant computer ethics content. The course at Virginia Tech was called “Professionalism in Computer Science,” with "Issues in Computer Ethics" being the synchronized course offered at Limerick. The fundamental idea of these courses was to follow a procedure developed by the faculty member at the University of Limerick involving a number of phases. The phases were: “getting to know you,” formation into teams, the conduct of a practice case study, structured on-line discussion associated with the formation of views with respect to the final case study, and the production of a 6000 word report on the final case study. The teams consisted of groups of 6, divided into pairs. Each pair was to take a different ethical perspective (utilitarianism, deontology, virtue ethics and so forth) and develop the arguments around the case studies from the point of view of that ethical perspective. The case studies were constructed to feature conflicts in much discussed and important issues in computer science and information-based ethics.

Two sections of the class were offered at Virginia Tech by two faculty members, with one in particular taking the lead in coordinating the distributed collaboration due to a long history of research in educational technology. Professionalism in Computer Science is a required class for computer science majors at Virginia Tech, and the sections consisted of 27 and 31 students respectively. Two sections were also offered at University of Limerick, as elective graduate and undergraduate classes. Enrollment in these sections was considerably lower, with 8 and 11 students respectively, both taught by the same instructor. Instructors were fairly balanced in subject matter expertise, with the result being a course that implements a CE model where all serve as experts and facilitators.

The configurations of these classes differed in country and position within their respective curriculum, and also differed considerably in gender and ethnic diversity. While both of the sections at Virginia Tech had exactly one woman enrolled, a majority of students at Limerick were female. Furthermore, while two international and three non-Caucasian students were in the Virginia Tech sections, the classes at Limerick included students from all over the world, with as many coming from outside Ireland as from within it. To some extent, this distribution reflects the demographics of Virginia Tech, where the undergraduate body is 85% from Northern Virginia, and resembles the demographics of undergraduate computer science in the university.

The distributed nature of the courses presented students with a unique opportunity to collaborate with local and remote peers in two interesting ways. The joint experience enabled students to (a) learn how other people, outside the familiar points of view represented by their peers, think about ethical issues in the world and (b) deepen their understanding and ability to write about ethical issues in the context of a particular complex case through the mechanisms of online discourse with peers.

## 3.3 Lessons Learned

Through exhaustive post mortem surveys and focus groups, discussions and retrospective analysis, a number of lessons were learned that could have improved our applications of a distributed expertise model. The learned lessons that we felt are the most crucial to an effective and successful distributed expertise experience are described here.

### 3.3.1 Game Design

**Minimize Complexity, Maximize Planning** - In the games course, we were very ambitious in our plans for cross-institutional student teams, individualized contribution based on each student’s major field of study, and live, weekly videoconferencing during class. The result of these ambitious plans was that some aspects, especially cross-institutional game design teams, were cumbersome and not very effective. Follow-up surveys indicated that the more successful elements of the course were sometimes overwhelmed by the complex organization of the course assignments and projects. In retrospect, a less ambitious approach would have reduced some of the complexity involved in managing the course, leading to a better learning experience for all involved.

**Synchronize Offerings** - Combining experience in student collaboration at a distance with faculty collaboration at a distance showed promise, but was complicated by students at TCNJ having experience with game design since they were in the second semester of a two-semester course, while the Villanova students were just beginning to learn about game design. The result was that the course content what out-of-phase, with students and faculty noting this as reducing the effectiveness of the collaboration and learning experience.

**Meet Early, Meet Often** - Students are not necessarily anxious to combine efforts with other students who are not local. The model of a remote “consulting” service, as was used, had some merit, but perhaps did not allay all the concerns about “outsiders” getting too involved in a preexisting project. In course evaluation surveys, the concept of distributed work teams resonated with students but their specific implementation did not. Many student and faculty comments expressed that meeting face-to-face at the start of the semester, and fully exploiting communication technology to continue frequent, virtual, face-to-face meetings between individuals and small teams would have led to better collaboration. Most agreed that the out-of-phase nature of the course material contributed to the lack of personal connection, but that meeting early and often may overcome this situation.

