**Context Statement**

NATIONAL SCIENCE FOUNDATION

Division of Computer and Network Systems
CISE Directorate

General Information for Applicants Computing Education for the 21st Century Competition

118 proposals were submitted to CISE's Computing Education for the 21st Century (CE21) competition. There were 89 unique projects (29 were collaborative proposals with multiple sites). Five projects were returned without review. The review panels, which met in June and July of August of 2011, had experts on relevant topics, including K-12 formal and informal education, community colleges, educational support for minorities, social science and evaluation, education research, computer science, computer science education, and each of the targeted underrepresented groups. There were 42 panelists. They placed 29 proposals in the Not Competitive category, 28 in Low Competitive, 20 in Competitive, and 5 in Highly Competitive category. We will fund 8-10 of these projects.

The panel that reviewed this proposal based its evaluation on three review criteria: intellectual merit, broader impacts, and broadening participation. This last of these was specific to the CE21 Solicitation; proposals that did not adequately address broadening participation were not recommended for funding. The panels also considered the relevance of the proposed activities to the CE21 program objectives and goals, and its many requirements.

The recommendation of the panel was based on substantive comments from both individual reviews and a collective assessment of the proposal by the panel.

Copies of all completed reviews of the proposals are available in FastLane. In reading them, please keep in mind that the reviewers are addressing their comments primarily to NSF, not to the principal investigator. Also keep in mind that though many reviewers do provide helpful information, they sometimes make remarks without giving detailed references or providing specific suggestions for improvement.

Decisions about particular proposals are often very difficult, and factors other than the reviewers' comments and ratings enter into the decision. The overall merit of the proposed activities, the qualifications of the principal investigator(s), and the broader impact of the proposed activities are critical considerations for all proposals. Maintaining appropriate balance of types of activities and targeted populations across the entire competition and the portfolio funded under CISE education and workforce activities, availability of other funding, and the geographic distribution of work supported by the Foundation, as well as the total amount of funds available to the program, are also important decision factors.

Information about reconsideration of declined proposals is found in NSF's Grant Policy Manual, which should be available at your institution, usually at the office that formally submitted your proposal. It is also available on the web at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag081&org=NSF. You may also contact the Program Officer directly with questions.

**Comments from the cognizant Program Officer:**

The panel was enthusiastically positive about this proposal: it was their favorite proposal by far (the only one they put in Highly Competitive), and it was the only proposal they saw that successfully integrated all three required aspects of the very complicated solicitation. They found the PIs claim that their teacher training efforts would have a significant impact on the number and diversity of students in computing (at least within Georgia) to be compelling. The panel liked that the project created materials for teacher training and involved teachers in the effort to ensure an engaging and appropriate product. They -- especially the teachers on the panel -- appreciated that that the PIs acknowledged the demands on teachers.

The panel liked that the effort expanded on proven methods (worked examples, cognitive tutoring, multiple modalities, supportive communications, etc.), potentially using them in a more robust manner. They agreed that the online components made the project scalable. They liked the research questions posed and agreed
that there was a strong plan with methodologies, instruments, and analysis all specified. They believed that the proposal had the potential to establish new best practices in teacher training.

The panel agreed that the Principal Investigators are well poised to carry out the research.

Project Goals and Outcomes: Clearly defined and appropriate.

Implementation Plan: Detailed and appropriate.

Evaluation Plan: Existing research informs the questions that will guide this inquiry; questions, outcomes, and proposed methods/assessments are closely aligned and have the potential to lead to efficient and economical alternatives to use of cognitive tutors.

Partnership Plan: There is a very solid plan for partnerships in this project. It is especially important to note the involvement of the educational psychologists, as that is a big piece of this project. It is also noteworthy that the PI and CoPI already have numerous contacts and relationships within the education community in Georgia.

Data Management Plan: The data management plan is appropriate.

Reviewers Ratings: E, V, E, E, and V.

Panel Recommendation: The panel found no notable weaknesses in this proposal and rated it as Highly Competitive.

