COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 04-23

NSF 06-536 **01/10/07**

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DUE - CCLI-Phase 2: Expansion

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Florida Institute of Technology
150 W UNIVERSITY BLVD
MELBOURNE, FL. 329016975

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TITLE OF PROPOSED PROJECT **Adaptation & Implementation of an Activity-Based Online or Hybrid Course in Software Testing**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **405,916**	**36** months	**10/01/07**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.A)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.B, II.C.1.d)
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CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 04-23. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

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By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Appendix C of the Grant Proposal Guide.

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Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

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This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **john politano**	**Electronic Signature**	**Jan 10 2007 1:20PM**

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Software testing is not widely taught in universities or in industry. The proposed project will accelerate the widespread adoption of an existing and successful course in software testing by (a) ***developing and sustaining a cadre of academic, in-house, and commercial instructors*** via an instructor orientation course offered online; an ongoing online instructors' forum; and a number of face-to-face instructor meetings; (b) ***offering and evaluating the course at collaborating research sites (including both universities and businesses)***—in the process, the project will create one adaptation of the course to a purely online environment and another adaptation for a minority-serving university; (c) ***analyzing several collections of in-class activities to abstract a set of themes / patterns*** that can help instructors quickly create new activities as needed; and (d) ***extending instructional support material including grading guides and a pool of exam questions*** for teaching the course.

All of the materials—videos, slides, exams, grading guides, instructor manuals, etc.—are Creative Commons licensed. Most are available freely to the public. A few items designed to help teachers grade student work will be available at no charge, but only to teachers.

The instructional model devotes class time to coached activities, interactive discussions and student presentations by assigning students to view studio-produced lecture videos delivered via the Internet before coming to class. At Florida Tech, students report that they work harder in this course than most others; that the course is more difficult than most others; and that they learn more than in most other courses. A blind evaluation of student performance on final exams confirms the students' impressions of their learning.

Intellectual Merit. Independent research on an almost identically designed course in human-computer interaction at Georgia Tech also yields positive results for this style of instruction.

Principal Investigator Kaner is well known for his work on software testing—for example, Wikipedia describes one of his texts as "the seminal work" in the modern approach to the field. Co-PI Fiedler is an experienced online instructor, teaching courses to Education graduate students on research design and on skills needed to succeed in purely online courses to both graduate students and practitioners. She wrote the first version of the facilitator support manual for the nationally-recognized *Florida Online Reading Professional Development Project*. She also has 20 years K-12 teaching experience.

The planned interaction between industry and academic instructors in the proposed instructor orientation courses and the instructor forum community creates a strong opportunity for mutual instructional support across the industry-versus-academic divide.

Broader Impact. The core of this proposal is that it promotes better learning through an innovative instructional approach. The proposal makes the innovation possible by developing expertise among and between industry practitioners and academic instructors. It builds the STEM education community by providing significant instructor training to software engineering practitioners and support for their more professional practice as trainers. It addresses an area (software testing) that is taught at too few universities but applied by a large portion of the practitioner community.

We will customize the course to make it more effective for staff and students Huston Tillotson University (a Historically Black University). According to the *America's Digital Schools 2006* report summarized in T.H.E. Journal [1], 31% of K-12 curriculum directors consider online learning valuable for their district because it "Enables expert teachers from other institutions to teach our students" and 19% believe it "Provides development of courseware our district could not otherwise offer." We believe that similar benefits will be seen at other minority-serving institutions whose overworked staff have tiny curriculum-development budgets and a strong personal motivation to help their students find professional employment.

This project is driven by a passionate belief that we can improve satisfaction and safety of software customers by improving the effectiveness of the software testing community, and that the current educational situation for testers is so weak that a few people can make a noticeable difference.

1. Overview

The proposed project will accelerate widespread adoption of a successful course in software testing by:	**Pages**
(a) ***developing and sustaining a cadre of academic, in-house, and commercial instructors*** via an instructor orientation course offered online; an ongoing online instructors' forum; and a number of face-to-face instructor meetings.	**6-7, 9-11**
(b) ***offering and evaluating the course at collaborating research sites (including both universities and businesses)***—in the process, the project will create one adaptation of the course to a purely online environment and another adaptation for a minority-serving university.	**12-13, 14-15**
(c) ***analyzing several collections of in-class activities to abstract a set of themes / patterns*** that can help instructors quickly create new activities as needed.	**9**
(d) ***extending instructional support material including grading guides and a pool of exam questions***	**8-9**
The instructional model developed under grant EIA-0113539 ITR/SY+PE: "Improving the Education of Software Testers" devotes class time to coached activities, interactive discussions and student presentations by assigning students to view studio-produced lecture videos delivered via the Internet before coming to class.	**2-3**
At Florida Tech, students report they work harder in this course than most others; that the course is more difficult than most others; and that they learn more than in most other courses. A blind evaluation of student performance on final exams confirms the students' impressions of their learning.	**2-3, 4-6**
Independent and in parallel with our work, Day and Foley [34] developed a similar instructional method for a course on human-computer interaction. They also found positive results for this style of instruction.	**6**

All of the materials—videos, slides, exams, grading guides, instructor manuals, etc.—are Creative Commons licensed. Most are available freely to the public. A few items designed to help teachers grade student work will be available at no charge, but only to teachers.

2. The Need for Improved Testing Education

In a recent survey of software development managers, the most often cited top-of-mind issue was software testing and quality assurance [159]. Testing is not quality assurance—a brilliantly tested product that was poorly designed and programmed will end up a well-tested, bad product. However, testing has long been one of the core technical activities that can be used to improve quality of software. Many organizations invest heavily in testing. For example, most Microsoft projects employ one tester per programmer [28, 49].

Despite enormous investment in testing *work*, testing *practice* is insufficient. For example, according to *The Economic Impacts of Inadequate Infrastructure for Software Testing* [128], software weaknesses cost the U.S. economy $59 billion per year. This is a lower bound estimate. For example, the NIST calculations do not include the many "one-time" software crises, such as $300-600 billion spent in 1996-2000 to fix the Year 2000 bug [120], loss of NASA's Mars Climate Orbiter [131], a defect that crippled the USS Yorktown for almost 3 hours while at sea [145], and recurring costs of dealing with viruses and worms that exploit holes in current software (estimated as high as $45 billion worldwide for 2002 and $119 to 145 billion for 2003) [55]. Better testing would not eliminate these costs, but weak testing contributes to them.

The need for skilled testing is greater, not less, when companies and government agencies outsource software development. If a company can't control how a product is made, it must carefully check what it gets. To deal efficiently with contracted software, we must improve our ability (including our educational support for developing that ability) in rapid, risk-focused investigation of contractors' products [127].

2.1 Level of Instruction

Until recently, software testing played a minor role in the undergraduate computer science curriculum. The ACM/IEEE computer science curriculum guides (1991, 2001) virtually ignored it, though a few universities offered a course or two. The recent curriculum for undergraduate software engineering [5] gives testing a larger role, equivalent to about a semester-length course.

It is tempting to make the one-semester required course a shallow survey because this is the only way to touch the breadth of the field. We can create tests for any type of software misbehavior and any negative impact of design on acceptability. The field's scope extends to the full diversity of potential problems and the technical and social challenges inherent in exposing these problems.

Much of what passes for testing is mere generation of voluminous paperwork. Some of this is necessary for project control, but this is not the *essence* of testing. Manufacturing quality control checks copies of the same type of widget for manufacturing flaws. Software testing focuses on *design flaws* –errors designed into the product, propagated into every instance of that product. This calls for strategies and skills different from those applied to manufacturing QC. ***The essence of software testing is technical investigation of product risks.*** The more skilled the investigator, the more / better insights we should expect about product (and perhaps underlying process) weaknesses. The better way to develop skilled software-quality investigators is through test-related education that fosters higher-order skills (i.e., analysis and evaluation) [11, 20], not through a shallow survey.

Many testing classes emphasize a catalog of test techniques. However, a test is an empirically-answerable question about a product. Test techniques are tools that structure the process of finding the answer to the question. Without the questions—the understanding of what we are trying to learn from the test—we have no way of deciding which technique is useful or whether our use of it was successful. We must train testers to create good questions.

3. Our Current Course (Black Box Software Testing—BBST)

We adopted the new teaching method in Spring 2005 after pilot work in 2004. Our new approach spends precious student contact hours on active learning experiences (more projects, seminars and labs) that involve real-world problems, communication skills, critical thinking, and instructor scaffolding [129, 136] without losing the instructional benefits of polished lectures. Central to a problem-based learning environment is that students focus on "becoming a practitioner, not simply learning about practice" [122, p. 3]

Anderson et al.'s [11] update to Bloom's taxonomy [20] is two-dimensional, ***knowledge*** and ***cognitive processing***.

- On the ***Knowledge dimension,*** the levels are *Factual Knowledge* (such as the definition of a software testing technique), *Conceptual Knowledge* (such as the theoretical model that predicts that a given test technique is useful for finding certain kinds of bugs), *Procedural Knowledge* (how to apply the technique), and Metacognitive Knowledge (example: the tester decides to study new techniques on realizing that the ones s/he currently knows don't apply well to the current situation.)
- On the ***Cognitive Process dimension***, the levels are *Remembering* (such as remembering the name of a software test technique that is described to you), *Understanding* (such as being able to describe a technique and compare it with another one), *Applying* (actually doing the technique), *Analyzing* (from a description of a case in which a test technique was used to find a bug, being able to strip away the irrelevant facts and describe what technique was used and how), *Evaluating* (such as determining whether a technique was applied well, and defending the answer), and *Creating* (such as designing a new type of test.).

For most of the material in these classes, we want students to be able to explain it (conceptual knowledge, remembering, understanding), apply it (procedural knowledge, application), explain why their application is a good illustration of how this technique or method should be applied (understanding, application, evaluation), and explain why they would use this technique instead of some other (analysis).

3.1 We organize classes around learning units that typically include:

- ***Video lecture and lecture slides.*** Students watch lectures before coming to class. Lectures can convey the *lecturer's* enthusiasm, which improves student satisfaction [158] and provide memorable examples to help students learn complex concepts, tasks, or cultural norms [47, 51, 115]. They are less effective for teaching behavioral skills, promoting higher-level thinking, or changing attitudes or values [19]. In terms of Bloom's taxonomy [11, 20], lectures would be most appropriate for conveying factual and conceptual knowledge at the remembering and understanding levels. Our students need to learn the material at these levels, but as part of the process of learning how to analyze situations and problems, apply techniques, and evaluate their own work and the work of their peers. *Stored lectures* are common in distance learning programs [138]. Some students prefer live lectures [45, 121] but on average, students learn as well from video as live lecture [19, 139]. Students can replay videos [53] which can help students whose first language is not English. Web-based lecture segments supplement some computer science courses [34, 44]. Studio-taped, rehearsed lectures with synchronously presented slides (like ours) have been done before [29]. Many instructors tape live lectures, but Day and Foley

[6] report their students prefer studio-produced lectures over recorded live lectures. We prefer studio-produced lectures because they have no unscripted interruptions and we can edit them to remove errors and digressions.

- ***Application to a product under test.*** Each student joins an open source software project (such as Open Office or Firefox) and files work with the project (such as bug reports in the project's bug database) that they can show and discuss during employment interviews. This helps make concepts "real" to students by situating them in the development of well-regarded products [118]. It facilitates transfer of knowledge and skills to the workplace, because students are doing the same tasks and facing the same problems they would face with commercial software [25]. As long as the assignments are not too far beyond the skill and knowledge level of the learner, authentic assignments yield positive effects on retention, motivation, and transfer [48, 52, 119, 153].
- ***Classroom activities.*** We teach in a lab with one computer per student. Students work in groups. Activities are open book, open web. The teacher moves from group to group asking questions, giving feedback, or offering supplementary readings that relate to the direction taken by an individual group. Classroom activities vary. Students might apply ideas, practice skills, try out a test tool, explore ideas from lecture, or debate a question from the study guide. Students may present results to the class in the last 15 minutes of the 75-minute class. They often hand in work for (sympathetic) grading: we use activity grades to get attention [141] and give feedback, not for high-stakes assessment. We want students laughing together about their mistakes in activities, not mourning their grades [134].
- ***Examples.*** These supplementary readings or videos illustrate application of a test technique to a shipping product. Worked examples can be powerful teaching tools [25], especially when motivated by real-life situations. They are fundamental for some learning styles [43]. Exemplars play an important role in the development and recollection of simple and complex concepts [23, 126, 146]. The lasting popularity of problem books, such as the *Schaum's Outline* series and more complex texts like Sveshnikov [148] attests to the value of example-driven learning, at least for some learners. However, examples are not enough to carry a course. In our initial work under NSF Award EIA-0113539 ITR/SY+PE: *Improving the Education of Software Testers*, we expected to be able to bring testing students to mastery of some techniques through practice with a broad set of examples. Padmanabhan [113, 132] applied this to domain testing in her Master's thesis project at Florida Tech, providing students with 18 classroom hours of instruction, including lecture, outlines of ways to solve problems, many practice exercises and exams. Students learned exactly what they were taught. They could solve new problems similar to those solved in class. However, in their final exam, we included a slightly more complicated problem that required them to apply their knowledge in a way that had been described in lecture but not specifically practiced. The students did the same things well, in almost exactly the same ways. However, they all failed to notice problems that should have been obvious to them but that only required a small stretch from their previous drills. This result was a primary motivator for us to redesign the testing course from a lecture course heavy with stories, examples and practice to more heavily emphasize more complex activities.
- ***Assigned readings.***
- ***Assignments, which may come with grading rubrics.*** These are more complex tasks than in-class activities. Students typically work together over a two-week period.
- ***Study guide questions.*** At the start of the course, we give students a list of 100 questions. All midterm and final exam questions come from this pool. We discuss use and grading of these questions in [60] and make that paper available to students. We encourage group study, especially comparison of competing drafts of answers. We even host study sessions in a café off campus (buying cappuccinos for whoever shows up). We encourage students to work through relevant questions in the guide at each new section of the class. These help self-regulated learners monitor their progress and understanding—and seek additional help as needed. They can focus their studying and appraise the depth and quality of their answers before they write a high-stakes exam. Our experience of our students is consistent with Taraban, Rynearson, & Kerr's [149]—many students seem not to be very effective readers or studiers, nor very strategic in the way they spend their study time—as a result, they don't do as well on exams as we believe they could. Our approach gives students time to prepare thoughtful, well-organized, peer-reviewed answers. In turn, this allows us to require thoughtful, well-organized answers on time-limited exams. This maps directly to one of our objectives (tightly focused technical writing). We can also give students complex questions that require time to carefully read and analyze, but that don't discriminate against students whose first language is not English because these students have the questions well in advance and can seek guidance on the meaning of a question.

