

BPC-DP: Broadening Participation in Computing via Community Journalism for Middle Schoolers Project Description

Faculty from Computer Science and Journalism/Professional Writing propose to collaborate with a gender/equity specialist on a **demonstration project** at our institution to broaden participation in computing through students' exposure to the emerging field of interactive journalism [36, 40]. Research in both the computing pipeline problem [18] and mathematics education [10, 54, 34, 17, 32] inform our position that significant constituencies (notably women and minorities) self-select out because they (1) do not see themselves as "computer types", (2) do not have experience in successfully navigating the culture of a traditional computing classroom, and (3) are ill-prepared academically for entry into existing undergraduate programs. The profound shift in journalism over the past decade due to the Internet provides a venue through which to engage these very students in computing via writing, information gathering and analysis, as well as the full range of digital media from graphics to still images to animation, 3-D graphics and video.

Our approach is unique, and has **intellectual merit**, because we focus on the thorough integration of computing and journalism as a balanced collaboration between two well-established fields, rather than presenting what is essentially a traditional perspective on computer science through its application to storytelling and multimedia. We posit that underrepresented groups are sufficiently disenfranchised that the latter approach is insufficient, and worse, is misguided. Foundational concepts of computer science, and programming in particular, are viewed as inaccessible to a significant portion of the American population. The intrinsic worth is lost on most students. A traditional treatment of these topics, regardless of the application domain, (e.g. robotics, multimedia) is still off the mark because students are focused on "what is" computer science rather than the larger questions of the intellectual underpinnings and practical usefulness of *computational thinking* [57] to careers and to everyday life.

Our approach has the potential to provide **broad impact** because it will demonstrate how a dramatically different approach to exposing young people to computing can influence career path choice. Journalism is only one of many fields recognized as *computing dependent*. We anticipate participating in an alliance within two years that extends this approach to other computing dependent fields. Evidence is mounting that a 21st century journalist will require a strong computing background [33, 37, 24], and 21st century computing professionals will increasingly apply their skills to information dissemination through an as yet to be imagined collection of venues, processes and media. Underlying both disciplines are foundational principles of information access and dissemination, fact analysis, process description and decision-making for results presentation. These neutral terms are equally embraced by journalists and computer scientists to describe how to construct a news item and a software artifact respectively. Consequently, we ascribe to a broad view of computing: one that embraces both the creator of software to support journalism as well as the journalist programmer¹ who can competently embrace emerging digital media. This viewpoint reflects the growing recognition of the importance of computing within the news industry [37]. Journalists are increasingly expected to

¹ This new professional description was first used by Adrian Holovaty [24] The prestigious Medill School of Journalism at Northwestern University announced in late May, 2007 that it is offering a full scholarship for graduate students interested in developing new computing applications for journalism : <http://www.medill.northwestern.edu/medill/admissions//programmers.html>

create and extract information from databases. They construct social network maps to unearth relationships and patterns of behavior. News presentation is also increasingly computer-driven, whether in the form of content management systems, flash-based animations, and user-customization tools. Fundamentally, as programmer-journalist Adrian Holovaty has observed journalism and computing are both concerned with the gathering, organizing and presenting structured data [24].

To attract young people into such careers we need to start early, because they will need well-established skills in both writing and quantitative reasoning. By the time they reach college, many students have segregated themselves into “good writers” or “good mathematicians.” Women traditionally will gravitate toward the former. Keeping them, as well as minority boys in math and science is a national problem [23, 13, 10, 54, 34, 17, 32]. We propose to address the computing pipeline problem by focusing on the critical point of 8th grade, when students make career dependent decisions on high school course selection based on preconceptions and misconceptions about computing careers and requisite preparedness for those careers.

Project Goals

We propose to use interactive journalism as a means of introducing middle school students from underrepresented populations to core skills and career opportunities in the computing sciences. To do this, journalism and computer science faculty and undergraduates at The College of New Jersey will conduct a week-long summer “Interactive Journalism Institute” for rising 8th graders. These middle school students will create an online news publication that incorporates database-driven infographics and interactive animated stories. Formation of an after-school club, advised collaboratively by their own teachers and TCNJ staff and students, will extend and support the institute throughout their 8th grade year. The club advisors will participate in their own week-long training session prior to the institute, and will act as programmer journalist mentors during the institute itself.

Extended exposure that fully integrates their summer experience with their school and home lives is key to success in changing attitudes about careers [18, 13, 23, 10, 54, 34, 17, 32]. Consequently, our goals are distinct because we directly address the relationship between student learning in the rarified context of a summer program and their regular school experience. Research shows that young people rely first on their families and then their school advisors in choosing career paths. In order to influence their decision-making we must fully engage those constituencies. The middle school students, and their club advisors and parents will have opportunities for further exposure to the computing professions through guest speakers, field trips and hands-on learning activities that extend the expertise they developed in the summer program.

We expect that students exposed to this program will demonstrate greater awareness of career opportunities in interactive journalism and the computing professions, as compared to a control group. Our hypothesis is that this immersive experience will serve to remove many of the preconceived notions about computing being “hard” or “nerdy” and about the lack of career potential. Involving middle school guidance counselors and teachers in the summer workshop assures that they gain a better awareness about computing and interactive journalism careers, enabling them to better guide the students. Students will experience for themselves the power of integrating computing and journalism, thus demystifying computer science and mitigating prejudices. We further expect that students will be more likely to choose courses in 9th grade that will prepare them to succeed in traditional computer science courses in college. We will

therefore use their course selections prior to their submission to the high schools to assess and evaluate the demonstration project's impact on their future choices.

This demonstration project is intended to provide us with solid evidence that the combination of an intense summer program focused on interactive journalism in conjunction with a year-long school-based enrichment program successfully places middle school students in the appropriate high school classes in anticipation of careers in the computing disciplines. This, in turn, will allow us to expand our program, and to connect it to existing alliances and initiatives.

A key aspect of our approach is that success in the secondary classroom will require software support that is (a) free (e.g. Alice [16], PostgreSQL [44], PHP [41], Scratch [31, 30]²) to eliminate the need for budget requests, (b) easy to install and maintain to reduce the reliance upon district technical staff, and (c) sufficiently open source to be supported and enhanced by volunteer TCNJ undergraduates through the college's institutional "community service" requirement.