**Focus Earlier on Skills** - There was a breakthrough at the end of the semester when some Villanova students were able to solve a technical problem that had long plagued the TCNJ students, earning some respect in the process. If the skills and talents of the students in this case, and generally of all students at both institutions, had been more fully recognized and actively used earlier in the semester, the collaboration would have been significantly improved. The students involved commented later that having more specific direction about what was needed, and how their skills could be used, would have given them a stronger sense of shared ownership of the design tasks and technical challenges.

### 3.3.2 Computer Ethics

**Define Collaboration More Precisely** - The importance of devising processes of collaborating were discussed in class, but since students had past experience with collaboration, they were left to develop their own techniques. The result was that most collaborations among distributed groups of students less fruitful than if specific and concrete steps for collaborating had been given.

**Identifying Relevance** – Cultural differences emerged when ethics topics were discussed, with students at Limerick being much more open to exploring outside ideas while Virginia Tech students tended to dismiss the relevance to computer science of most professional and ethics topics. This is perhaps the most challenging of the lessons learned, since the way to address this is to encourage students to welcome, rather than fear, uncertain knowledge and convince them to seek the connections between diverse topics and computer science on their own.

**Reduce E-Noise, Improve Communication** – A major problem for the Virginia Tech faculty was the excessive volume of email messages (200/week, 3,000 during the 16-week course). With such an overload of communication, missed information and misunderstandings were inevitable. Finding better technical solutions to the communication needs of a distributed course is mandatory if such collaboration is to be successful.

# 4 Seeds of Collaboration

A number of potential multi-disciplinary courses with computing as a major component have been identified and many more could be designed that take advantage of distributed expertise to offer appealing subjects where they might not otherwise be practical to offer. The subject matter for these courses always has a computer science foundation, but can be cross- or multi-disciplinary in content. Among candidates being discussed for future semesters are:

**Game Design, second offering** – building on the previous offering, TCNJ and Villanova may seek new outside partners and clone the course as a way to spread the existing expertise at TCNJ to a new institution while using Villanova's in-progress expertise to another new partner institution. During the Spring 2010 semester, this course was offered at TCNJ and collaborated with a Software Engineering course at Villanova.

**Green Computing and the Environment** – a course that combines expertise from a small college faculty with expertise in environmental studies and a larger university with green computing research expertise. Computer science faculty would focus on the technology for reducing the impact of computing technology on the environment, while faculty in biology and environmental studies would explore the impact on nature and the environment in terms that are more general. This course will be offered in Fall 2010 at Villanova, in collaboration with the Geography and the Environment Department and other outside collaborators.

**The Digital Polyglot** – faculty in foreign languages and computer science collaborate to teach students all they need to develop digital resources, such as a web site that is designed for use by elementary level educators all over the world to teach about the cultural traditions and languages of many different countries. Computer science students and faculty could take the lead on the underlying technology, those in the humanities could contribute content, and those in the foreign languages could translate the content into multiple languages.

**Computer Science Across Topics** - within computer science, faculty develop areas of expertise, both for their research and teaching. In smaller programs, often there are holes in the areas of expertise resulting in instructors sometime teaching a course where some important areas may not be given their full due as a result of lack of background or expertise in that particular area. Through a digital distributed classroom approach, two computer science faculty at geographically distant institutions can team-teach a course and draw on each other's areas of expertise while also improving their own understanding of the expertise offered by their collaborator. Over time, this collaboration can improve each faculty member involved, enabling him or her to offer better-rounded instruction in the future.

**Google Mashups for the Humanities** - with the popularity of Google, and the wide variety of possible applications it can lead to, the opportunities for interdisciplinary humanities and technology education are abundant. The idea of a Google "mashup," a web site that makes use of the technology devised by Google to create new, interesting and important ways of gathering and presenting information, is gaining in popularity. A recently introduced web project, and just such a Google mashup, is TimeSpaceMap (www.timespacemap.com), which is described as "an encyclopedic atlas of history and happenings that anyone can edit, a geographic wiki." To teach this course, faculty from computer science with experience in making use of the available Google APIs, or who can quickly become expert, are needed in addition to faculty from one or more areas of the Humanities. The areas of available Humanities will determine the direction and coverage of each offering of the course.