3.2 Assessment of the Course

So far, we have evaluated the course in four ways:

- Employer evaluations of our students (*informal*)
- Student performance on assignments and in-class discussion, compared across terms (*informal*)
- Student evaluations (course-customized Student Assessment of Learning Gains (SALG))
- Student performance on examinations (blind comparison of final exam performance across terms)

Our data are available to you. We store student evaluations (SALG data for Spring 2005 through Fall 2006) and more detailed summaries of final exam comparisons on a password-protected site created for managing this project. If you are willing to respect the confidentiality of these materials, you are welcome to inspect the data. To access the account anonymously, go to **http://graybox.cs.fit.edu/moodle/,** log in as '[redacted]

[redacted]**.**

3.2.1 Employer Evaluations of Our Students

We do not have formal evaluations. We hope to develop an evaluation process in this proposed project.

In terms of informal feedback, there is intense competition for our students among such well known companies as Microsoft, Google, Progressive Insurance, and many others recruiting for testers. Students often bring work products from their testing course(s) to interviews—we got so many positive interviewer reactions that we now advise students to do this. We have talked at conferences with test managers who hire one or more of our students and usually get strong positive reactions. Several of these managers are colleagues we know reasonably well; they are willing to be blunt and critical if appropriate.

The reputation of this course is such that there is a far stronger demand for our students than we can possibly fill. In Fall 2006, Kaner spoke at practitioners' meetings in Portland (Oregon), Indianapolis, and Columbus (Ohio). From discussions at these meetings alone, he had requests to send students to interview for over 50 testing positions from employers who stressed their interest in hiring Florida Tech-trained testers.

3.2.2 Student performance on assignments and in in-class discussion, compared across terms

We grade all assignments every term. We have not established a process for thorough comparisons across terms. We will compare assignments across institutions / courses in this proposed project.

Kaner has taught the testing course at Florida Tech for 10 terms, the first six in a traditional lecture format, the next four (beginning in Spring 2005) under the new design. Our impression is that students performed equivalently on the first two assignments under both approaches, but for assignments done later in the term, performance under the new course design has been more sophisticated. Some of our more recent assignments are broader in scope and require more judgment than earlier ones; most students are rising to this harder work, some very impressively so.

Our impression is that we have seen more improvement in assignments and discussions than final exams.

Our planned adoption of qualitative methods to explore student, teacher, and employer knowledge and attitudes in a richer way stems from our subjective impression that our evaluation of final exam performance misses much of the impact of the new instructional method.

3.2.3 Student evaluations, using a course-customized *Student Assessment of Learning Gains*

In Spring 2005, we started collecting detailed student course evaluations using the *Student Assessment of Learning Gains* (SALG) at the end of the term[3]. Funded by NSF, this instrument gathers far more information about the strengths and weaknesses of the course than traditional student evaluations [130, 143, 144]. We allocate a full 75-minute class for completion of the survey. We encourage students to be critical and thorough. They can supplement most ratings with comments. During each term, we pointed out changes to the course that were based on student evaluations—by the time they take the survey, many students realize we take this data seriously.

- Relatively few students expected A's in the course: Fall 2005 (undergraduate students, 0% expected A), Spring 2006 (graduate students, 38%), Fall 2006 (undergraduate, 10%).
- Students considered this course more difficult than others at Florida Tech: Spring 2005 (77% rated the course more difficult), Fall 2005 (100%), Spring 2006 (62%), Fall 2006 (100%).
- Students felt the course was more time-consuming than others at Florida Tech: Fall 2006 (90%) and consistent comments in previous years.
- Student comments were not unanimously positive but overall we received a surprisingly positive response given student perceptions that they were working harder but getting lower grades than in their other courses.

- We use the SALG as a formative evaluation instrument. We sometimes supplement the ratings with informal (greet-students-in-the-hallway) discussions at the start of the next term. Here's an example: Not everyone watches the video before coming to class, but many in-class activities depend on students' having watched the video. Therefore, we struggled with means to incent the students. We tried multiple choice quizzes at the start of some classes. Students convinced us that these quizzes, at best, punished students who had not watched the video rather than directly helping them watch and understand the lecture. In Fall 2006, we made the questions available with the lecture and encouraged students to take the quiz open-book, as they watched the lecture, closing the quiz at the start of class. In terms *before* Fall 2006, students tolerated the quizzes; in the Fall 2006 evaluations, *students complained that we didn't provide more of them*. (Of course, we intend to do so under this grant.)

3.2.4 Student performance on examinations, with blind comparisons across terms.

We select all midterm and exam questions from a pool of 100 questions that we distribute at the start of term. Some questions are short answer essays (10 points), some long answer essays (20 points). Every exam includes some questions that have appeared on previous exams.

Recently, we examined the final exams from all ten terms that Kaner taught the course, identifying questions in Spring 2005, Fall 2005, Spring 2006 and Fall 2006 that had appeared on at least one previous exam. For each reused long essay question, a research assistant typed a copy of the answer and assigned it a random number identifier. We printed the answers (each on its own page) for blind regrading.

Pat Bond (Associate Professor of Computer Science at Florida Tech), Scott Barber (President of PerftestPlus, a consulting firm) and Kaner blindly regraded the answers together, reaching a consensus ranking from worst answer to best for each question. We then performed a Kruskal-Wallis test for each question. For example, the following question was asked in Fall 2004, Fall 2005 and Fall 2006.

"Compare and contrast all-pairs combination testing and scenario testing. Why would you use one over the other?"

The mean rank of the answers in Fall 2004 was 25.7, Fall 2005 was 15.3 and Fall 2006 was 10.8. The Kruskal-Wallis test rejected the hypothesis that the medians across years were equal at the 0.01 level of significance. Across the 9 questions studied, there were 3 statistically significant results at the 0.05 level or beyond. The number of rejections follows the binomial distribution with parameter 0.05. If the null hypothesis (no differences across exams) is correct, the probability of obtaining 3 or more rejections (0.05) from a sample of 9 is less than 0.01. Therefore, across the 10 terms studied, there were differences across the terms.

In Fall 2006, 6 questions were repeats from previous exams. The best mean rank was Fall 2006 in 4 of these 6 cases.

We ran a pilot version of this comparison in Fall 2005 but cross-grader variability was the dominant effect. It was apparent from that pilot was that we had been grading essay exam answers too generously across all terms. We decided to demand better performance from our students.

In Spring 2006, Kaner more clearly communicated expectations by providing more grading feedback in class and explaining that midterm and final exam grading would be quite strict.

- In Spring 2006, we expected stricter grading to depress exam scores so we allowed students to earn a few bonus points during the term. This backfired. Students with excellent term grades didn't work hard for the final exam. The Spring 2006 finals compared poorly to the other 9 terms even though this was a very good group of students.
- We readjusted in Fall 2006. We dropped bonus points but created a video grading demonstration to help convey our expectations. We continued the harsher exam grading. The result was the best set of exams of the ten terms.

Measuring instructional success by final exam grades is only one window into a complex learning process. Factors like student time management across competing courses and perceived demand characteristics of the exam can have a major influence on measured performance, obscuring the underlying competence. However, especially because we believe we understand the performance influence in Spring 2006, we believe these data are consistent with all of our other impressions that students have been working harder and learning more since we adopted this new approach.

3.3 An Independent Replication

Jason Day and James Foley [30-34] independently developed a Human Computer Interaction course similar to ours.

- Their students watched videos before coming to class and engaged in in-class discussions and activities.
- In total, Day and Foley provide 843 minutes of video to their students [46]; we present 838 minutes.
- Their videos feature an experienced lecturer in a quiet but inexpensive setting, as do ours.

- Our videos are more intensely edited to eliminate speaking errors, pauses, anything else that can waste viewer time. Our slides are also more dense. Day and Foley claim video production time is low ("The upfront time investment to record and publish Web lectures is only a little more than half of the time the instructor would need to give the same lecture(s) in class" [34, p. 421]). In contrast, Kaner requires several "takes" which we edit into a final lecture. *When we consider all costs beyond initial preparation of the slides*, a 40-minute video costs 30-40 person-hours. Commercial colleagues have told us that preparation of comparable-quality videos (cheap studio background, carefully planned lecture and slides) takes 60-80 hours or more because of the additional planning and review. Foley's videos are good—we mention the cost difference because it is striking, not because our videos are very much better.
- Day and Foley's students needed motivation to consistently watch the videos. They used "lecture homeworks," designed to elicit higher-level work (e.g., synthesis). Students watched the lecture and submitted homework answers before the start of the next class. Our most successful intervention used multiple-choice questions that addressed lower-level knowledge, familiarity with basic concepts. As with Day and Foley, students submitted these by the start of the class that applied or discussed the lecture. We provided our higher-level questions as exam candidate questions in the study guide. We urged students to craft answers to these as they watched the lectures but in practice, most worked through groups of questions in preparation for midterms and the final.
- Day and Foley [34] were inspired by work of Schwartz and Bransford [142] that suggests that students learn well when they engage in a discovery activity first (such as generating contrasting cases) followed by lecture or text that presents and organizes the material for them. Day and Foley hypothesized that their approach, lecture-followed-by-activity, was in the spirit of Schwartz and Bransford's activity-followed-by-lecture. We also expect video-then-activity to be more effective than traditional lecture. However, we sometimes set up activity-then-video with a "preparatory exercise" activity [61]. We give students a hypothetical problem that we don't expect them to be able to solve and we grade for effort rather than correctness. The goal is to get students to think through enough of the issues that make the problem challenging that they will appreciate a lecture that discusses those complexities. "Cognitive conflict or puzzlement is the stimulus for learning and determines the organization and nature of what is learned" [141, p. 2].

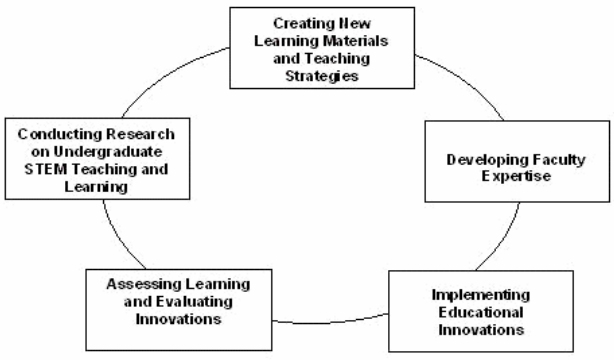
Day and Foley's students gave mixed subjective evaluations. For example, they rated the videos between 3 (Neutral) and 4 (Quite Useful) on a 5 point scale (5 is "Very Useful") [33, 34]. Our SALG data were comparably critical too, but amplified with thoughtful, and often more positive, comments.

Day and Foley taught two parallel sections of the same class, giving them comparable assignments. In their study, students who watched lectures before coming to activity-based classes fared significantly better than students who attended live lectures. This is consistent with our results.

4. Project Objectives

In discussing the Cyclic Model shown in Figure 1, we follow the definitions included in the Program Solicitation (06-536) that our proposal responds to.

To this point, we have focused primarily on developing a teaching strategy and associated learning materials (the BBST course). The core objective of the present proposal is ***implementation***, that is, enabling broad-based adoption of the course. To achieve that, we will also have to do significant work on ***faculty expertise*** and on the ***creation of materials to support faculty***.



Cyclic model for knowledge production and improvement of practice in undergraduate STEM education

Figure 1. Cyclic Model from NSF CCLI Program Solicitation 06-536

4.1 The Market for Implementation

Our target is the instructor (or institution) who needs a full set of course materials and guidance on how to use them. Many of these instructors will mature and evolve their courses into something quite different from the foundation that we provide—but for now, they need a foundation.