Expected Outcomes

This pilot is informed by (1) direct experience of two of the PIs with secondary school cohorts of both students and teachers in both journalism and computing, (2) significant support from the TCNJ Center for Mathematics, Science, Technology, and Pre-Engineering (MSTE)[19] in particular through the participation of the center's gender/equity specialist and assessment and evaluation consultant, and (3) the rather significant body of literature in women in computing and mathematics as well as African American participation in math and science [1, 2, 3, 4, 5, 6, 7, 8, 14, 15, 21, 22, 26, 28, 29, 35, 38, 39, 42, 43, 45, 47, 51, 53, 55, 63]. The unifying theme of the three perspectives is that expanding participation in the pipeline will require inquiry-based student engagement that allows them to be innovators rather than simply users of computing technology. The experience must create a supportive, cooperative culture that extends beyond the classroom in which all members develop confidence and competency [10, 54, 34, 17, 32]. Such an immersive experience must be supported by solid information about what is to come in the pipeline. This includes (1) explicit information about what courses in high school are necessary for success, (2) how to be a self-advocate in such courses, (3) how to get necessary cultural support within those courses to maintain confidence and competency, and (4) finally how to choose a college and a major that supports the student's passions, vision, goals, and cultural needs.

As a pilot project we anticipate demonstrating through formal qualitative methods that there is a change in attitude, perception and competency within the student cohort as well as their teachers who participate in the summer sessions and continue to support the students through the academic year program. Furthermore we anticipate that there will be changes in perceptions about computing among the undergraduates who participate, and that their own career aspirations and implementation plans may change as a result. Finally, we expect a significant outcome to be integration of our pilot into existing programs and alliances that broaden participation.

² Alice is a icon-based programming language that produces 3-D graphics. It has gained wide-spread acceptance as an introductory language at the undergraduate level. PostgreSQL and PHP are database and interface tools respectively. Scratch is new icon-based programming language for storytelling, games and animation developed by the Lifelong Kindergarten Group at the MIT Media Lab.

Outcomes targeted toward middle school students

- Evidence that middle school students in our cohort will be able to create computing technology that supports interactive journalism including databases, procedural animations, and dynamic information in a variety of media.
- Increase in real computing skills.
- Increased interest in enrollment in college programs and courses in computing related fields, both at our institution and elsewhere.

Outcomes targeted toward middle school teachers

- Evidence that middle school teachers are able to support basic computing and journalism activities in a school-based enrichment program.
- An increase in awareness of computing careers in publishing and social media, articulated with appropriate short term goals for course selection at the high school level both among the teachers in our cohort and their peers at the school.
- Evidence of advocacy for improved integration of computing technology into language arts using inquiry based-methods that supports students as innovators.

Outcomes targeted toward college undergraduates

- Evidence that college undergraduates in our cohort can articulate in a sophisticated manner the relationship between journalism and the computing disciplines.
- A change in attitude about expectations of who can be successful in both writing and computing careers.
- An increase in real computing, writing and communication skills.

Outcomes targeted toward forging alliances

The purpose of this demonstration project is to create the seed for an alliance of like-minded academic and industrial institutions and organizations to further develop knowledge about, and programs and materials for multidisciplinary approaches to broadening participation in computer science. Our supplemental materials include letters of support for this enterprise from: (1) Mitchel Resnick, Papert Professor of Learning Research at MIT Media Laboratory; (2) Sharon J. Sherman, K-16 Professor of Education, TCNJ, and founder of the Center for Mathematics, Science, Technology, and Pre-Engineering; (3) Charles R. Hardnett, Computer Science Department, Spelman College, Atlanta, GA; (4) Raymond J. Hennessey, Editor, SmartMoney.com; (5) Virginia Teller, Professor and Chair, Hunter College-CUNY.

Implementation Plan

Need

Computer science foundations concepts, as distinguished from technology use concepts and skills, appear absent from state mandated K-12 curricula [9]. There is an educational need to explicitly include the computing sciences in the curriculum. Secondary school students are not exposed to the computing sciences in a way that ignites their interest in pursuing further education in these fields. Enrollment in computing sciences courses and majors at the undergraduate level is critically low [8]. Yet the needs of the global economy dictate that America develop a workforce that focuses on the “creation” not merely the “consumption” of computing technology [25]. This requires a workforce that not only includes highly skilled

programmers, but managers, analysts and designers, who have a firm grounding in essential concepts of computer program design. Jeannette Wing described this as *computational thinking* [57].

Until recently, the computing disciplines were isolated. A technologically elite group created the tools and toys upon which we have become so dependent. However, a significant change is occurring. Skilled professionals in many fields are increasingly being called upon to make informed decisions that are based on core computing concepts. Computational models and paradigms including database management, 3-D modeling, information analysis, and data abstraction are becoming essential skills for professionals in fields as diverse as finance, medicine and dentistry, art, music, and basic scientific research.

The computing sciences are no longer simply for an elite core of future programmers immersed in the technology culture. Igniting excitement requires consideration for gender equity/diversity infusion for all students. It requires meeting the educational needs of students from historically underrepresented groups, including girls, minorities, and the economically disadvantaged. It requires nurturing environments that not only support inclusiveness and diversity, but also enhance and embrace it.

There is evidence [13, 21, 23] that the level of students' motivation affects their levels of engagement with a task, their enjoyment of activities, how and what they learn, and ultimately, their performance. Students, and girls in particular, are more motivated by activities they perceive to be useful, and socially relevant. Further, all students, but minority students in particular benefit from a culture in the classroom that is fun, collaborative, informal and active [54].

There is a conflict between the need to excite a diverse population about computing and the reality of public education. Enrollment in both secondary school and undergraduate computing courses is at an all-time low because of misconceptions of what the computing sciences are, what computer scientists do, and how they do it. Foundational computing concepts include, but are not equivalent to programming fundamentals. However, the misconception among high school students is that computer science is "just programming", and that "programming is hard"³.

Changing these perceptions is problematic when standards for computer science (which are not the same as the technology literacy standards) are missing from the state mandates. There are long-range movements within NSF and the Association for Computing Machinery to address this through the establishment of standards [20]. However, at the practical level there simply is no more room in the K-12 curriculum to add another focus without taking something from other culturally critical disciplines such as science, fine art, creative writing, or music.

The current disconnect between the rich computer-based culture of secondary school students outside the classroom and the lack of well-integrated computing science curriculum in the secondary schools will only serve to further exacerbate the technology divide, especially for underrepresented student populations. Students choose careers based on local influences, especially their parents, yet most guidance counselors cannot advise a student on a career in the video game industry, in the rapidly expanding web-based journalism field, or in emerging areas such as social computing [23, 13]. We posit that it is insufficient to create secondary curriculum that isolates the computing sciences from the vast array of fields that increasingly depend upon it.