**Other topics** - Because the influence of computing and technology is so broad, many other crossover subjects that combine computer science and other disciplines can be found.

# 5 Conclusions

The use of a distributed expertise approach to team-teaching across disciplines and institutions is a valuable one, but is not without challenges. Having expertise available enables a new course to be prepared more quickly, and enables an instructor who lacks experience with a subject to be mentored and quickly gain enough background to understand and teach the new subject. Students benefit from courses in specialties or multi-disciplinary topics that otherwise might not be available, and which further develop skills in computational thinking. Challenges to the approach include potential problems with communication and ownership; students may not feel a personal connection to students at a remote university, and thus communication may not be effective and a sense of shared purpose may be lacking. Consensus among all involved is that face-to-face meetings, particularly at the beginning of a course offered in this way, is a critical step on the path to overcoming the potential for a lack of personal connection and investment across institutions.

In the immediate future, we plan to pursue two or three offerings, with likely topics being green computing, game design and computer ethics. In particular, the opportunity to spawn new distributed expertise collaborations based on experience, and to gain perspective from subsequent offerings, is a major goal. As a result, we are actively seeking collaborators from inside and outside of computer science, experts and facilitators alike, who can offer know-how or benefit from a distributed expertise approach.

# 6 Acknowledgment

The work reported in this paper was partially funded by NSF CPATH award IS-0829616.

# 7 References

[1] F. P. Albritton, Jr., "Multinational Faculty Collaboration: Does culture matter?" in Papers and articles of the Community Colleges for International Development, 2007.

[2] L. Cassel, R. E. Beck and R. H. Austing, "Interdependence of Disciplines: Computer Science as a Full Partner," Proc. of the 5th World Conference on Computers in Education, 1990.

[3] L. N. Cassel and D. Kumar, "Distributed Expertise in Teaching," The 7th IFIP World Conference on Networking the Learner: Computers in Education, Copenhagen, Denmark, 2001.

[4] L. Cassel, T. Way and S. Potluri. "CPATH: Distributed Expertise - Collaborating with Other Disciplines." Poster presentation. 14th Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE 2009), Paris, France, July 6-9, 2009.

[5] B. C. Collins, M. L. Hemmeter, J. W. Schuster and K. B. Stevens, "Using Team Teaching To Deliver Coursework via Distance Learning Technology," Teacher Education and Special Education, vol. 19, pp. 49, 1996.

[6] S. W. Cone, L. M. Gehr, R. Hummel and R. C. M. F. Merrell, "Remote Anesthetic Monitoring Using Satellite Telecommunications and the Internet," Anesthesia and Analgesia, vol. 102, pp. 1463-1467, 2006.

[7] M. J. Eisen and E. J. Tisdell, "Team Teaching: The Learning Side of the Teaching-Learning Equation," Teaching Excellence, 14 (6), 1-2, 2003.

[8] A. H. Hains, S. Conceição-Runlee, P. Caro and M. A. Marchel, "Collaborative Course Development in Early Childhood Special Education through Distance Learning," Early Childhood Research & Practice, vol. 1, 1999.

[9] S. M. Pulimood and U. Wolz, "Problem Solving in Community: A Necessary Shift in CS Pedagogy," SIGCSE Technical Symposium (SIGCSE 2008), pp. 210-214, 2008.

[10] X. Wang, J. F. Dannenhoffer, III, B. D. Davidson and J. M. Spector, "Design Issues in a Cross-Institutional Collaboration on a Distance Education Course," Distance Education, vol. 26, pp. 405, 2005.

[11] J. M. Wing, "Computational Thinking," Communications of the ACM, vol. 49, no. 3, pp. 33-35, March 2006.

[12] U. Wolz, C. Ault and T. M. Nakra, "Teaching Game Design through Cross-Disciplinary Content and Individualized Student Deliverables," The Journal of Game Development, 2(1), Feb. 2007.

[13] U. Wolz and S. M. Pulimood, "An integrated approach to project management through classic CS III and video game development," SIGCSE Technical Symposium (SIGCSE 2007), pp. 322-326, 2007.