We host a 278-member email discussion list for people who tell us they want to teach or help develop the BBST

course. The list is low traffic—many people apparently join then abandon. ***Our desire to capture usage and abandonment data for the course led us to decide to transition course materials to a registration-requiring site, the Moodle sites we now use. We will complete this transition and be able to capture such data in this proposed project. The high abandonment rate and some associated comments helped us decide that instructor support activities and materials are needed, which we propose to develop in this project.***

People apply to join the mailing list by sending an introduction that can give us insight into who is trying to learn how to teach our course and why. We gain a further sense of the market from applications to attend *Workshops on Teaching Software Testing* (we will host WTST 6 this January), from discussions of our tutorials on the teaching of software testing [61, 63, 65, 69, 72, 77, 78, 83, 84, 90-92, 97, 108-110, 150], and from Kaner's history as a commercial trainer (BBST evolved out of Kaner's highly profitable commercial course) and collegial network of commercial trainers.

Our impression of our core market includes four groups:

- ***Experienced university instructors who were asked to teach a testing course but lack domain [software testing] expertise.*** According to the *America's Digital Schools 2006* report summarized in T.H.E. Journal [1], 31% of K-12 curriculum directors consider online learning valuable for their district because it "Enables expert teachers from other institutions to teach our students" and 19% believe it "Provides development of courseware our district could not otherwise offer." We have not seen comparable data for community colleges or universities but we expect particularly strong interest at schools with tight budgets, such as minority-serving institutions whose overworked staff are often especially motivated to help their students find professional employment.
- ***Inexperienced university instructors who have domain knowledge.*** Every year, WTST gets a few requests from recent Ph.D.'s who are creating a testing course. Often, they know more about software engineering in general or about a leading edge testing technology than about the state of testing practice. They need help with course design, student assessment, and with some of the content of the course.
- ***Commercial trainers***. These trainers offer open-enrollment courses and private courses to client companies. They are often charismatic subject matter experts and rarely have formal pedagogical training. Assessment activities, if they exist, are often simplistic, for self-evaluation, or as practice for a broad-and-shallow tester-certification exam. Some trainers see BBST as a threat to their livelihood; others see it as a potentially valuable introduction to teaching online and as training wheels for gradual development of their own online courses.
- ***In-house trainers***. Commercial short courses are often a poor investment. The trainer visits for a few days, spews an overwhelming amount of material, then vanishes, leaving behind thick course notebooks that gather dust. During the course, students have little time to evaluate or try to apply new ideas to their work. Adult learners often ignore material that doesn't seem useful in the near-term [117]. To provide better training for their staff, many test managers create their own training materials. These are less polished than commercial materials, but can be tailored for their company's needs. Trainers like these often have domain expertise but little pedagogical knowledge and less course development time. A course like ours provides an alternative paradigm for in-house training. Staff can watch a 30-minute video segment on Monday, try to apply the ideas to current projects through the week, then compare notes and watch the next video next Monday. This course spans more calendar time but probably fosters much more learning.

We are interested in these markets because we believe that most people who take testing courses will take most of their courses from these types of instructors. We believe that if we can help them substantially improve their instruction, we can impact the state of the practice.

4.2 Materials to Support Implementation

The main BBST site is at http://www.satisfice.com/moodle. (Choose the BBST Public Course and use the enrollment key "whitebox".) This gives instructors the experience of the course in the context of a full-featured (free) course management system. We saw repeatedly in attendees' pleasantly surprised reactions to our most recent tutorials on teaching BBST, CMS is still new technology for many instructors [63, 64, 77].

4.2.1 Revisions to the BBST Course Content

This project is primarily focused on implementation of the Black Box Software Testing (BBST) course, rather than development of its materials, but a few changes will support implementation, such as:

- ***A few new topics are important.*** The ACM/IEEE curriculum guide includes programmer testing techniques as core material. BBST course doesn't cover glass box (programmer-testing) techniques because, at Florida Tech,

we teach programmer testing as a full second course. Some instructors at other schools will want this covered. It is easy to provide definitions, concepts, and mathematical models. Developing a learning unit that spans only a few lecture-hours and includes application-level exercises will be more challenging. Another key missing topic is high-volume test automation, which is important for testing embedded, especially safety-critical, applications.

- ***The lectures should be revised to diversify the role models.*** At present, our only instructor is a middle-age white man. Most of our students will not be middle-age white men. We are aware of mixed attitudes and results with respect to the idea that it might be more motivating or instructionally successful for students to have several same-gender, same-race role models among their teachers [10, 24, 37]. We are not experts in this area but some evidence indicates that our students might benefit if we diversify the pool of instructors [18, 35, 38, 116] or might help shape their perception of their ability to achieve highly in the field [147]. We intend to diversify the video set by replacing some videos with updates that feature a different presenter and supplementing others with panel discussions that feature diverse panelists ***who are legitimate experts in the field and suitable role models***.
- ***Provide links to alternative online testing education materials.*** We created a small repository of materials at Florida Tech, http://www.testingeducation.org. With project funding, we can extend the repository to a wealth of new material that has appeared over the past three years. This facilitates broad adoption of BBST by helping instructors customize the course to best serve the needs of their students.

4.2.2 Instructional Support Materials

We will develop an online course, an instructor's manual, and an actively-hosted instructors' forum to help faculty improve their domain or pedagogical skills to a degree needed for this course. We'll consider these in more detail in Section 4.3 Supporting Development of Faculty Expertise.

In addition to these materials, we see several specific ways to ***incrementally improve the teachability of the course***:

- ***Develop a much larger pool of multiple-choice questions***, to help students focus and check their basic comprehension as they watch video lectures.
- ***Develop several more grading videos***. For Fall 2006, Scott Barber and Kaner sorted answers to one long essay question. Barber synthesized four answers, representative of each quartile of answers (best 25% through worst 25%). Kaner created a 43-minute video to demonstrate and explain grading of these four answers. You can access it (in two parts) at:

  http://www.testingeducation.org/BBST/videos/BBSTGradingFirstSet.wmv
  http://www.testingeducation.org/BBST/videos/BBSTGradingSecondSet.wmv

  Student reaction was favorable. In the Fall 2006 SALG, 100% of the students rated grading as fair (80%) or exceptionally fair (20%) even though 100% rated the course more difficult than others, 90% rated it more time-consuming than others, 90% rated the grading as strict, and 60% said they expected a C or D as their final grade. (They actually fared better because they wrote good finals.)

  We decided to provide this support after a grading analysis of Fall 2000 through Spring 2005 final exams. We distributed anonymized answers from these exams to five colleagues (senior practitioners, representative of people who hire our students). They and Kaner independently blindly ranked answers (best to worst). Despite detailed notes to guide grading, cross-grader variability was high. Rankings were weakly correlated.

  The structure for well-written answers is not mysterious—a typical essay question has identifiable parts. We allocate points for each part. An excellent answer to only half of a question fails. Shotgun answers gain no credit for irrelevant information but lose credit for irrelevant errors. (A holistic grader might rank answers differently.)

  After each midterm, Kaner gives a lecture to explain his grading. When asked, "Was grading explained satisfactorily?" between 90 and 100% of the students responded "Yes" in all 4 SALG-using terms. However, students still show performance weaknesses that suggest they might understand how their own answer was graded but they don't know how to generalize this to other questions as they answer them.

  This is a general issue. For example, we see the same problems when graduate students take their software engineering comprehensive exams. Kaner rarely sets or initially grades these exams, but he is called on to independently regrade the lot when the failure rate is high (sometimes 50% fail). These students show the same problems as BBST students—sloppy answers that answer only part of what was asked and answer something else instead. This is often a problem of performance (weak handling of the question) rather than competence (underlying knowledge of the subject matter).

  Given an apparently common weakness in writing and assessing essay answers among students and commercial

trainers, we believe that instructors would appreciate the following grading support:

- Several hundred essay questions covering all areas of the course (we already provide these)
- Several grading videos, covering different styles of questions
- Grading guides for several dozen specific questions, on a password-protected instructors-only site
- An instructors-only discussion forum for comparing grading notes.

- ***Develop a design framework (with supporting examples) that categorizes many types of activities (with supporting examples) to help instructors develop their own activities.*** The current activities work well for us but need much better documentation. Only some of our activities involve the application under test. Others develop a theoretical point from lecture, address a question in the study guide, address a question raised by a student, or help students work through a complex section of one of the readings. As we've developed activities, we've noticed themes, or activity design patterns. As the course is adapted for several audiences, we must develop broader guidance on how to create activities that align well with the instructor's objectives and we believe we would serve the community best by providing a rich set of examples with explicit discussion of commonalities to make it easier for an instructor to imagine how to apply a theme to create a new activity. We believe that activity themes will be particularly useful for people who have less course design experience, such as new faculty and in-house trainers. There are plenty of resources to work with:
  - There are several relevant repositories for software engineering instructional activities, such as SWENET [4] and HCC [2]
  - There are useful materials in other fields, such as the American Psychological Association collection [16, 17, 123, 124], the WebQuest design patterns [36], assessment activities [12], cooperative learning strategies [39-42], think-pair-share [58], jigsaw [13] and several reading strategies identified by the National Reading Panel [26, 27, 54, 133, 137, 140, 154].

4.3 Supporting the Development of Faculty Expertise

Our Instructor Support Plan is modeled on several successful online professional development models with which we are familiar: the nationally recognized *Florida Online Reading Professional Development Project* housed at the University of Central Florida; the *Inquiry Learning Forum* housed at Indiana University; *TappedIn*, a teacher professional development community originally funded by NSF and Sun Microsystems and now under the auspices of SRI International; and the University of Maryland University College's *Teaching With WebTycho Training* for online instructors.

The Florida Online Reading Professional Development (FOR-PD) has received recognition from the U.S. Department of Education as a "state initiative to improve teacher quality" and an "innovative example of e-learning programs for educators." FOR-PD was also mentioned in the National Educational Technology Plan as a model project to prepare "highly qualified teachers." Funded by the Florida Department of Education, the popular course has enrolled over 20,000 teachers from its inception in January of 2003. FOR-PD leaders attribute much of their success to the quality of the facilitators who serve as the human connection between course participants and the course materials – including the course technology. Rebecca Fiedler was a program assistant and instructional designer at the start of the project - helping to design many aspects of the course and assisting with the facilitator support materials including the first version of the Facilitators' Manual. She later served on the program evaluation team and will transfer the most successful strategies FOR-PD uses to train their facilitators to our project to help software testing instructors develop the pedagogical skills they need to successfully use the BBST materials in their courses. The most relevant components of the FOR-PD facilitator support system are described here.

- To be certified as a FOR-PD facilitator, qualified applicants must complete the ***FOR-PD Facilitator Training Course***. This five-lesson course introduces would-be facilitators to the FOR-PD project, objectives, and course materials. In addition, participants learn tips and strategies to provide a successful online experience for their respective students. They also become acquainted with the various support options available for both students and facilitators to ensure a successful experience for all. Finally, tutorials and practice exercises familiarize participants with course tools such as discussion boards, chat rooms, and quiz tools. Once the course is completed, the participant is a "Certified FOR-PD Facilitator" and awaits his or her first course.
- The ***Facilitators' Forum*** is an online community designed to provide ongoing support for FOR-PD facilitators. The Forum offers virtual space for lively interactions between facilitators who wish to share success stories, ideas about facilitating the course, insights surrounding course materials or course facilitation, or ask for help from others. The Forum is monitored by a FOR-PD staff member who fields questions and handles problems as necessary. However, the primary voices in the Facilitators' Forum are those of the facilitators themselves.

- The ***Facilitator's Manual*** is a reference outlining start-of-course procedures and checklists, sample welcome messages for participants, grading guidelines, participation rubrics, and project policy guidance. The Manual offers details about a variety of tasks facilitators perform throughout the course including how to deal with difficult participants, providing feedback to students, setting expectations, and encouraging discussion and collaboration among participants. Course wrap-up is an important component of the facilitator's role and the Manual guides facilitators through the variety of tasks to bring a course to a successful conclusion.

FOR-PD sponsored several opportunities for course facilitators to meet in face-to-face environments. The focus of these meetings was project related (focus group interviews to collect formative assessment data or work sessions to develop course revisions). Facilitators who participated in these activities were excited to "work" on the project; they positively "raved" about the opportunity to meet project staff and other facilitators face-to-face. They spoke enthusiastically about the value of these face-to-face meetings in forging stronger relationships and renewed enthusiasm for the project as they returned to their teaching. Similarly, Barab, et al (2003) claimed that face-to-face meetings were important extensions to Indiana University's *Inquiry Learning Forum* and that they led to some of that project's "greatest successes." Preece [135] calls this notion *sociability*.

4.3.1 University of Maryland University College

UMUC provides another strong model for our work. Fiedler has completed University of Maryland University College's *Teaching With WebTycho* five-week training course to prepare professors and adjuncts to teach online. UMUC has won a variety of awards for their distance education programs. In contrast to FOR-PD whose facilitators teach already-developed materials, UMUC *WebTycho* training prepares participants to develop their own online courses and materials. In addition to an overview of the university, policies, and tutorials of course management tools, UMUC participants focus on instructional design considerations such as content, objectives, sequence, pacing, activity ideas, integrating web resources, designing assignments, designing rubrics, providing feedback, and assigning grades. UMUC participants also consider the very real challenges of teaching online including promoting interactions, managing workload, and providing the first line of technical support for participants. One of the central features of the *WebTycho* training is the opportunity to apply workshop lessons to a practice classroom for instructor review and comment.