³ Over the past year we have informally polled high school students, entering college freshman and high school teachers on "What is computer science" and "What do computer scientists do." These two quotes are the single two most frequent responses.

In this demonstration project we address the question of how to ignite excitement in young people toward the creative computing disciplines to become practitioners in these fields and to appreciate how their anticipated profession requires formal grounding in the computing sciences. We posit that to appreciate the computing sciences students must get experience beyond that of *using* information technology. They must get experience in *being innovators* of information technology. Furthermore, their experience must be *immersive*, extending over a significant period of time, engaging them in information technology in school that is as relevant to them as the technology they use outside of school.

Activities

Four initiatives constitute the activities of this project:

1. An “Interactive Journalism Institute” (IJI) in which a cohort of 18 rising 8th graders will create an online magazine. This one-week session will occur in late June/early July. Directed by our PIs and gender equity specialist, writer/programmer mentors will include middle school teachers/guidance counselors and TCNJ undergraduates.
2. An after school club for this cohort that will continue the production of the online magazine through the school year, as well as provide industry speakers and field trips for the students, their parents and teachers. The writer/programmer mentors will manage this program.
3. Development of a middle school appropriate online content management system by TCNJ undergraduates. These researchers and volunteers from two campus student organizations will act as writer/programmers. (See letters of support from DeDuca & Shaw.)
4. Writer/Programmer mentor training workshops: A one-week summer session (prior to the IJI) for identified middle school teachers and guidance counselors and undergraduate researchers. A semester “kick-off” workshop each semester for undergraduate volunteers.

The Fisher Middle School in Ewing NJ has been a collaborator on a number of initiatives at TCNJ. A letter of commitment from the school district superintendent (see Broach) is included in the supplemental materials. Those materials also contain evidence of the diversity within Fisher that will provide us with a cohort and control group that meets our demographic needs.

Timeline

Our anticipated timeframe is Spring 2008 – Fall 2009 and includes (1) recruitment activities for the middle school student cohort, their teachers/guidance counselors, (2) undergraduate research and volunteer recruitment, (3) mentor training, (4) student institute/club planning and implementation, (5) assessment instrument development, application and analysis. Evaluation protocols and timeline are elaborated in a later session.

Spring 2008:

- Recruit 18 rising 8th graders, based on the “underrepresented” profile from the computing pipeline literature [18, 17]. We are particularly targeting, but not limiting ourselves to children who are not academically talented in math and science. We will identify children with similar characteristics for our control group. Both groups would be asked to complete a set of surveys and participate in interviews.
- Recruit a guidance counselor, language arts teacher and technology teacher as well as two additional teachers (e.g. social studies, math, science) These teachers will receive stipends

for their participation in the IJI and for mentoring the after school club. Identify a group of teachers with similar profiles as a control group who will be asked to fill out a pre and post survey and submit to at most two interviews over the course of the year.

- Recruit six undergraduate researcher students to develop our middle school appropriate content management system and act as mentors. Recruit student volunteers for Fall '08.

Summer 2008:

- A one week programmer/writer mentorship workshop for Writer/Programmer Mentors.
- Followed by the one week Interactive Journalism Institute. Eighteen students will work with four TCNJ faculty/staff, three – five middle school staff and six undergraduates for a 3/1 student/expert ration and almost 2/1 student/mentor ratio.

Both of these weeks will follow this general outline:

- Day 1:** Overview of journalism, database workshop, Scratch workshop, organizing the magazine staff.
- Day 2:** Research stories, design a database, sample editorial art (Scratch). Master chart. Set up of the organizational structure, assign jobs. Production schedule create deadlines.
- Day 3:** Organizing that research. Choose a medium to tell your story, database query, visualizing data. Writing day.
- Day 4:** Copy editing & production.
- Day 5:** Final production showcase and reflection time.

Academic Year 2008-09:

- TCNJ faculty and undergraduate volunteers actively support an after school program led by the middle school teachers. Guests from industry will be arranged, as will field trips. Extensive qualitative data collection will occur as well as surveys of this group (teachers and students) as well as our control groups. Parents will be invited to selected events with their children as well as to parent only events.
- Formal recruitment from industry will occur to sustain the program beyond this pilot year.
- Development of alliance connections for broadening participation will be pursued.

Summer 2009: TCNJ faculty/staff and middle school teachers will meet to review outcomes. Formal qualitative analysis will take place.

Fall 2009: TCNJ faculty/staff complete qualitative analysis and continue to develop alliances.

Creative and Strategic Actions

At TCNJ the Computer Science Department in partnership with the Program in Interactive Multimedia has used the perspective of *students as innovators* to develop college-level curriculum to address specific content needs in computer science [58, 61, 59]. Also at TCNJ, the Center for Mathematics, Science, Technology and Pre-Engineering, promotes inquiry and

design-based learning and acts as a demonstration and professional development center. This project is collaboration between our two groups.

Our primary theme will be to exploit *interactive storytelling* [33] as a vehicle for creating innovation in information technology. Computer games are a subcomponent of this growing information technology field. An interactive story is one that is told through visual graphics, sound, and logic decision-making structures. The implementation of an interactive story requires techniques from database management, graphics, sound production, artificial intelligence, and human-computer interface design. An interactive story may or may not contain an adversarial component. When it does, it is considered a game. When it is primarily a vehicle for reporting information it is *interactive journalism*, a rapidly expanding profession. Interactive stories typically contain video, sound and animation. When that animation is based on scientific and mathematical models of the natural world, the story or game becomes an *immersive world*, a *serious game*, or a *simulation*. We propose to expose students to these genres through primary engagement in interactive journalism. They will also be shown how this field relates to other compelling genres within the interactive storytelling family. This is not simply about letting students tell stories, but rather about teaching them language arts skills of the 21st century.

As of this writing we expect to use Alice [16], Scratch [31, 30] and PostgreSQL [44] /PHP [41] because they are available free on the Internet and are extremely easy to download and install. Furthermore, they provide manipulative vehicles through which students can immediately create novel solutions to information problems. Our intent is to give them solid grounding in principles of design and software engineering, and not just teach them basic programming skills.