We believe that much of the UMUC course will apply well to BBST instructors.

4.3.2 Application to the Present Project

We intend to create an Instructor's Course, Manual and Forum. By the end of the project, they will be useful and used by many people, but they will not be so polished that they can be generalized to 20,000 people without significant additional refinement. FOR-PD was a multimillion dollar project; our project is not. Our intent in this Phase 2 project is to mature the courseware and the instructor support to the extent that, by the completion of this project, the steps necessary to move to a Phase 3 implementation will be obvious and achievable.

We face several instructional challenges:

- As with the FOR-PD facilitators, the testing instructors will have little experience facilitating online courses.
- In contrast to the FOR-PD facilitators who were all experienced teachers, many of our instructors (particularly from industry) will have little pedagogical expertise.
- Several instructors will prefer to lead face-to-face courses and so we face the challenge of transfer from an online instructional course to face-to-face application.
- FOR-PD facilitators typically knew a great deal about reading already. Some of the testing instructors will have weak domain knowledge.
- As they mature, the testing instructors will customize the course, set their own learning objectives, and incorporate other material.

We plan to start a first-draft no-fee-to-enroll instructor's course in late January 2007 with about 15 colleagues. This first draft will probably continue through August at a mutually agreed pace of 5 hours per person per week. In February or March, we will open a testing course to members of the Association for Software Testing. The participants in the instructor's course will collectively teach this course and another offered to AST members beginning April or May. These courses will give us opportunities to coach each other and to deal with challenges not yet anticipated in the instructor's course.

The first draft course will give us a better understanding of the scope of the needs of the students. We expect / hope to evolve this into two 5-week courses, one focused on pedagogical issues, the other focused on domain-related

issues. Many instructors-in-training will take only the pedagogical course. Much of that course will be drawn from the FOR-PD and UMUC courses.

4.3.3 Notes on the First Draft Instructor's Course

This course is not funded by NSF. You should think of it as a pilot study to help us prepare for the more formal work ahead. That said, here are some of our notes on the structure of this first course:

- We will alternate between ***domain-emphasis***—watching the videos and discussing how to supplement them, what activities would work well for this specific subject, how to grade them, etc. and ***pedagogical-emphasis***—how to set learning objectives, give feedback, and so on.
- Modeled after the UMUC training, we will create a separate Moodle course for each instructor and create practice exercises that everyone does in their own space.

One of the important unresolved questions is how instructors should assess student performance. Serious assessment is rarely done in commercial and in-house courses. Strictly-graded final exams are unlikely to be a tool of choice for non-academic instruction. Because instructors and students can spread the BBST course out over a long time, there is time for practice, application, and critical evaluation. Given that time, several practitioners who have signed up for the first instructor's course intend to carefully explore the opportunities for assessment in commercial courses.

4.3.4 Face-to-Face Meetings

The expanded face-to-face opportunities listed here are inspired by Fiedler's experience with the FOR-PD project and Barab et al's [15] observations that the *Inquiry Learning Forum*'s greatest successes came as a result of face-to-face opportunities for online community members.

Several members of this first BBST instructor group intend to form the core of an instructional support community analogous to the communities that form around some open source software. This is where we will recruit volunteers to offer a second generation course. We intend to host a workshop at the annual meeting of the Association for Software Testing each year to bring instructors face to face. We will also organize informal gatherings at some other conferences. We are also continuing to host the annual Workshop on Teaching Software Testing—an intense working meeting of up to 20 people and some of the instructors will also meet at that Workshop.

4.3.5 Instructor Forum

The **Instructor Forum** is modeled after FOR-PD's Facilitator's Forum. Hosted in Moodle, the Instructor Forum will provide 24/7 opportunities for Forum members to interact with each other and software testing experts to share domain knowledge; offer and solicit ideas for using the materials; suggest new materials or modifications to existing materials; seek technical or instructional design help; develop meaningful relationships to support them as they change their practices; provide for diverse perspectives to illuminate practice; and to share success stories. Links to course content and instructor support materials will provide convenient access for all instructors to offer feedback to each other and project staff. Other discussion boards will be dedicated to such things as sharing project news, meeting other instructors, and a CoffeeHouse to facilitate interactions of a more social nature.

5. Tester Certification

Adelman [7] described widely varying standards for information technology certification exams. Certification in software testing is a powerful marketing tool for course providers but current exams often ask simplistic questions that miss skill and higher level knowledge (see [9] for sample questions). They are often based on outdated materials—the bodies of knowledge published by the British Computer Society [21, 22] and the American Society for Quality [8] would have been suitable in 1983, when Kaner started writing *Testing Computer Software* [93].

Despite the weaknesses, many employers use testing certification as a screening tool or for qualifying or managing remote contractors. This has generated significant certification-related interest in BBST—the most commonly emailed question from visitors to the testing course website is whether it leads to a certificate.

In June 2006, Mike Kelly (President of the Association for Software Testing) and Kaner co-hosted the first *Workshop on Open Certification of Software Testers (WOC).* Most of the 18 senior people who attended have volunteered to help develop exam questions and associated software. The basic idea is a free exam based on a large pool of publicly visible, openly discussed questions. For more details, see http://www.freetestingcertification.com. WOC 2 is schedule for July 2007 in conjunction with the next AST Conference.

Certification is an *application* of our core project, not the driver of it. This proposal does *not* ask NSF for funding to support the certification. (However, if this proposal is approved, Satisfice Inc. will donate $10,000 to the project to support certification-related work.) We mention certification here to make two things visible to reviewers:

- We noted above (Section 3.2.3) the benefit of providing objective, computer-scorable questions for students to answer while watching the course video. The certification project will create many of these questions.
- The WOC exam will be based on freely available source material. The BBST course will not be the only source for study material for the exam but it was the existence of a comprehensive course that made this idea look plausible. This is a significant outcome of the BBST work.

6. Research and Evaluation

We see three clusters of questions and prioritize them as follows:

- ***How well is the testing course working and what is needed to improve it?***
- ***How well is the instructor training working and how can we improve it?*** This is new development. We intend to create something useful but not as polished as the BBST course that it supports.
- ***How can we foster an instructor support community?*** A strong, self-sustaining community will take years to evolve. It is desirable for a Phase 2 project rather than necessary as it would be for Phase 3.

6.1 How Well is the Course Working and What is Needed to Improve It?

This project is primarily focused on this question. That is, in our view, the project is a success if we can demonstrate that other institutions are adopting the course and that it is serving their students well. Under the criteria provided in the Program Solicitation, a Phase 2 project refines a previously created innovation, tests it on diverse users in several settings and demonstrates that it has been brought to a state from which it *can be* broadly adopted, not that it *has been* broadly adopted. The innovation that we are refining is the testing course.

The core of this evaluation is to get other people to teach the course and give us data on what happened. As with the materials collected at Florida Tech, we will collect student reactions (SALG), instructor reactions, student performance results and instructor retrospectives.

We have letters of commitment from organizations who have agreed to teach the course at least twice during the project period and provide us with assessment data. Please refer to the letters for details of their commitments. (With respect to the letters themselves, Kaner spent most of his discretionary time in Fall 2005 negotiating the terms of templates for these letters with prospective collaborators. It is challenging to get everyone to agree to the same terms but Kaner (an attorney) considers this important for managing a collaboration among volunteers. The signatories to these letters have carefully reviewed their terms and understand that they are making a firm commitment.) If this project is funded, Kaner will resume negotiations for additional collaborators, trusting that some people who took the instructor's course will sign on. Our goal is 12 collaborators who agree to terms like those in the letters of support we have submitted here, with at least 8 left at the end of the project after what we see as inevitable attrition.

Two collaborators are universities, Huston Tillotson University and the University of Illinois at Springfield (UIS).

- Huston-Tillotson is a historically black university and our collaborator is Allen Johnson, the Department Chair. He has significant expertise in software testing and experience as a videotaped teacher. He will star in some of our videos. We intend to work with Johnson to make these materials successful at Huston Tillotson, and thus more likely to be successful at other minority-serving universities.
- UIS has a strong online presence. We believe it is an excellent pilot location for introducing an online BBST at a quality level appropriate for a fully accredited undergraduate program.

Two collaborators, Microsoft and Quardev, are training in-house. This gives us the opportunity to survey the students and their supervisors, some time (perhaps a month) after the course has completed, asking whether the training made any difference in the staff member's subsequent performance.

For courses conducted online, we will analyze the quality of the online interactions, looking for factors that drive toward shallower or deeper interactions.

We also intend to do qualitative work, interviewing instructors and, when we can reach them, their students. Rebecca Fiedler has relevant experience: her dissertation project used qualitative methods to study the impact of an instructional intervention at two distant universities. She will analyze the content of online discussions [see, e.g. 114], interview instructors at the workshops and, where feasible, instructors and students at their institutions.

6.2 How Well is Instructor Training Working and How Can We Improve It?

We see our assessment as formative, a series of indicators of problems and potential improvements. Our primary instruments will be online questionnaires, some focused on specific issues and others broader (especially the SALG, which we will administer once or twice per course). This course is online and its success will depend on the quality of interaction among participants. Therefore analysis of discussions in terms of their depth is appropriate [114]. We will also interview instructors during the instructors' workshops and perhaps in other settings.

We are particularly interested in the usefulness of the catalog of activity themes / patterns. We will seek examples of cases in which instructors were aided by the catalog and others in which the catalog didn't help them.

6.3 How Well is Instructor Support Community Working and How Might We Improve It?

Barab and his colleagues asked a question much like the one we are asking: "How do we design an online community that promotes the professional development of pre- and in-service math and science teachers?" [14, 15, 122] They used activity theory as a lens to identify tensions (inherently conflicting demands or expectations) in the process [14]. Their lessons learned will help us avoid some mistakes and mitigate some conflicts, but we suspect that we will find many of the same tensions as we try to design an online community that promotes professional development of teachers of software testing and we plan to report our experiences in terms comparable to Barab's.

6.4 Board of Advisors

The collaborators will form a first Board of Advisors for the course. We will add selected volunteers, typically graduates of the Instructors' Course. The Board will meet often by email and annually face-to-face to

- review assessments of the BBST and instructor course materials, recommending additional or alternative assessments
- recommend policies regarding review and acceptance of contributed materials and updates
- recommend topics, learning objectives and depth for new or replacement instructional units
- review objectives for existing instructional units and the relationship between objectives and the units' associated activities and evaluation materials

We will meet in conjunction with either the Workshop on Teaching Software Testing or the Instructors' Workshop that we host at the annual Association for Software Testing conference. The difference between this meeting and the Instructors' Workshop is that ***this meeting is intended to help us assess and manage the project*** whereas the ***Instructors' Workshop is to help Instructors teach more effectively***.

The Board will start as a purely advisory group. We hope to gradually transform this into an executive board that makes decisions about the course and finds ways to raise funds to support it.

The potential economic benefits of free courseware and a free certification exam are particularly strong for larger corporations. One of our objectives during the grant period will be to persuade some of these companies to support the course through donations and contracted-for customized course segments.

7. Dissemination

- ***Creative Commons licensing:*** Any course materials funded under this grant will be published on the Web and licensed to the public under a Creative Commons license. We will tag these products with descriptive metadata (http://dublincore.org/ and http://metamanagement.comm.nsdlib.org/outline.html) to ensure they can be indexed and cataloged within the National Science Digital Library (http://nsdl.org).
- ***Instructor training:*** We will offer instructor training courses, publish a training manual, host an instructors' forum and instructors' workshops.
- ***Hosting:*** We will allow instructors to use our Moodle sites (at Satisfice or Florida Tech) to run their first pilot courses. We cannot afford to host all courses for everyone—our intent is to help them get started.
- ***Publicity:*** Kaner has given several papers and tutorials on teaching software testing to university and practitioner audiences [60, 61, 63-65, 69, 72, 73, 77-79, 89-92, 97, 106, 108-110, 113, 150, 152]. We will continue to do so.

8. Project Plan

- ***Fall 2007.*** Kaner is on sabbatical through academic 2007-2008. During this time, we expect to do significant work on the infrastructure of the course, such as: Recruit more collaborators (the goal is 12, with at least 8 staying through the full project). Negotiate details of evaluation and nondisclosure agreements. Begin an

instructor training course (online). Co-offer at least one BBST course with a graduate of the instructor training course that begins in January 2007. Interpret and publish data from the January through August instructor training and associated BBST courses. Outline the instructor training manual, focusing on pedagogical issues. Begin planning the courses at UIS and Huston Tillotson. Create at least one video with Dr. Johnson (Chair at Huston Tillotson). Plan and schedule the first advisory board meeting. Create additional reading material to support the course (Kaner has contracted with Wiley to write the 3rd Edition of *Testing Computer Software*).

- ***Spring and Summer 2008.*** Begin a detailed review of classroom activity descriptions; publish a first draft framework on testingeducation.org with examples. Create at least one more grading video. Tag existing materials with metadata. Offer at least one Instructors' Course. Host a 1-2 day Advisory Board meeting at Workshop on Teaching Software Testing. Host an Instructors' Workshop at the Association for Software Testing conference. Circulate outlines and slides for programmer-testing units of the course. Begin recruiting additional video instructors. Complete the first content analysis of the online courses. Begin collecting instructor experience reports. Complete a set of review questions (multiple choice) for every learning unit.
- ***Fall 2008***. Create videos for the first segments of the programmer-testing units. Kaner returns from sabbatical and recruits students. Begin (student projects) abstracting learning objectives from existing learning units, circulating drafts to the Advisory Board. Tape updates for at least 3 segments of the course. Updates might replace existing materials or supplement them. By this time, some courses will have been offered at other sites (e.g. in-house training, other universities)—begin interviews with course participants. Begin collecting instructor experience reports with specific activities and some student evaluations of individual activities. Continue offering the Instructors' course and continue reviewing data collected from other courses.
- ***Spring and Summer 2009***. Create videos for high volume automated testing. This might happen sooner but the goal is to drive the process with a student who focuses research in this topic area. (If no other student is available, Kaner has extensive relevant lecture material and can create his own video.) "Complete" the activity review, framework and collection of examples—that is, publish a high caliber set of materials on the website, with the expectation that they will evolve as others critique them and add materials to the repository. Complete an advanced draft of the instructor's manual(s). Host the second Advisory Board meeting and the second Instructors' Workshop. By this time, every remote instructor will have offered the testing course at least once and so we should have comparative data from at least 3 university courses, at least 3 in-house trainings and at least 3 public trainings, along with the online free course data.
- ***By the end of 2009***. Most remote instructors will have offered the course at least twice, at least 30 people will have *completed* instructor training and at least 100 will have *completed* the online free course. By this point, we will probably be providing support services to additional universities. A draft certification exam should be in place and driving more interest in the BBST course. We will have updated at least 6 more video segments, published the learning objectives for existing segments and solicited critiques of them.
- ***2010.*** We will have 2nd draft evaluations of the Instructors' Course and manuals, another round of data on course results from multiple institutions, content-analysis-based recommendations for improving student participation in online testing courses, adaptation of several activities from classroom or synchronous-online activities to asynchronous-online activities that still work. We will have several instructor experience reports for several adapted activities. By this point we will have made substantial revisions to the testing course and the instructor training course in response to assessment data, along with a collection of comments (this change stems from these assessment trends or those suggestions).

9. Broader Impact

The core of this proposal is that it promotes better learning through an innovative instructional approach and more effective teaching and training—with collaboration and cross-evaluation by academic teachers and commercial trainers. It builds the STEM education community by providing significant instructor training to software engineering practitioners and support for their more professional practice as trainers. It addresses an area (software testing) that is taught at too few universities but applied by a large portion of the practitioner community.

We will customize the course to make it more effective for staff and students Huston Tillotson University (a Historically Black University). According to the *America's Digital Schools 2006* report summarized in T.H.E. Journal [1], 31% of K-12 curriculum directors consider online learning valuable for their district because it "Enables expert teachers from other institutions to teach our students" and 19% believe it "Provides development of courseware our district could not otherwise offer." We believe that similar benefits will be seen at other minority-serving institutions whose overworked staff have tiny curriculum-development budgets and a strong personal motivation to help their students find professional employment.

We have disseminated our work broadly (see Section 11, Results) and will continue to do so. Finally, in terms of overall benefit to society, this project is driven by a passionate belief that we can improve satisfaction and safety of software customers by improving the effectiveness of the software testing community, and that the current educational situation for testers is so weak that a few people can make a noticeable difference.

10. Intellectual Merit

Developing exemplary materials and showing that they can be implemented in diverse contexts is the core of this proposal. The blend of academic and commercial instructors creates a strong opportunity for mutual instructional support across the industry-versus-academic divide. As we share and discuss our assessment materials, we will naturally gain further insight into each others' needs and expectations.

Kaner and Fiedler are married. Kaner is the senior author of the bestselling book on software testing [107] and another successful testing book [103]. With a doctorate in human experimental psychology and a legal background focused on the law of software quality [86, 94], Kaner is drawn to the interface of the social sciences and software engineering [88, 104], including the educational issues that gate the state of the practice.

Fiedler has 20 years' K-12 teaching experience, the last 7 as a technical specialist. Her doctoral research used qualitative methods to examine the education-related impacts, primarily on students, of a technological educational innovation (portfolio management systems). She authored the first edition of the instructor training manual for FOR-PD and developed a popular online course, *CyberTools for Today's Schools,* for the Southeast Initiative Regional Technology Education Consortium. As an adjunct for the University of Illinois (Springfield), she teaches *Foundations in Teacher Leadership,* which helps students develop skills needed to succeed in an online program. She has also taught research design for UIS and, as a doctoral student, for University of Central Florida. She currently consults on educational issues, primarily through Acclaro Research Solutions and has developed course materials for the GSA and the US Department of the Interior.

The resource in short supply on this project is the student researcher. Florida Tech is primarily a science/engineering school, rather than a magnet for students who are intrigued by the intersection of engineering, psychology and education. At Florida Tech, more undergraduates are more willing to experiment outside their box and so we have budgeted primarily for undergraduate support, leaving several tasks to Fiedler that we would prefer to supervise in a dissertation. If we find an appropriate doctoral candidate, we plan to shift Fiedler's role to include more mentoring, less individual contribution, and fewer hours—shifting funding that would have gone to that student instead.

11. Results from Prior Support

Kaner received NSF Award EIA-0113539 ITR/SY+PE: "Improving the Education of Software Testers" for $469,668.00 for 36 months starting 09/01/01. The period was extended to 8/31/06. The primary outcome of the award is the BBST course that is the subject of this grant. In addition, we supervised two theses on failure mode and effects analysis as it applies to software (and to training of software testers) [56, 155], a thesis on challenges in teaching the most popular test technique (domain testing) [132] and published many articles and presentations to the academic and practitioner communities [50, 57, 59-61, 63, 64, 66-68, 70-73, 75-77, 79, 80, 85, 87-90, 92, 95, 97, 101, 105, 106, 108-111, 113, 125, 150-152, 156][62, 65, 74, 78, 81, 82, 96, 98-100, 102, 103, 112, 157].

12. A Closing Note

Kaner has served on a few NSF panels and has occasionally heard the comment that the authors of a proposal are making such good progress on their own that they don't need NSF support. A colleague joked that you might have that impression about this proposal. If you don't have that impression, please forgive our use of this last section to address an irrelevancy. Unfortunately, the NSF review process doesn't include a mechanism for checking misunderstandings with proposal authors and we feel a need to address this potential misunderstanding directly.

We have made substantial progress, but this project extends far beyond what we can do on our own. At this point, the project is at a crossroads. We believe the project we propose can yield a far greater impact than the work we have done so far. Without funding, we will invest our personal time and funds to preserve the public value of what we have created so far, but the impact of that work will be much less. For example, the sponsors we know are not interested in funding evaluation efforts or diversity initiatives and will resist public availability of any artifacts they believe they solely funded. Without NSF funding, the impact of most future work will be commercial and proprietary, with little benefit to the scientific or public education community. In our view, that would be a waste.

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Allen M. Johnson, Jr. Ph.D.
Huston-Tillotson University
Interim Chair Computer Science Department
900 Chicon Street
Austin, Texas

To: The National Science Foundation
Regarding: CCLI grant application by Cem Kaner
Date: January 5, 2007
From:

This letter indicates our support for the project proposed by Dr. Kaner.

I am Dr. Allen M. Johnson, Jr. Department of Computer Science, School of Business and Technology, Huston-Tillotson University (Ph.D., The University of Texas at Austin, 1989). I am the Interim Chair of Computer Science at Huston-Tillotson University. I am the chair of the Student and Academic Relations Committee of the Association of Software Testing. In workshops and presentations, I have been a advocate for the scholarship of teaching and learning. I have over twenty five years of experience teaching courses to graduate and undergraduate students at Universities, teaching students from industry in a 48 week course as a part of the University of Texas Software Engineering Institute certificate program for project management, and teaching courses for state agencies and private corporations such as IBM and Motorola.

At Huston-Tillotson University, our goal is to have a computer science program that gives students the skills and experience to be competitive and productive in the workplace. We have several courses that provide the opportunity for students to work in teams on projects. An essential element in these courses is the development of software testing skills. We will utilize elements or components of the courses created by Dr. Kaner in the following courses which typically have some element of software testing.
CSC 323 Database and Information Retrieval
CSC 373 Software Testing
CSC 403 Software Engineering 1
CSC 413 Software Engineering 2
CSC 493 Computer Science Research/Project

I have reviewed the instructional materials that Dr. Kaner has published at http://www.testingeducation.org/BBST. I have used some of this material in the classes I've taught.

If the National Science Foundation awards funding to Dr. Kaner to extend these materials, we have agreed to collaborate in this project in the following ways:

- In the period 2007 to 2009, I will teach a course based on these materials at least twice
- In each case, I will evaluate the course and the instruction at several levels:

- At the start of the course, I will advise students in writing that this course is part of an international research project on the effectiveness of teaching software testing and that I intend to share their work products (such as exams and homework) and evaluations with other instructors after stripping their names and other information that could identify them or their company, and that we may publish research reports that quote briefly from their work products or their evaluations. I will advise students that they have the right to withhold their permission for us to use their data. I will not forward or make any use of permission-withheld work products. However, because the evaluations are submitted anonymously, if a student submits one, the research group will share it and use it. I will encourage all students, especially students who are dissatisfied with the course or who find it difficult, to allow us to include their work in our studies.
- I will collect student reactions to each instructional unit (a unit includes its associated activities)
- I will note my instructor reactions to each instructional unit as I teach the course
- I will collect detailed student evaluations at the end of the course using a questionnaire based on the Student Assessment of Learning Gains
- I will provide a detailed instructor evaluation at the end of the course, using a questionnaire that asks the instructor to reflect on how the instructional materials helped (or did not help) achieve my course objectives, and what changes to the materials could make the course more effective next time.
- A single course may involve several instructors, or an instructor and several teaching assistants. In this case, I will collect reactions from each instructor / TA to the instructional units they worked on, and I will collect end-of-course reflections from each of them, with the understanding that they may leave some parts of that questionnaire blank because they weren't sufficiently involved in it.
- I will ask students to allow me contact them some time (perhaps six months or a year) after the end of the course for a reflection on the value of the course and the extent to which the lessons in this course helped them in later courses or other work.

We have not settled on the details of the questionnaires. I expect to develop questionnaires in collaboration with Dr. Kaner and perhaps with other companies or instructors who are working on this project. I agree that the questionnaire I actually use will be subject to Dr. Kaner's approval and I understand that one of his reasonable objectives is a degree of standardization across research sites.

I expect to offer this course under much the same structure as Dr. Kaner has offered it at Florida Institute of Technology. Students will watch lectures before coming to class, possibly take a quiz at the start of class, and then participate in an in-class activity. I expect to use a mixture of activities developed by Dr. Kaner's lab and activities that I

already use or that I develop over the next few years. I expect to base many of the application activities on the taxonomy of activities and collection of examples that are developed as part of this research. I will share descriptions of the activities with Dr. Kaner and grant permission for their inclusion in the free courseware. At some point I do expect to develop web-based courses utilizing this material which will have little or no fact-to-face instruction.

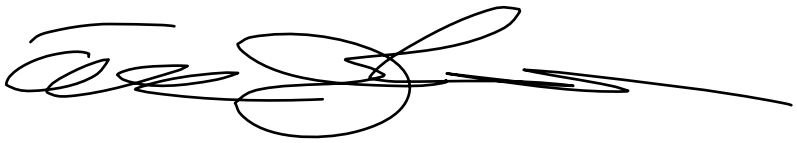
I understand that I will not be financially compensated for participation in this project. I am donating the significant labor that will be involved in the assessments and their analysis.

I expect reimbursement for reasonable travel expenses when I travel to meet with Dr. Kaner and other researchers to discuss our results and next steps. I understand that his travel budget will be limited and that it may not stretch to cover all of my expenses.

I understand that Dr. Kaner is trying to develop an open source, free certification exam for software testers that would be based on the testing course and on other materials freely available on the Web. I believe that there is a significant need for a trustworthy certification of knowledge of the basic facts of testing and of the ability to apply the basic techniques of testing. I will decide on the extent to which I can assist with this work as I come to understand the details better how I could contribute. In principle, I believe that this is a worthy endeavor, that it might help some of my students get appropriate jobs, and that it should be supported. I have not seen any other certification program that I would be satisfied with in this area.

We anticipate that some publishable research may result from this project. We will collaborate with Dr. Kaner and give appropriate credit to the National Science Foundation. We also expect that Dr. Kaner will cosign some or all of these papers with our faculty and that he will acknowledgement in various publications, presentations, or on his website(s).

Regards,



Allen M. Johnson, Jr. Ph.D.

SATISFICE, INC.

To: The National Science Foundation
Regarding: CCLI grant application by Cem Kaner
Date: January 6, 2007
From: James Bach, Satisfice, Inc.

This is a letter of support for Dr. Kaner's project.

My name is James Bach, I am the CEO and Principal Consultant of Satisfice, Inc., a software quality assurance and testing company.

I have reviewed and contributed to the instructional materials that Dr. Kaner has published at http://www.testingeducation.org/BBST. I teach a testing class of my own, called Rapid Software Testing (see http://www.satisfice.com/rst.pdf) , and my materials draw upon Dr. Kaner's work extensively. In some cases I have imported his material, and in many cases I refer to his videos, both in my class, and on my blog. The BBST materials provide a wonderful foundation for my own classes.