To create meaningful experiences for middle school students and their teachers we must take the long broad view. Consequently, our approach is to provide intensive initial training followed by a full year of active participatory support and collaboration. We are firm believers in the power of face-to-face communication to establish and sustain community. However, we are also cognizant of the increasing influence of web-based social communities such as YouTube [64], Second Life [50], and collaborative problem solving environments such as the much maligned “World of Warcraft” [62]. These information technologies are second-nature to middle school and high school students. It is insufficient for college and secondary school faculty to promote computing career paths without direct input from young people. The ubiquitous culture of computing that encompasses video games and online social communities belongs to them. Without young people fully engaged, we cannot develop a thoroughly integrated multidisciplinary curriculum for secondary school. Consequently we are fully committed to engaging undergraduate researchers and volunteers into all facets of our project. We can learn from them and they can learn from the middle school students. We are confident that by nurturing a diverse community in the broadest sense we can create solid role models for our youngest constituents while broadening the perspectives of all of our members.

As part of this demonstration project, we intend to expand an existing content management system designed and built at TCNJ for the online magazine *Unbound* [56]. We anticipate adapting this into a social community called Mid CAFÉ (Middle School Collaboration and Facilitation Environment) that provides a highly interactive medium that goes well beyond the concept of website as resource. The CAFÉ will be implemented by undergraduate researchers at TCNJ based on extensive and successful experience we have had with both summer and school year undergraduate research [27]. The middle school cohort will not only learn how to use this system, but throughout the year will learn about the underlying design and software engineering principles that went into it as well as the specific database and programming techniques that

support the implementation. We should stress that the middle school students will not build the Mid CAFÉ, but that they will provide extensive comment as expert users.

Underlying Principles and Research that Inform this Project

We bring together a journalist, a database specialist, a computer science educator and a gender/equity coach. These perspectives inform the project.

Equity

The touchstone of our approach is that to achieve equity in science, technology, engineering and mathematics (STEM) requires changing preconceptions and biases about these fields by changing the culture of the classroom. This is not simply a public relations problem. Our approach is informed by substantive engagement in formal gender and diversity training. The MSTE [19] incorporates equity into its activities, most notably through the True Colors program. This formal program engages participants in identifying their learning and problem solving styles via four “color types.” Participants learn that they have a combination of attributes as risk takers, organizers, and creative thinkers. Through collaborative exercises they learn how to solve problems with others who do not necessarily think the way they do.

Underrepresented groups must feel at home in the STEM culture whether it is the classroom, the research lab or the industrial setting. This is particularly true for information technology and computer science [48]. Jo Sanders, in *Lessons I’ve Learned in 22 Years of Working with Teachers About Girls in IT* [49], states that educators sincerely believe they consciously mean no harm by lack of enrollments in IT fields by females and minorities, but that “they have no idea that differences in treatment of students are usually below the level of conscious awareness, and they certainly have no idea of the cumulative power of these small differences”. In 2000, the American Association of University Women Educational Foundation (AAUW-EF) report *¡Si, Se Puede! Yes, We Can: Latinas in School* [4] found that U.S. schools do not meet the educational needs of America's fastest-growing female minority population—Latinas. According to another AAUW-EF report, *Tech-Savvy: Educating Girls in the New Computer Age* [3], “as violent electronic games and dull programming classes turn off more and more girls to the computer culture, schools need to change the way information technology is used, applied, and taught in the nation's classrooms”. The report recommends that adults who directly influence young peoples’ lives need to reinforce aspirations to be “designers and producers of software and games, rather than as consumers or end users of games”. Themes consistent with other research mandate a consideration for social consciousness.

Our approach resonates precisely with these recommendations. An outreach activity conducted in April 2007 with Fisher Middle School (our proposed student population) corroborated these findings. A summary report appears in the supplemental materials. The students who participated (slightly more girls than boys with a diverse ethnic background) were highly enthusiastic about (rating “excellent”) those activities that engaged them as innovators. They were less enthusiastic (mixing “excellent” evenly with “good” rating) about activities that kinesthetically taught them computer processes. They want to “do” computer science, not simply learn concepts about it.

Computer Science Education and Undergraduate Research Mentorship

Curriculum development in computer science is problematic because the field is so new and there are significant controversies as to what should be taught, and when. We take a radical, but

practical approach: tie foundational computing concepts, as articulated in the ACM/IEEE Computing Curriculum document [25, 19] to domains of interest to secondary school students. As demonstrated in current computer science research, game and interactive story design provide examples for a multitude of core concepts such as graphics, sound production, database management, human computer interactivity, networks, and knowledge structure [45]. It is not sufficient for either educators or computer scientists to attempt to proscribe solutions to this problem. Rather, we view multidisciplinary collaboration between computer science faculty, journalism faculty, and equity/diversity experts as key toward successful outcomes. We hold firm to the principle of partnership between secondary teachers, college faculty, and undergraduate researchers. Our proposal is grounded by successful outcomes from previous funded projects at TCNJ, as well as successful models of undergraduate participation in research. A grant from Microsoft Research to create a multidisciplinary upper-level undergraduate video game design course informs our approach to selecting and implementing content for this project. There has been national recognition for this approach [58, 61, 59, 11, 12].

We have extensive experience in mentoring undergraduate research. For example, an internally funded Summer Undergraduate Research Program (SURP) [27], allowed us to bring together an interactive journalist, a database systems designer and an interface designer to construct an environment to support the collaborative construction of an online magazine, Unbound [56, 52]. Through formal courses in “Mentored Research in Computer Science” and “Projects in Interactive Multimedia” students developed online resources to support collaborative environments [60] and multiple storyline feature writing. These projects inform our vision of the “CAFÉ.”

The demonstration project will be managed through the Center for Mathematics, Science, Technology and Pre-Engineering at TCNJ (MSTE) [19], whose work is most recently funded through grants from US Department of Education and the NJ Department of Education. The center is devoted to developing successful models of inquiry-based learning. By partnering with faculty engaged in cutting-edge computing we meld state-of-the-art content with state-of-the-art teacher preparation. Through previous grants we have addressed the “teacher gap” between high-poverty and wealthier schools by addressing the resource needs of teachers including professional development, especially in the curriculum content areas. The “Urban Teacher Academy” is a summer program for high school students to engage them to become teachers in inner city schools. Our day-to-day program, our curricular structure, as well as our recruitment model, and project management approach are modeled on this highly successful program.

Critical to this approach is strong, continued collaboration during the school year. TCNJ faculty and their students will use well-established formal mechanisms at the college including “Faculty Mentored Research,” and “Community-based Learning” to create strong ties with participating schools. We have ten years of experience in computing sciences undergraduate research (especially in collaborative web-based systems) including over two-dozen refereed student publications. We view the relationship with schools as a genuine collaboration where faculty and undergraduates gain practical experience in issues including the technology divide, interface design, and collaborative systems. We anticipate that enthusiastic participation of teachers and middle school students will foster natural career development opportunities as TCNJ students and faculty promote positive images of “what computing scientists do”.

Interactive Journalism, Databases and Computing

A key concern for us is selection of interactive storytelling environments that are easily accessible to middle school students and teachers. Scratch is such an environment. Alice is another, which has gained tremendous popularity as a gateway at the college level. As of this writing we intend to consider Alice, but we have some reservations. Effective, structured story telling in Alice has a steep learning curve, both in terms of using Alice itself and in gaining mastery of the 3-D animation. Given that our week-long institute is tightly packed, we anticipate using Alice during the school year rather than in the initial exposure in the summer.

Scratch, on the other hand is relatively new with little information from the computer science community regarding its effectiveness as a first programming language. However, our own experience suggests that essential concepts are transparent to the new user and the overhead of getting started is very low. This interactive storytelling environment is an example of the kind of environment in which students can sketch out the story they wish to tell, and illustrate the intended special effects via animation. Scratch employs standard two dimensional computer drawing techniques that most high school students have mastered. For example, they are part of the NJ State Standards for both Fine Art and Technology. Constructing an animated story requires manipulating a small set of icons that represent programming constructs or “building blocks.” Story construction occurs by assembling these building blocks into scripts. Characters interact by broadcasting information and responding to broadcasts, much as actors act and react on a stage. Combining storytelling elements with sufficiently sophisticated mathematics provides the potential for true simulation. Furthermore, Scratch supports an online social computing network where students can post their own work and study the work of others.

Both Alice and Scratch are intended as introductory environments in which secondary school students can develop skills that can be applied in real-world environments (such as Photoshop, Java, or C++ based environments). A concern of ours was how quickly middle school students can come up to speed on these languages since programming is not the central focus of our summer institute or after school program. As a proof of concept, Co-PI Ursula Wolz recently conducted a two morning interactive story telling workshop with first graders at the Stony Brook School in Pennington NJ. The students were immersed in a “writing to read” program, and were able after four hours to successfully manipulate the Scratch environment to contribute to a full-class collaborative branching story that tied back into their writing/reading curriculum. The lesson plan and a letter of acknowledgement from the teacher, Ms. Kristy Hazlett, appear in the supplemental materials. This recent experience suggests that if 1st graders can successfully and independently manipulate programming constructs in 4 hours to create a story, then older students should be able to use Scratch successfully for journalistic purposes.

We also posit the need to provide exposure to database access and information presentation tools. The importance of database systems has increased dramatically in the last two decades. In a world now dominated by Google, it is imperative that students understand how information propagation is influenced by databases. Almost every facet of our lives is touched by data that we must analyze in some form or another to be able to make informed decisions. As complexity of this data increases it is no longer sufficient to store the data in flat file structures (like spreadsheets). Many secondary school courses include some exposure to spreadsheets. We view this as a severe impediment to students’ understanding of information access because it encourages a flat, two dimensional, rather than relational approach to information storage. It is also imperative to be able to retrieve data in interesting ways to answer simple and complex questions, and in a form that is conducive to reasonable analysis. Today, databases are crucial to the efficient management of data whether in commercial organizations, educational institutions,

or non-profit enterprises. They play a central role in almost every aspect of life today, helping people to be more effective and productive in the pursuit of their daily tasks. Report writing, regardless of the discipline will become increasingly dependent upon the results of database access.

Billions of dollars are spent on software application development yet there are serious problems in the cost, timeliness, and quality of many software products. Software engineering aims to integrate the principles of computer science and other disciplines to develop systematic models and reliable techniques for producing high-quality software. In just over a decade, the Internet and the World Wide Web have fundamentally changed the way information is delivered, interpreted and acted upon. Interactive multimedia have, in fact, become so central to so many economic, cultural and political institutions that issues affecting content design and delivery have become vital issues within those entities. Leaders in the news and entertainment industries, for example, see networked interactive multimedia as integral to their business plans. Similarly, artists and storytellers are finding new ways to mine emerging media technologies to create new esthetic experiences.

We will engage students in real creative writing and journalism assignments that incorporate interactive multimedia. At this writing we propose to use PostgreSQL [44] /PHP [41] to introduce eighth graders to the fundamental concepts necessary for designing, implementing, and using a simple database for their journalistic pursuits. We will also introduce preliminary software engineering concepts so that students can learn to design innovative technology-based solutions to problems that are bound to arise. In support of this effort we will adapt the content management system that was designed by our computer science undergraduates for 'Unbound' [56], an online magazine created, and managed by the magazine writing students at TCNJ.

The summer workshop curriculum will employ activities that are fun, collaborative, and kinesthetic. Frequently students may be quite unaware that they are acquiring important life lessons and computer science fundamentals as they complete their journalism assignments. Some of the core concepts the students will learn are:

- *Computer Science Foundations*: use and support for abstraction; concept of a system; human factors; implementation.
- *Database Systems*: database modeling concepts; entity-relationship diagrams; fundamentals of the relational data model; queries in SQL.
- *Software Modeling and Analysis*: modeling principles; behavioral modeling; documentation.
- *Software Design*: fundamental design issues and trade-offs.
- *Group Dynamics and Communication Skills*: dynamics of working in teams/groups; dealing with uncertainty or ambiguity; team and group communication.

Journalists often use databases as a tool for researching, organizing and presenting news. By accessing and creating their own databases, students will be learning about this aspect of journalistic practice, as well as fundamental computing concepts. Creating and linking datasets will help them understand the power of database technology. The process of creating a database will help them think about ways to organize and present information that are useful both to themselves as journalists and to their audiences.

In 1981, Co-PI and journalism professor Kim Pearson served as assistant director of the first Urban Journalism Workshop at New York University, under the direction of former NBC news producer, Elliot Frankel. The Urban Journalism Workshop, founded by the Dow Jones

Newspaper Fund in 1978 as part of the commitment made by the American Society of Newspaper Editors in 1975 to diversify the nation's newsrooms, is run on campuses in New York and New Jersey for two weeks each summer. The camp exposes a select number of high school students (typically 15-20) to professional journalists, newsroom tours, and real news events, such as press conferences. Our summer institute is based on this model.