I am eager to see more of this material available for training of my remote associates.

I have witnessed Dr. Kaner's classes. I have given guest three guest lectures to his students. It is my impression that the Black Box Software Testing class, as it is taught at Florida Tech, represents a wonderful achievement in tester training.

This is the commitment I will make in the event that Dr. Kaner receives an NSF grant:

- Satisfice, Inc. will host the train the trainer courses, at my website, for which I will not charge a fee. I will participate in those courses and help evaluate the materials.

- Satisfice, Inc. will donate $10,000 to the tester certification project.

Thank you for your consideration,

James Bach
CEO and Principal Consultant
Satisfice, Inc.

UNIVERSITY OF ILLINOIS
AT SPRINGFIELD

Computer Science Program
University Hall, Room 3100
One University Plaza, MS UHB 3100
Springfield, Illinois 62703-5407

TO : NSF, DUE, CCLI
FROM : Keith W. Miller, Professor of Computer Science
DATE : January 2, 2007
RE : CCLI grant application from Dr. Cem Kaner

This letter is in support of a grant proposal from Dr. Cem Kaner on the topic of software testing education. I teach computer science at the University of Illinois at Springfield, and I used materials from the website http://www.testingeducation.org/BBST while teaching an online graduate seminar in software testing during the Fall 2006 semester. I found these materials insightful and well presented, and I plan to use them this spring in the next offering of the seminar. In addition to the materials from Dr. Kaner's website, I use materials that I have developed myself (podcasts, PowerPoint presentations with my narration, journal articles, automated quizzes, and online discussions). I found that Dr. Kaner's materials gave the students a solid foundation about the motivations and protocols for important testing techniques. My students and I agreed that the practical suggestions and concrete examples in Dr. Kaner's materials were particularly helpful.

If Dr. Kaner's CCLI application is successful, I have agreed to collaborate in the ensuing work. I am committed to the following:

- During 2007-2009, I will teach my graduate seminar in software testing at least three times using the materials Dr. Kaner makes available.
- Each time I teach the course, my students and I will complete several different kinds of evaluations.
    - At the start of each course, I will have each student fill out a form detailing how their assignments and tests in this class will be used, with their permission, in the CCLI project. This use will include statistics about class performance and may include direct quotes from the students' work. Students will be given the option of granting or withholding their permission for me to use their data in the project. I will not use data from any students opting out of participation. This permission will determine whose data is used in the study, not how the students evaluate the course or how well they succeed.
    - I will collect student evaluations of each instructional unit, including any activities associated with that unit.
    - I will record my own reactions to each unit and its activities.
    - I will require all students to fill out an evaluation of the materials at the end of the course, using a questionnaire based on the Student Assessment of Learning Gains. Only data from students who have agreed to participate in the project will be forwarded to Dr. Kaner.
    - I will fill out and return an instructor's evaluation at the end of the course in which I will reflect on the effectiveness of the instructional materials, and I will suggest any changes that I think could improve the course.
    - I will be available after teaching each course to give feedback of the lasting effect of Dr. Kaner's material on my students and my subsequent teaching about software testing. I will ask students participating in the study for permission to be contacted by Dr. Kaner six months after the class so that he can obtain their feedback about the effect of the course materials on them.

Phone (217) 206-6770 UIS Fax (217) 206-6217

The evaluations I will use with my students will be based on information from Dr. Kaner. I will submit all the evaluation forms I use for this project to Dr. Kaner for his approval before they are distributed to the students. I understand that the forms I use may have to be adjusted to obtain consistency of evaluations across the different sites using his materials.

The graduate seminar I teach is called "Software Testing and Reliability," and it is an advanced graduate seminar for masters level students in computer science. The course is a semester long and is taught online. In the past, I've taught the course face-to-face. In its current form, the course includes several units of Dr. Kaner's materials, readings from current and classic journal articles about software testing, and pedagogical aids that I've developed myself. Assessments include online quizzes, discussion groups, homework, and a comprehensive, face-to-face final exam, proctored for distant students. In the past, I've found Dr. Kaner's materials well suited asynchronous, online pedagogy.

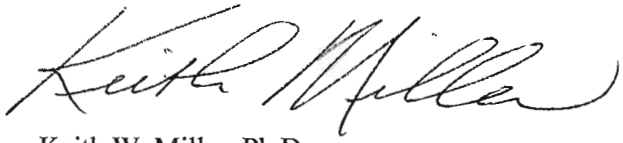
If this proposed work is funded, I will submit my personal teaching materials to Dr. Kaner in case he might find them useful in developing his materials. If there are proprietary materials that I use in the course, I will share them with Dr. Kaner with the understanding that he may publish summaries of those materials, but not the materials themselves.

I agree that I will not be financially compensated for my participation in the project. I think the project is important, and the materials have already proved useful to me. Therefore I am donating my time and effort in evaluating the materials that will be produced for the proposed work. If Dr. Kaner finds it necessary to meet face-to-face with me in regards to this project, I hope that it will be possible to receive some reimbursement for travel expenses to meet with Dr. Kaner. However, I recognize that this may or may not be possible due to limitations of funding.

Dr. Kaner has announced his intention to attempt the development of an open source, free certification exam based on the testing course and other web-based materials. As a university professor who teaches software testing, and as a computer ethics researcher who writes about the responsibilities of computing professionals, I am convinced that this kind of certification could be an important step in fulfilling two important needs, needs that are currently unmet: the need for a practical certification of professional competence in testing, and the need for more computing professionals who are competent in testing. Because of these critical, unmet needs, I think that Dr. Kaner's attempt to provide such a certification exam is a project worthy of NSF support.

I hope to submit academic publications based on my experiences and the data generated in relation to this project. In any such publications, I will give appropriate credit to the NSF and to Dr. Kaner's project.

Sincerely,



Keith W. Miller, Ph.D.
Professor of Computer Science
Vita available at http://people.uis.edu/kmill2/keith.htm

appLabs TECHNOLOGIES

www.applabs.com

To: The National Science Foundation
Regarding: CCLI grant application by Cem Kaner
Date: January 03, 2007
From: Geetha Narayanan, CSQA, PMP,
Manager Technical Services, AppLabs Technologies

This letter indicates our support for the project proposed by Dr. Kaner.

We are AppLabs Technologies, a global IT Services Company assessed at CMMI level 5, specializing in Quality Management, software testing and certification services. We have reviewed the instructional materials that Dr. Kaner has published. The video lectures, slides, and various additional types of learning aids are useful reference materials to our internal training programs. At AppLabs I teach at the AppLabs center of Excellence for Software Testing, an internal training program that is conducted at least two times every year. We have used the material from the website http://www.testingeducation.org/BBST and we have found the material to be well structured and the trainees concurred that it helped them in assimilating the concepts better. We intend to use these materials in all our internal training programs, going forward.

If the National Science Foundation awards funding to Dr. Kaner to extend these materials, we have agreed to collaborate in this project in the following ways:

- In the period 2007 to 2009, we will teach a course based on these materials at least three times
- In each case, we will evaluate the course and the instruction at several levels:
    - At the start of the course, we will advise the trainees in writing that we are part of an international research project on the effectiveness of teaching software testing and that we intend to share their work products (such as exams and homework) and evaluations with other instructors after stripping their names and other information that could identify them or their company, and that we may publish research reports that quote briefly from their work products or their evaluations. We will advise the trainees that they have the right to withhold their permission for us to use their data. We will not make any use of permission-withheld work products. We will encourage all trainees, especially those who are dissatisfied with the course or who find it difficult, to allow us to include their work in our studies.
    - We will collect trainee reactions to each instructional unit (a unit includes its associated activities)
    - We will collect instructor reactions to each instructional unit

- We will collect detailed trainee evaluations at the end of the course using a questionnaire based on the trainee Assessment of Learning Gains
- We will collect a detailed instructor evaluation at the end of the course, using a questionnaire that asks the instructor to reflect on how the instructional materials helped (or did not help) achieve her or his course objectives, and what changes to the materials could make the course more effective next time.
- A single course may involve several instructors. For example, one member of our staff might instruct/coach trainees on issues involving a test design technique that she is particularly skilled with, while another staff member might be the resource for issues involving status measurement and reporting. In these cases, we will attempt to collect a retrospective evaluation from each instructor, but some instructors might have nothing to say about some of the learning units.
- We will ask trainees and the instructor to allow us to contact them some time (perhaps six months) after the end of the course for feedback on the impact of the course on their work.

We have not settled on the details of the questionnaires. We expect to develop questionnaires in collaboration with Dr. Kaner and perhaps with other companies or instructors who are working on this project. We agree that the questionnaire we actually use will be subject to Dr. Kaner's approval and we understand that one of his reasonable objectives is a degree of standardization across research sites.

We intend to integrate these materials into a six-week course that we offer to people who are newly employed as testers or seeking work as testers. We expect to combine the video instruction with live lecture and to use a mixture of activities developed by Dr. Kaner's lab and activities that we already use or that we develop over the next few years. We expect to base many of the application activities on the taxonomy of activities and collection of examples that are developed as part of this research. Some of our activities and materials are proprietary and some of the activities that we develop based on this research will be proprietary. We will share the others with Dr. Kaner and grant permission for inclusion in the course.

We also normally provide face-to-face instruction over short time periods, such as three-day or five-day courses as part of Individual development plan for our testers. We are not sure how to present an intense short course that is based on the BBST material. This

project is an opportunity for us to try to develop a new structure that is more activity-based. We expect to benefit in this from the taxonomy of activities and organized collection of example activities that are to be developed as part of this research. It is our expectation that, as part of this NSF-funded project, Dr. Kaner will assist us, without further compensation, in thinking through several of the details of the new structure. We will report what we try, sharing our experiences and our activities, though we reserve the right to protect those of our activities and lectures that involve confidential information or are otherwise proprietary.

If it is necessary to enable him to understand what happened in our courses, we will also share proprietary materials with Dr. Kaner, but under a nondisclosure agreement that

allows him to publish an honest summary but one that omits proprietary details. We will draft the nondisclosure agreement when and if it is needed but we have agreed in principle that it will allow him to present such summary data as is needed to give the reader an honest appreciation of the instructional issues and results.

We understand that we will not be financially compensated for participation in this project. We are donating the significant labor that will be involved in the assessments and their analysis.

We do expect partial reimbursement for reasonable travel expenses for at least some of the times when we travel to meet with Dr. Kaner and other researchers to discuss our results and next steps. However, we understand that Dr. Kaner's budget will be limited and that his prioritization of funds for reimbursing travel expenses will favor individual instructors (academic professors and unincorporated individual consultants) over corporations.

We understand that Dr. Kaner is trying to develop an open source, free certification exam for software testers that would be based on the testing course and on other materials freely available on the Web. We believe that there is a significant need for a trustworthy certification of knowledge of the basic facts of testing and of the ability to apply the basic techniques of testing. We will decide on the extent to which we can assist with this work as we come to understand the details better how we could contribute. In principle, we believe that this is a worthy endeavor and that it should be supported.

We expect to publicize our work in this project. We understand that our publicity must give appropriate credit to the National Science Foundation, but we also expect that Dr. Kaner will help us write up descriptions of our work that would be published in channels our

customers are likely to read. We also expect that Dr. Kaner will cosign some or all of thes papers with our staff and that he will publicize our efforts in other ways, such a acknowledgements in publications or on his website(s).

Regards,

N. Geetha

Name: Geetha Narayanan, CSQA, PMP
Title: Manager, Technical Services
AppLabs Technologies
www.applabs.com
Date: 03/Jan/2007

Quardev
Laboratories

To: The National Science Foundation
Regarding: CCLI grant application by Cem Kaner
Date: January 8, 2007

This is a letter of support for Dr. Kaner's project.

My name is Jon Bach, Manager for Corporate Intellect and Technical Solutions at Quardev, Inc., a Seattle-based software quality assurance and testing company. We provide onshore outsourcing to compete with similar companies overseas – helping to keep jobs for software testers here in the United States. We are not cheaper, but that means we have to be better, and I am convinced that helping to develop Kaner's course will help us to provide value to our clients to justify the extra cost of keeping testing projects in the US.

I have reviewed the materials Dr. Kaner published up on http://www.testingeducation.org/BBST and teach testing classes internally here at Quardev to a staff of 40 local contractors. My teaching materials draw strongly upon my brother James Bach's work as well as Dr. Kaner's. Though I have not yet taught Kaner's BBST course myself, I have referred my staff directly to his videos and plan to use them as a basis for paced training. With respect to his proposal, I think Kaner's BBST materials would provide a great foundation for other classes I would like to create here at the lab to make us a competitive force for offshore outsourcing companies.

I would like to see more of this type of material available for remote training of my staff because a lot of our projects do not take place in the lab, but onsite at clients in the Seattle area. Delivering training to our onsite staff as well as those here in the lab is a key imperative for us.

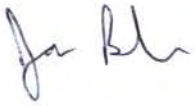
I have taken Dr. Kaner's BBST class and have given a guest lecture to his students at Florida Institute of Technology. It is my impression that the Black Box Software Testing class, as it is taught at Florida Tech, represents a wonderful achievement in tester training and I'm excited about its potential to reach many more testers who need to improve their skill through a balance of practice and theory.