In 1993, Pearson drew upon these and other experiences in constructivist pedagogy to create and run a magazine workshop with a third-grade class at Wicoff Elementary School in Plainsboro, New Jersey. In a brief period at the end of the school year, she and a class of 36 students and three teachers created a magazine from the ground up. In a few mini-lectures, Pearson taught the children the structure of a magazine, and how to write resumes and application letters. Students then applied for positions ranging from Editor-in-chief to advertising manager. A personnel committee of student volunteers reviewed the applications and placed people in jobs. She worked with the editors to help them plan the work to be done by each group, and helped the teams with their individual work plans. Ultimately, the students created a 36-page magazine with interviews, columns, a survey presented as an infographic, ads and editorials. Based on information Pearson provided about average salaries in the magazine industry, the bookkeeping team created a budget for the project that was incorporated in a report published by the personnel committee.

In 2001, Pearson ran a journalism workshop for high school students participating in TCNJ's Collegebound program. In four one-hour sessions, students from underserved school districts throughout New Jersey learned enough journalism basics to produce solid articles on topics ranging from teacher burnout to the Human Genome project.

Key Staff

Ursula Wolz, TCNJ Associate Professor of Computer Science and Interactive Multimedia, the Principal Investigator for the Microsoft Research project on Multidisciplinary Game Development is a recognized computer science educator with a broad range of publications who has taught students including disabled children, urban teachers, and elite undergraduates.

Monisha Pulimood, TCNJ Assistant Professor of Computer Science is a database and grid computing expert and a collaborator on the "Unbound Collaborative Content Manager" project. She is establishing herself in the computer science education community through publications on undergraduate research, project management, and diversity.

Kim Pearson, TCNJ Associate Professor of English and Interactive Multimedia is a recognized web-journalist, and collaborator on both the "Unbound Collaborative Content Manager" project, and Microsoft Games project. She has experience mentoring journalism students, professional and educators from diverse backgrounds through her activities as member of the National Association of Black Journalists, where she serves on the Digital Journalism Task Force.

Mary Switzer, is a Gender Equity/Diversity Specialist working with educators and students K-16 in urban and suburban high needs districts over the past 18 years. As our project manager she will ensure full integration of equity/diversity training into our program.

Meredith Stone, Ed.D., is a Learning and Evaluation consultant with more than twenty years experience in educational research and evaluation, who, over the past five years has served as an

independent evaluator for projects funded by both federal and state agencies as well as private institutions, including the USDOE, NJDOE, Princeton University and The World Bank.

Evaluation Plan

The evaluation plan provides a framework from which program staff, with the assistance of the external evaluator, will collect, analyze, and interpret evaluation data to monitor and revise immediate objectives and long-term goals. The design will take into account the relatively small number of participants and hierarchical structure of populations in education (students nested in classes). In addition to quantitative and summative analyses, the project will utilize goal-oriented iterative participatory qualitative assessment and feedback processes for formative and process analyses [46]. The project team includes an experienced external qualitative evaluator, who will work closely with the PIs and the project manager-equity/diversity specialist to develop appropriate instruments for each of the four activities and the participants involved. Given the small cohort size of this pilot, qualitative analysis will be used to document changes in attitudes and expectations, while quantitative analysis will be used to document changes in real computing, writing and communication skills.

Formative and summative evaluation will be developed for each of the activities listed in the design: As soon as the grant is awarded, the faculty will meet to determine what the specific curriculum objectives will be for each of the week-long summer institutes. Baseline data on both the student cohort and their teachers will need to be collected in the spring as soon as they are recruited (before they learn much about the program content). Instruments will include pre- and post- open-ended questionnaires to determine perceptions and attitudes concerning computer science curriculum and careers in computer science. Questions will also address equity and diversity and how these are dealt with in their classrooms. A focus group on both topics will be organized for the treatment and control teacher groups separately. Observations will be made during the Interactive Journalism Institute to document what is being taught, how participants react to training, and if their behavior changes in noticeable ways. The two week-long institutes, one for teachers and TCNJ student researchers (Writer/Programmer Mentor Institute) and the second for the students (Interactive Journalism Institute) will be followed by a post-questionnaire on the participants' perceptions and attitudes. The answers to the questionnaires will be qualitatively analyzed to develop a rubric around these attitudes and perceptions. Quantitative measures of knowledge with respect to equity/diversity and computer science will also be administered at the beginning and end of the two institutes. Depending on the findings the objectives for the enrichment sessions and the CAFÉ sessions may be revised.

During the 2008-2009 school year, observations will be made in the participants' enrichment sessions and classrooms. We would expect that the equity/diversity training can be implemented immediately (fall 2008 and spring 2009), although embedding computer training into a standard subject curriculum will take more time. Middle school students' participation in the after school club and TCNJ students' Mid CAFÉ activity will be tracked and documented. An additional component of the data collection will be "exit interviews" with any student, teacher or undergraduate dropping out of (leaving) the program. These observations will form the basis of a qualitative/process analysis that will inform the content extending this pilot into a more extensive program within an envisioned alliance.

Dissemination and Sustainability

Our primary venue for dissemination is the CAFÉ system we will build. We anticipate three other forms of dissemination (1) through traditional scholarly venues, (2) through school network organizations both local and national, (3) through extending our reach by creating computing ambassadors among our teacher cohorts and their students.

Traditional forms of dissemination will occur by publishing results in both educational and computing venues including *Educational Researcher*, *Journal of Research in Science Teaching*, *Journal for Research in Mathematics Education*, and *School Science and Mathematics*. We anticipate presenting at conferences such as the National Educational Computing Conference (NECC), the ACM Symposium on Computer Science Education, Frontier in Education and American Educational Research Association.

As mentioned previously, TCNJ has a well-established network of professional development in the New York, Philadelphia region. We intend to exploit that to the fullest to promote our program. Furthermore, the MSTE staff member Henry Harms is the New Jersey state corporate advisor to the Technology Student Association which serves 150,000 student in 2,000 schools in 48 states. (See Sherman letter).

The primary ancillary material to be developed is a Mid CAFÉ web site. This extends an e-Mentoring system developed by Dr. Sharon J. Sherman and the MSTE center [19]. (See Sherman letter.) The CAFÉ will provide interactive vehicles through which TCNJ faculty and staff, cohort teachers and their students can post their materials and provide commentary, and engage in live chat sessions. Our website design is modeled on two existing systems built by the TCNJ participating computing faculty and their students. The *CEDAR* project is a collaborative tool for curriculum development. *Unbound*, which began as research into online magazine formats is a vibrant student-run web publication. These highly interactive collaborative existing systems will be synthesized into a venue appropriate for the multifaceted collaboration expected in this project. The web team led by Dr. Pulimood will create a design that can be adapted by other groups, but still meets our specialized needs to support student work in variety of multimedia venues.

The materials posted on the CAFÉ will include print-based materials, hyperlink (HTM) documents and multimedia animations, games and video. They will be developed by (1) the middle school students in our cohort, (2) TCNJ faculty, staff and students, (2) teachers in our cohort. They will be made available to the general public after being vetted by a review board comprised of TCNJ faculty and cohort teachers.

We anticipate that having established this program at TCNJ we will be able to sustain at least the summer institute through corporate sponsorship as well as via the TCNJ MSTE. We anticipate that TCNJ computer science students will be able to maintain the CAFÉ with minimal funding beyond the scope of this grant. It is highly likely that as technology evolves, future versions of the CAFÉ will be implemented through other funding sources.

References Cited

- [1]. American Association of University Women Educational Foundation. (2004). Under the Microscope: A decade of gender equity projects in the sciences. Washington, DC.
- [2]. American Association of University Women Educational Foundation. (2001). Beyond the "Gender Wars": A Conversation About Girls, Boys, and Education. Washington, DC.
- [3]. American Association of University Women Educational Foundation. (2000). Tech Savvy: Educating girls in the new computer age. Washington, DC.
- [4]. American Association of University Women Educational Foundation. (2000). ¡Sí, Se Puede! Yes, We Can: Latinas in School. Washington, DC.
- [5]. American Association of University Women Educational Foundation. (1998). Gender Gaps: Where Schools Still Fail Our Children. Washington, DC.
- [6]. American Association of University Women Educational Foundation. (1996). Girls in the Middle: Working to Succeed in School. Washington, DC.
- [7]. American Association of University Women Educational Foundation. (1995). Growing Smart: What's Working for Girls in School. Washington, DC.
- [8]. ACM Education Board, ACM Education Board Annual Report for FY 2005, Association for Computing Machinery, New York, NY, 2005
- [9]. ACM K-12 Task Force Curriculum Committee, A Model Curriculum for K-12 Computer Science, Association for Computing Machinery, New York, NY, 2003.
- [10]. Adair, J. K., Reyes, M. A., Anderson-Rowland, M. R., and Kouris, D. A. "Workshops vs. Tutoring: How ASU's Minority Engineering Program is Changing the Way Engineering Students Learn", Thirty-first ASEE/IEEE Frontiers in Education Conference, October 2001, Reno, NV, T4G-7-11.
- [11]. Ault, C., T. Nakra, K. Pearson, P. Sanders, and U. Wolz, "Collaborative Learning via 3-D Game Development", (Panel), SIGGRAPH 06, August 2006, Boston MA
- [12]. Ault, C., T. Nakra, K. Pearson, P. Sanders, and U. Wolz, "Video Game Design as a Vehicle for Multidisciplinary Collaboration", The 2006 NMC Summer Conference June 7-10, Cleveland, OH.
- [13]. Barker, L. J., E. Snow, K. Garvin-Doxas, T. Weston, Recruiting Middle School Girls into IT: Data on Girls' Perceptions and Experiences from a Mixed-Demographic Group, in Women and Information Technology: Research on Underrepresentation, Cohoon & Aspray, The MIT Press, Cambridge MA, 2006. pp113-136.
- [14]. Blum, L., Frieze, C., Hazzan, O., and Dias, M. B., A Cultural Perspective on Gender Diversity in Computing, <http://www.cs.cmu.edu/~lblum/PAPERS/CrossingCultures.pdf>.
- [15]. Blum, L., Transforming the Culture of Computing, <http://www.cs.cmu.edu/~lblum/PAPERS/TransformingTheCulture.pdf>, October 2001.
- [16]. Carnegie Mellon University, Alice, <http://www.alice.org/>.
- [17]. Chinn, D. and K. Martin, Work in Progress: Adapting the Treisman Model to Computer Science, 36th ASEE/IEEE Frontiers in Education Conference, Oct 28 – 31, 2006, San Diego, CA, pp 23-24.
- [18]. Cohoon, J. M. and W. Aspray, (eds.) Women and Information Technology: Research on Underrepresentation, The MIT Press, Cambridge MA, 2006.
- [19]. The Center for Mathematics, Science, Technology, and Pre-Engineering. <http://mst-center.intrasun.tcnj.edu/>.
- [20]. Computer Science Teachers Association: <http://www.csta.acm.org/>.
- [21]. EPPI-Center. A systematic review of what pupils, aged 11–16, believe impacts on their motivation to learn in the classroom. <http://eppi.ioe.ac.uk/cms/Default.aspx?tabid=304>.