This is the commitment I will make in the event that Dr. Kaner receives an NSF grant:

- I will help evaluate the BBST materials.
- I will provide feedback as to the course's efficacy in a commercial testing lab where clients don't give us much time to test their software.

- I will experiment how best to teach the course to a wide variety of testers who have different levels of expertise, background, and learning styles.

Thank you for your consideration,



Jon Bach
Manager for Corporate Intellect and Technical Solutions
Quardev, Inc.

LATVIJAS UNIVERSITĀTE
FIZIKAS UN MATEMĀTIKAS FAKULTĀTE
D A T O R I K A S N O D A Ļ A

Raiņa bulv.19, Rīga, LV-1586; fakss 7225039; tālr.7034490;

e-mail: Juris.Borzovs@lu.lv

Rīgā

09.01.2007 Nr. DN-46/2007

Uz _____ Nr._____

To: The National Science Foundation
Regarding: CCLI grant application by Cem Kaner
Date: January 5, 2007
From: Prof. Juris Borzovs

This letter indicates our support for the project proposed by Dr. Kaner.

I am a professor at the University of Latvia, Latvia. I teach software testing within Software Engineering course and serve as a supervising lecturer for software development courses module that includes, in particular, Software Testing I (undergraduate) and Software Testing II (master).

I have reviewed the instructional materials that Dr. Kaner has published at http://www.testingeducation.org/BBST. I use part of those materials in my course.

If the National Science Foundation awards funding to Dr. Kaner to extend these materials, we have agreed to collaborate in this project in the following ways:

- In the period 2007 to 2009, I will teach a course based on part of these materials at least twice;
- In each case, I will evaluate the course and the instruction at several levels:
    - At the start of the course, I will advise students in writing that this course is part of an international research project on the effectiveness of teaching software testing and that I intend to share their work products (such as exams and homework) and evaluations with other instructors after stripping their names and other information that could identify them or their company, and that we may publish research reports that quote briefly from their work products or their evaluations. I will advise students that they have the right to withhold their permission for us to use their data. I will not forward or make any use of permission-withheld work products. However, because the evaluations are submitted anonymously, if a student submits one, the research group will share it and use it. I will encourage all students, especially students who are dissatisfied with the course or who find it difficult, to allow us to include their work in our studies.

- I will collect student reactions to each instructional unit (a unit includes its associated activities)
- I will note my instructor reactions to each instructional unit as I teach the course
- I will collect detailed student evaluations at the end of the course using a questionnaire based on the Student Assessment of Learning Gains
- I will provide a detailed instructor evaluation at the end of the course, using a questionnaire that asks the instructor to reflect on how the instructional materials helped (or did not help) achieve my course objectives, and what changes to the materials could make the course more effective next time.
- A single course may involve several instructors, or an instructor and several teaching assistants. In this case, I will collect reactions from each instructor / TA to the instructional units they worked on, and I will collect end-of-course reflections from each of them, with the understanding that they may leave some parts of that questionnaire blank because they weren't sufficiently involved in it.
- I will ask students to allow us me contact them some time (perhaps six months or a year) after the end of the course for a reflection on the value of the course and the extent to which the lessons in this course helped them in later courses or other work.

We have not settled on the details of the questionnaires. I expect to develop questionnaires in collaboration with Dr. Kaner and perhaps with other companies or instructors who are working on this project. I agree that the questionnaire I actually use will be subject to Dr. Kaner's approval and I understand that one of his reasonable objectives is a degree of standardization across research sites.

I expect to use a mixture of activities developed by Dr. Kaner's lab and activities that I already use or that I develop over the next few years. I will share descriptions of the activities with Dr. Kaner and grant permission for their inclusion in the free courseware.

I understand that I will not be financially compensated for participation in this project. I am donating the significant labor that will be involved in the assessments and their analysis.

I expect reimbursement for reasonable travel expenses when I travel to meet with Dr. Kaner and other researchers to discuss our results and next steps. I understand that his travel budget will be limited and that it may not stretch to cover all of my expenses.

I understand that Dr. Kaner is trying to develop an open source, free certification exam for software testers that would be based on the testing course and on other materials freely available on the Web. I believe that there is a significant need for a trustworthy certification of knowledge of the basic facts of testing and of the ability to apply the basic techniques of testing. I will decide on the extent to which I can assist with this work as I come to understand the details better how I could contribute. In principle, I

believe that this is a worthy endeavor, that it might help some of my students get appropriate jobs, and that it should be supported.

Juris Borzovs

Microsoft Corporation
1065 La Avenida
Mountain View, CA 94043

Tel 650 693 4000
Fax 650 693 3329

Microsoft

To: The National Science Foundation
Regarding: CCLI grant application by Cem Kaner
Date: January 05, 2007
From: Marianne Guntow, Test Manager
MSTV, Microsoft Corporation

This letter is in support of a grant proposal from Dr. Cem Kaner on the topic of software testing education. I am a Test Manager in Microsoft TV (MSTV) at Microsoft Corporation. My organization, MSTV, employs approximately 90 testers at this time.

MSTV has had a difficult time finding and hiring qualified testers – as has Microsoft in general. We have a continuous need for a large number of skilled testers and are simply unable to find them. Many testers already working in the industry, often for many years, do not have rigorous training. Often their skill has been picked up "on the job" and is narrowly focused. Further, there is often a lack of understanding around the purpose of their activities, making it difficult for them to adapt to changing circumstances. On the other end of the spectrum, MSTV and other groups at Microsoft have also experimented with hiring individuals with no test experience with the expectation that we can teach intelligent individuals those skills. While the latter approach has been fruitful, it is also problematic.

Managers of these new testers often do not have a plan for how to impart the needed testing skills or, more often, the time needed to do so. While Microsoft has some excellent internal training programs, these are almost universally single time events. The yield of skills acquired for the time investment (usually 1-5 days) is relatively low. Many individuals report that they aren't able to absorb the information without time to integrate it with their current views or environment and without time to practice using it.

I believe Dr. Kaner's materials have the potential to aid us significantly in solving this problem. Both the experienced testers (with knowledge gaps) and those new to testing would benefit. Particularly important to me is Dr. Kaner's focus on providing a solid foundation that includes the motivations and reasons for important testing techniques in addition to specific techniques. I have found that ability to adapt to changing circumstances to be a critical skill for our testers. Without a foundation that includes the underlying motivations for the techniques, the techniques are applied blindly and fail in many circumstances. I and my team have used some of Dr. Kaner's other materials over several years – articles from his website and the books *Testing Computer Software* and *Lessons Learned in Software Testing*. These materials have been consistently preferred over others because of their practicality. Dr. Kaner understand how testing is done and needs to be done in the industry. His concrete examples and practical suggestions enable our testers to see the relevance of the material and help them understand how to apply the information to experiences they have daily.

If the National Science Foundation awards funding to Dr. Kaner to extend these materials, we have agreed to collaborate in this project in the following ways:

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Tel 650 693 4000
Fax 650 693 3329

Microsoft

- In the period 2007 to 2009, we will teach a course based on these materials at least three times
- In each case, we will evaluate the course and the instruction at several levels:
  - At the start of the course, we will advise the trainees in writing that we are part of an international research project on the effectiveness of teaching software testing and that we intend to share their work products (such as exams and homework) and evaluations with other instructors after stripping their names and other information that could identify them or their company, and that we may publish research reports that quote briefly from their work products or their evaluations. We will advise the trainees that they have the right to withhold their permission for us to use their data. We will not make any use of permission-withheld work products. We will encourage all trainees, especially those who are dissatisfied with the course or who find it difficult, to allow us to include their work in our studies.
  - We will collect trainee reactions to each instructional unit (a unit includes its associated activities)
  - We will collect instructor reactions to each instructional unit
  - We will collect detailed trainee evaluations at the end of the course using a questionnaire based on the trainee Assessment of Learning Gains
  - We will collect a detailed instructor evaluation at the end of the course, using a questionnaire that asks the instructor to reflect on how the instructional materials helped (or did not help) achieve her or his course objectives, and what changes to the materials could make the course more effective next time.
  - A single course may involve several instructors. For example, one member of our staff might instruct/coach trainees on issues involving a test design technique that she is particularly skilled with, while another staff member might be the resource for issues involving status measurement and reporting. In these cases, we will attempt to collect a retrospective evaluation from each instructor, but some instructors might have nothing to say about some of the learning units.
  - We will ask trainees and the instructor to allow us to contact them some time (perhaps six months) after the end of the course for feedback on the impact of the course on their work.

The evaluations I will use with the team will be based on information from Dr. Kaner. I will submit all the evaluation forms I use for this project to Dr. Kaner for his approval before they are distributed to the students. I understand that the forms I use may have to be adjusted to obtain consistency of evaluations across the different sites using his materials.

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Microsoft

If this proposed work is funded, I will submit my personal teaching materials to Dr. Kaner in case he might find them useful in developing his materials. If there are proprietary materials that I use in the course, I will share them with Dr. Kaner with the understanding that he may publish summaries of those materials, but not the materials themselves.

I agree that I will not be financially compensated for my participation in the project. I think the project is important, and his materials have already proved useful to us. Therefore I am donating my time and effort in evaluating the materials that will be produced for the proposed work. If Dr. Kaner finds it necessary to meet face-to-face with me in regards to this project, I hope that it will be possible to receive some reimbursement for travel expenses to meet with Dr. Kaner. However, I recognize that this may or may not be possible due to limitations of funding.

I understand that Dr. Kaner is trying to develop an open source, free certification exam for software testers that would be based on the testing course and on other materials freely available on the Web. I believe that there is a significant need for a trustworthy certification of knowledge of the basic facts of testing and of the ability to apply the basic techniques of testing. I will decide on the extent to which I can assist with this work as I come to understand the details better how I could contribute. In principle, I believe that this is a worthy endeavor, that it might help identify appropriate candidates who would be successful in our organization and the industry in general and that it should be supported. I have not seen any other certification program that I would be satisfied with in this area.

Sincerely,

Marianne Guntow, Test Manager
MSTV, Microsoft Corporation
http://www.microsoft.com/tv/

acclaro
Research Solutions, Inc.

January 9, 2007

To Whom It May Concern:

Acclaro Research Solutions, Inc. is an 8(a) certified, woman-owned small business that provides management consulting, and training design and development services. Acclaro is registered in the Central Contractor Registry and holds a GSA MOBIS schedule and is also available via 8(a) sole source contracts.

Many of our consultants have national and international reputations in their respective areas of expertise and have worked with government, private industry and not for profit organizations throughout the U.S. and around the world. Some areas of particular expertise include:

- Workforce Analysis and Task Analysis
- Program Design and Evaluation
- Training Needs Assessment, Training Design and Development
- Survey Research and Organizational Attitude Surveys
- Performance Measurement and Management Systems

Acclaro has served a number of federal Government agencies including: General Services Administration, Defense Logistic Agency, Office of Naval Research and Department of Interior.

Acclaro brings together the right team with the right experience and expertise to guarantee the success of your project. The Acclaro team aligns our goals with the goals of your organization to support your vision and strategy. We are committed to the success of our clients and to providing an efficacious and cost-effective solution.

If you have any questions please do not hesitate to contact me.

Regards,

Katherine Fiedler

Katherine Fiedler, Ph.D.
President

15316 Carroll Road, Monkton, MD 21111 phone: 410.472.1447 fax: 410.510.1746 email: info@acclaroresearch.com www.acclaroresearch.com

Chameleon is loading...

BBST Public Course 1.0 October 2006

SatisficeMoodle » BBST-0001

Turn editing on | Turn student view on

People
- Participants

Activities
- Assignments
- Forums
- Glossaries
- Quizzes
- Resources

Search Forums
>
Advanced search

Administration
- Turn editing on
- Settings
- Edit profile
- Facilitators
- Participants
- Groups
- Backup
- Restore
- Import
- Reset

Topic outline

Welcome to the Black Box Software Testing Course!

Use of this course is subject to agreement to the Satisfice acceptable use policy. Access to the material at this site is conditional--you may not use this site if you do not agree to the terms of this policy.

- Announcements
- Discussion forum
- Course syllabus
- Course glossary
- Notes on assessment (study guides; how instructors grade exams, etc..)

1 Overview for Instructors

- Video: Overview for Instructors [13:39]
- Slides: Overview for Instructors

2 Overview for Students

- Course orientation: Some norms, expectations and tips
- Video: Overview of the course [14:17]
- Slides: Overview of the course

3 Fundamental issues in Software Testing

- Section Notes: Fundamental Issues in Software Testing
- Quiz on the first lectures (up to oracles)
- Quiz on complete testing
- Submit the Oracles pretest
- Submit the Complete Testing pretest

Latest News

Add a new topic...

8 Oct, 02:22
Cem Kaner
Intellectual property rights
more...

8 Oct, 01:54
Cem Kaner
Greetings! more...

Older topics ...

Upcoming Events

There are no upcoming events

Go to calendar...
New Event...

Recent Activity

Activity since Tuesday, 9 January 2007, 11:24 PM
Full report of recent activity...

Nothing new since your last login

Reports
Questions
Scales
Grades
Files
Help
Teacher forum

My courses

BBST Instructor Course
BBST Public Course 1.0 October 2006
Michael Bolton's BBST site
Master
WOC
All courses...