- [22]. Frost, D. 2007. Fourth grade computer science. In Proceedings of the 38th SIGCSE Technical Symposium on Computer Science Education (Covington, Kentucky, USA, March 07 - 11, 2007). SIGCSE '07. ACM Press, New York, NY, 302-306.
- [23]. Goode, J., R. Estrella, and J. Margolis, Lost in Translation: Gender and High School Computer Science, in Women and Information Technology: Research on Underrepresentation, The MIT Press, Cambridge MA, 2006. pp 89-113.
- [24]. Holovaty, A., "A fundamental way newspaper sites need to change." Holovaty.com. September 6, 2006 <http://holovaty.com/blog/archive/2006/09/06/0307/?highlight=structured%2520data>
- [25]. Joint Task Force on Computing Curricula IEEE/ACM, Computing Curricula 2001 Computer Science, Association for Computing Machinery, New York, NY, 2001
- [26]. Kestenbaum, D. and Knuth, D., Founding Artist of Computer Science, NPR, <http://www.npr.org/templates/story/story.php?storyId=4532247>, March 2005.
- [27]. Knox, D. L., DePasquale, P. J., and Pulimood, S. M. 2006. A model for summer undergraduate research experiences in emerging technologies. In Proceedings of the 37th SIGCSE Technical Symposium on Computer Science Education (Houston, Texas, USA, March 03 - 05, 2006). SIGCSE '06. ACM Press, New York, NY, 214-218.
- [28]. Lenhart, A., Lewis, O., Rainie, L. Teenage Life Online: The rise of the Instant Message Generation and the Internet's Impact on Friends and Family Relationships. Pew/Internet. June 21, 2001. http://www.pewinternet.org/PPF/r/36/report_display.asp
- [29]. MentorNet News, Think IT & Computer Science Jobs Are History? Think Again!, <http://www.mentornet.net/documents/about/news/newsart.aspx?nid=6&sid=1>, January 2006.
- [30]. MIT Media Lab, Scratch. <http://scratch.mit.edu/>.
- [31]. Monroy-Hernandez, A. ScratchR: sharing user-generated programmable media Interaction Design for Children Conference, Aalborg, Denmark, 2007.
- [32]. Moreno, S. E. and Muller, C. "Success and Diversity: The Transition through First-Year Calculus in the University", American Journal of Education, 108 (Nov 1999), 30-57.
- [33]. Murray, J. H. Hamlet on the Holodeck, The Future of Narrative in Cyberspace, MIT Press, Cambridge MA, 1997.
- [34]. Nelson, C. E. "Student Diversity Requires Different Approaches To College Teaching, Even in Math and Science", American Behavioral Scientist, vol. 40, no. 2, Nov/Dec 1996, 165-175.
- [35]. National Center on Education and the Economy, Tough Choices or Tough Times: The Report on the New Commission on the Skills of the American Workforce, Jossey-Bass, Somerset NJ, 2006
- [36]. Nieman Reports, Goodbye, Gutenberg, Vol. 60, No. 4 Cambridge: Nieman Foundation for Journalism, Harvard University. <http://www.nieman.harvard.edu/reports/06-4NRwinter/index.html>.
- [37]. Niles, R. The Journalist as Programmer: Q & A with Adrian Holovaty. Online Journalism Review June 5, 2006, <http://www.ojr.org/ojr/stories/060605niles/index.cfm>.
- [38]. Oregon University System, Campaign Launched to Expand Computer Science Pipeline in Oregon, http://www.ous.edu/news_and_information/news/032206.html.
- [39]. Oregon University System, Get Real - Explore Computer Science, <http://getreal.ous.edu/explore.htm#hs>.
- [40]. PBS Frontline. News War What's Happening to the News. <http://www.pbs.org/wgbh/pages/frontline/newswar/part3/>.
- [41]. PHP. <http://www.php.net/>.
- [42]. Pitts, V.R. (2005). High expectations: A "how" of achieving equitable mathematics classrooms. Negro Educational Review. 56(2&3), 127-134

- [43]. Poettker, H., News and its communicative quality: the inverted pyramid – when and why did it appear?, In *Journalism Studies*, Volume 4, Number 4 / November 2003, pp. 501-511.
- [44]. PostgreSQL. <http://www.postgresql.org/>.
- [45]. Prensky, M., *Don't Bother Me Mom – I'm Learning*, Paragon House Publishers, New York, NY, 2006
- [46]. Quinn P. M., *Qualitative Research and Evaluation Methods*, Sage Publications, New York, NY 2001
- [47]. Rodger, S. H. and Walker, E. L., PipeLINK: Connecting Women and Girls in the Computer Science Pipeline, <http://citeseer.ist.psu.edu/60649.html>.
- [48]. Sadker, D. and Silber, E. S. *Gender in the Classroom (2007). Foundations, Skills, Methods, and Strategies Across the Curriculum*. London and Mahwah, NJ: Lawrence Erlbaum Associates.
- [49]. Sanders, Jo (2005) *Lessons I've Learned in 22 Years of Working with Teachers About Girls in IT, Crossing Cultures, Changing Lives: Integrating Research on Girls' Choices of IT Careers* (Oxford, England). pp.4-7.
- [50]. Second Life. <http://secondlife.com/>.
- [51]. Simpson, J.C., Segregated by Subject: Racial Differences in the Factors Influencing Academic Major between European Americans, Asian Americans, and African, Hispanic, and Native Americans. *The Journal of Higher Education*, Vol. 72, No. 1. (Jan. - Feb., 2001), pp. 63-100.
- [52]. Summer Undergraduate Research Program (SURP) project description. <http://cs.tcnj.edu/06SummerResearchProgram.php>.
- [53]. Tharp-Taylor, S. and Nelson-Le-Gall, S. 2005. Social Orientations at Home and at School: Gender Differences in Black Children's Perceptions and Preferences. *The Negro Educational Review*. v56 n4 p245-257.
- [54]. Treisman, Uri. Studying Students Studying Calculus: A Look at Minority Mathematics Students in College. *The College Mathematics Journal*, Volume 23, #5, November, 1992, pp. 362-372, <http://math.sfsu.edu/hsu/workshops/treisman.html>.
- [55]. UCLA, Out of the Loop, <http://outoftheloop.gseis.ucla.edu/>.
- [56]. Unbound. <http://www.tcnj.edu/~unbound>.
- [57]. Wing, J. M. 2006. Computational thinking. *Commun. ACM* 49, 3 (Mar. 2006), 33-35.
- [58]. Wolz, U, T. Barnes, I. Parberry, M. Wick, "Digital Gaming as a Vehicle for Learning", (Panel) SIGCSE 06, March 2006, Houston, TX.
- [59]. Wolz, U., C. Ault and T. M. Nakra, "Teaching Game Design through Cross-Disciplinary Content and Individualized Student Deliverables", 2nd Annual Microsoft Academic Days Conference on Game Development , February 22 - 25, 2007 (extended version invited to submit to *The Journal of Game Development*).
- [60]. Wolz, U., M. Massimi and E. Tarn, r-MUSIC: A Collaborative Music DJ for Ad Hoc Networks, 4th International Conference on Web Delivering of Music, September13-15, 2005, Barcelona, Spain
- [61]. Wolz, U. and Pulimood, S.M. An Integrated Approach to Project Management through Classic CS III and Video Game Development, in *Proceedings of the 38th Technical Symposium on Computer Science Education (ACM SIGCSE)*, Covington, Kentucky, March 7 – 10, 2007.
- [62]. World of Warcraft. <http://www.worldofwarcraft.com/index.xml>.
- [63]. Yasuhara, K., Women in Computer Science Academia, <http://www.cs.washington.edu/homes/yasuhara/women-in-cs/>.
- [64]. YouTube <http://www.youtube.com/>.