4 Bug Advocacy
- Section Notes: Bug Advocacy
- Quiz on bug advocacy
- Submit the first half of your assignment (your analysis / rework of the first bug report)
- Submit the second part of your assignment.

5 Quality Cost Analysis
- Section Notes: Quality Cost Analysis
- Quiz on quality-related costs

6 Advanced Topics in Bug Advocacy
- Section notes: Advanced Topics in Bug Advocacy

7 Test Technique: Domain Testing
- Section Notes: Domain Testing 1 -- Introducing the approach
- Submit the domain testing _lab_ (in-class activity) here
- Submit the domain testing _assignment_ here

8 Technique: Domain testing (perspective)
- Section Notes: Domain Testing 2 -- Perspective
- Submit the Risk-Based Domain Testing Assignment Here

9 Test Technique: Scenario Testing
- Section Notes: Scenario Testing
- Submit Your Scenario Activity Notes Here
- Quiz on Scenario Testing

10 Test Technique: Function Testing
- Section Notes: Function Testing

11 Perspective: Test Design
- Section Notes: Test Design

Submit Your Test-Design Lab here
Submit Your Test-Design Assignment here

12 Test Technique: Risk-Based Testing
Section Notes: Risk-Based Testing
Submit your Risk-Based Testing Assignment here

13 Test Technique: Combination Testing
Section Notes: Combination testing
Submit your COMBINATIONS activity (lab) here

14 Test Technique: Specification-Based Testing
Section Notes: Specification-based Testing

15 Introduction to Regression Testing
Section Notes: Regression Testing

16 Scripted Testing
Section Notes: Scripted Testing

17 Exploratory Testing
Section Notes: Exploratory testing

18 Analyzing Requirements for Test Documentation
Section Notes: Analyzing Requirements for Test Documentation

19 Introduction to GUI Regression Testing
Section Notes: GUI Regression Automation

20 Analyzing Requirements for GUI Regression Automation
Section Notes: Analyzing Requirements for Regression Automation

21 Test Technique: High Volume Test Automation
Section Notes: High volume test automation

22 Measurement in Software Testing

Section Notes: Measurement in Software Testing

23 Perspective: The Context-Driven Approach to Testing

- Software Testing as a Social Science
- Context-Driven Testing
- The Ongoing Revolution in Software Testing

Section Notes: Perspectives on software testing

24 Patterns for Classroom Activities

Section Notes: Instructors' notes on patterns of activities / assignments

25 Instructor Resources for Assessment

Source documents for slide sets

Standalone extracts from lecture videos

Grading rubrics (including class participation and project work)

Study guides for essay exams

Moodle Docs for this page

You are logged in as Rebecca Fiedler (Logout)

Home

Fundamental Issues in Software Testing

Black box testing is the craft of testing a program from the external view. We look at how the program operates in its context, getting to know needs and reactions of the users, hardware and software platforms, and programs that communicate with it.

Testers who do primarily black box testing account for 20% to 60% of the technical staff on a typical software development project--there is an enormous market for skilled testers.

Testing is often misperceived as a fairly routine set of procedures for verifying that a program is correct (as if we could actually do that) or for finding bugs. In fact, skilled testing is a cognitively complex activity, as difficult and as creative as designing and writing code.

This opening section of the course looks at the variety of missions given to test groups and a few of the key problems that make testing so difficult and so interesting.

Reference Materials:

- **Videos**
  - Introducing the fundamental issues [5: 54] [SLIDES]
  - Mission and strategy of the testing effort [7:51] [SLIDES]
  - The oracle problem [19:07] [SLIDES]
  - The measurement problem and the impossibility of complete testing (Part 1) [29:37] [SLIDES (parts 1 & 2)]
  - The measurement problem and the impossibility of complete testing (Part 2) [26:44]

    [*On some browsers, clicking on a video link to play the video will not work. To play the video, download it to your disk and play the downloaded copy with Windows Media Player 9 or later.*]

- **Articles**
  - Hoffman: Heuristic test oracles
  - Hoffman: Exhausting your test options
  - Kaner: Impossibility of complete testing
  - Marick: How to misuse code coverage
  - Simmons: When will we be done testing? Software defect arrival modeling using the Weibull distribution
- **Some worked examples**
  - Examples of applications of oracles
  - Examples of computing the number of possible tests of a feature

    [*Note: these examples are early draft student projects. They are limited in scope and sometimes a bit rough. However, some students find them quite useful.*]

Activities and Assessments:

- Pre-test on oracles-- *Submit your answer to this on the main moodle screen*
- Pre-test on complete testing -- *Submit your answer to this on the main moodle screen*
- Review / drill questions -- *These are available from the main moodle screen*
- Activity: Contrasting strategies for testing the same program.
- Activity: Statement and path coverage of simple program fragments.

Summary of the Learning Unit

Software testing is an investigation conducted to provide quality-related information about a product. We test in many ways, looking for different types of information. We do the work on behalf of stakeholders (such as project managers) who need the information to improve the product or to make some decision such as whether to release the program for use or to sue the company that made the program for its provable defects.

We open our discussion of testing with a quick look at four key challenges:

1. One of the fundamental challenges in software testing is figuring out what your testing objectives are at a given time, and deciding what to do to achieve them. The manager of a single project may have different objectives for the testing of that project at different times. Your testing strategy--your overall plan for achieving your objectives--will depend on your objectives. We will study several testing techniques in the course. Different techniques are more useful for some objectives than others.
2. Another fundamental challenge in software testing is figuring out how to determine whether the program has passed or failed a given test. This is more complex than it looks, and our comparisons will inevitably involve a subset of the possible comparisons that we could make between the ideal behavior of the product under test and its actual behavior. The oracle problem is fundamental to our ability to do automated testing (and meaningfully interpret the results).
3. The third challenge is the impossibility of complete testing. It's impossible to fully test a program. There are too many inputs, too many combinations, too many paths, too many places where too many types of interrupts can impact the execution of hte program, too many ways the program can be used, and too many interesting ways the program can fail. In the face of an infinitely large testing task, we have to treat with skepticism the statements that some people make that the testing project must *always* do this or *always* deliver that. In the face of an infinitely large task, everything is a tradeoff--work spent on one task is work not allocated to another. The proper allocation of resources to tasks and deliverables has to be a function of the information objectives of the project at hand.
4. Finally, we have the challenge of measuring how much testing you have completed and how much you have left. Several metrics appear to check how close we are to completeness of testing, and thereby define testing completeness. Coverage measures are an example; so are defect arrival rate probability models. If "complete testing" means that there are no remaining unknown bugs, then these approaches cannot measure completeness of testing. Instead, they must mean, complete according to some artificial criterion. There are predictable risks of using these metrics. (For example, you are likely to miss the long-sequence bugs that show up after extended use of a program, like the telephone stack example in the lecture. Many of the bugs that programmers think are "irreproducible" --the ones that are mysteries to the tech support staff when you call to report a failure-- are long-sequence bugs.) People who rely on them often distort how the project is run, in ways that often yield worse testing. Coverage measurement has value, but not as an indicator of how *close* we are to completion of testing.

PerfTestPlus, Inc.
1285 Douglas St.
Palm Bay, FL 32909

To: The National Science Foundation
Regarding: CCLI grant application by Cem Kaner
Date: January 9, 2007
From:

This letter indicates our support for the project proposed by Dr. Kaner.

PerfTestPlus, Inc. is a small expertise-based consulting company specializing in providing professional software testing services and training software testers. More information is available on our website at http://www.perftestplus.com.

We have reviewed the instructional materials that Dr. Kaner has published at http://www.testingeducation.org/BBST and it is our professional opinion that these materials are, hands down, the best available pre-packaged, general software testing educational material when used as intended – pay or free. PerfTestPlus is very excited about working with Dr. Kaner to evaluate the effectiveness of various delivery models for this course as well as assisting or enabling additional courses to be developed.

To that end, PerfTestPlus has actively supported this effort since Fall of 2005 by reviewing course materials; participating in the blind re-grading of exams for comparative analysis; facilitating and participating in Kaner's workshops dedicated to the improvement of instructional materials and methods for software testing; and contributing to training materials for practitioner instructors. Additionally, I have enrolled in the first "train the trainer" version of the course slated to begin in mid-January. Each of these activities has been conducted without monetary compensation.

If the National Science Foundation awards funding to Dr. Kaner to extend these materials, we have agreed to collaborate in this project in the following ways as described in a separate Letter of Agreement:

- In the period 2007 to 2009, we will teach a course based on these materials at least three times
- In each case, we will evaluate the course and the instruction at several levels:
    - At the start of the course, we will advise students in writing that we are part of an international research project on the effectiveness of teaching software testing and that we intend to share their work products (such as exams and homework) and evaluations with other instructors after stripping their names and other information that could identify them or their company, and that we may publish research reports that quote briefly from their work products or their evaluations. We will advise students that they have the right to withhold their permission for us to use their data. We will not make any use of permission-withheld work

products. We will encourage all students, especially students who are dissatisfied with the course or who find it difficult, to allow us to include their work in our studies.

- We will collect student reactions to each instructional unit (a unit includes its associated activities)
- We will collect instructor reactions to each instructional unit
- We will collect detailed student evaluations at the end of the course using a questionnaire based on the Student Assessment of Learning Gains
- We will collect a detailed instructor evaluation at the end of the course, using a questionnaire that asks the instructor to reflect on how the instructional materials helped (or did not help) achieve her or his course objectives, and what changes to the materials could make the course more effective next time.
- A single course may involve several instructors. For example, one member of our staff might instruct/coach students on issues involving a test design technique that she is particularly skilled with, while another staff member might be the resource for issues involving status measurement and reporting. In these cases, we will attempt to collect a retrospective evaluation from each instructor, but some instructors might have nothing to say about some of the learning units.
- We will ask students and the instructor to allow us to contact them some time (perhaps six months) after the end of the course for feedback on the impact of the course on their work.

We have not settled on the details of the questionnaires. We expect to develop questionnaires in collaboration with Dr. Kaner and perhaps with other companies or instructors who are working on this project. We agree that the questionnaire we actually use will be subject to Dr. Kaner's approval and we understand that one of his reasonable objectives is a degree of standardization across research sites.

PerfTestPlus is currently exploring several models for delivering the course to corporate clients. Over the course of this project we anticipate that we will be able to deliver the course 3 times using each of the two models below, for a total of 6 courses. We are not excluding the possibility of trying other models as well, but we are ready to commit to making every reasonable attempt to offer each of the models below at least yearly during this project.

- **Facilitated On-Line Model** – In this model, students will be placed into groups of approximately 20 and assigned to a "Name Brand" facilitator to form an online classroom. The students will proceed through the class on their own time, but have due dates to turn in certain assignments that must be completed for a course completion certificate to be issued. The facilitator will review assignments and answer questions asynchronously throughout the week and will schedule at least 1 hour a week to answer questions and discuss course materials with the class as a whole in a live, online, chat setting.

- **Facilitated On-Line Plus Model** – This model is virtually identical to the Facilitated On-Line Model, except the students and the facilitator will meet face-to-face for workshops on the course material, once at the start of the course, once at the end of the course and approximately monthly during the course. These workshops will include time for student questions and comments; instructor-led and individual exercises; and time for students to share their experiences implementing the course materials in their workplace. During all of these exercises, students will be encouraged to work together and to provide constructive, professional critiques of one another's material.

PerfTestPlus has further agreed to the following:

- If it is necessary to enable him to understand what happened in our courses, we will also share proprietary materials with Dr. Kaner under a nondisclosure agreement that allows him to publish an honest summary but one that omits proprietary details. We will draft the nondisclosure agreement when and if it is needed but we have agreed in principle that it will allow him to present such summary data as is needed to give the reader an honest appreciation of the instructional issues and results.

- We understand that we will not be financially compensated for participation in this project. We are donating the significant labor that will be involved in the assessments and their analysis.

- We do expect partial reimbursement for reasonable travel expenses for at least some of the times when we travel to meet with Dr. Kaner and other researchers to discuss our results and next steps. However, we understand that Dr. Kaner's budget will be limited and that his prioritization of funds for reimbursing travel expenses will favor individual instructors (academic professors and unincorporated individual consultants) over corporations.

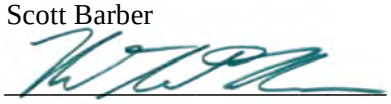
- We understand that Dr. Kaner is trying to develop an open source, free certification exam for software testers that would be based on the testing course and on other materials freely available on the Web. We believe that there is a significant need for a trustworthy certification of knowledge of the basic facts of testing and of the ability to apply the basic techniques of testing. We will decide on the extent to which we can assist with this work as we come to understand the details better how we could contribute. In principle, we believe that this is a worthy endeavor and that it should be supported.

- We expect to publicize our work in this project. We understand that our publicity must give appropriate credit to the National Science Foundation, but we also expect that Dr. Kaner will help us write up descriptions of our work that would be published in channels our customers are likely to read. We also expect that Dr. Kaner will cosign some or all of these papers with our staff and that he will

publicize our efforts in other ways, such as acknowledgements in publications or on his website(s).

PERFTESTPLUS, INC.

By: R. Scott Barber

Signed: 

Title: President and Chief Technology Officer

Date: 1/9/2007