Panel Summary #1

Proposal Number: 1138378

Panel Summary:

Summary of Proposed Work: The proposed project would use educational psychology practices combined with the realization that students have learned to write code without learning design, implementation or debugging practices to create an examples + practices methodology for training teachers in computer science.

Intellectual Merit: The proposed activities reflect compelling and current research related to instructional design and educational psychology that have yet to be tested in the field of computer science. Existing research informs questions that will guide this inquiry; questions, outcomes, and proposed methods/assessments are closely aligned and have the potential to lead to efficient and economical alternatives through the use of cognitive tutors and evidence related to the promise of using (this) new approach not yet tested for use to teach teachers.

Broader Impacts: The proposed project will develop techniques that can be used by other teachers or CS students. It also will establish models and design guidelines that can be used for the creation of other learning materials. Because the proposed activity focuses on teachers, it can potentially have broad impact by demonstrating strategies for bringing new CS teachers online. Published design guidelines for creating effective distance learning materials for CS will be a great resource for broader acceptance. The Language Independent Assessments planned for this project enable use in a variety of situations, enabling a broader exportability. The multiple modalities for feedback also have great potential for impact. Once the course delivery is flushed out, it can easily be transferred to additional CS courses, such as the new AP
course in the works.

Broadening Participation: The proposed project has the ability to reach an extremely broad audience due to its distance learning format. Further, the partnerships with majority-minority high schools helps to ensure that underrepresented populations in computing will be reached through this project.

Required CE21 components:
- The Principal Investigators are well poised to carry out the research that could establish new best practices for distance learning for teachers, particularly in computer science.
- The research questions are well aligned for this project.
- There is a very solid plan for partnerships in this project. It is especially important to note the involvement of the educational psychologists, as that is a big piece of this project.
- Proven methods (cognitive tutor) are being expanded upon and brought to use in a more robust manner for this project.
- A major component of this project is the teacher training. Not only does this project create materials for teacher training but the researchers acknowledge the demands on teachers and engage them in helping to make an appropriate and engaging product.
- This project is poised well to determine if teachers can learn well by working online.
- Due to the online nature of this project for teacher training, it is fairly scalable.

General Comments:
The dashboard has the potential to provide teachers and students with feedback and is a very powerful design feature. The mixed-modalities for feedback (audio and visual) will be helpful to learners.

After careful consideration, the panel ranked this proposal as Highly Competitive. The summary was read to the panel and the panel agreed that it accurately reflects the panel discussion.

**Panel Recommendation:** Highly Competitive

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**Review #1**

**Proposal Number:** 1138378  
**NSF Program:** Computing Education for the 21st Century (CE21)  
**Principal Investigator:** Guzdial, Mark  
**Proposal Title:** Type 1: Using Instructional Design Techniques to Create Distance CS Education to Support In-Service Teachers  
**Rating:** Very Good
**REVIEW:**

What is the intellectual merit of the proposed activity?

The project proposes to use worked examples with practice informed by instructional design principles to produce materials for in-service teachers for use in learning computer science. The example presentations will be informed by the modality principle of multimedia design. The content of examples and practice will be informed by a structure-behavior-function model of knowledge. The structure and order of examples and practice will be informed by cognitive tutors research. The team will be developing new best practices in computing education especially for distance learning and self-study.

What are the broader impacts of the proposed activity?

This project intends to develop and test new pedagogies for training teachers in CS in a distance learning environment. It aims to test the effectiveness of examples + practice and worked examples, among other methods. A key is combining worked examples with cognitive tutors. The intended broader impact is to develop effective ways for in-service training to reach CS10K goals.

**Summary Statement**

This proposal aims to help reach the CS10K goal of 10,000 CS teachers ready to teach AP CS courses in high school. It aims to use worked example, multimedia modality principles, cognitive tutor, and a number of other research-tested methodologies to approach the problem of needing in-service rather than pre-service training. The working hypothesis of the proposal is that the CS10K goal cannot be met by pre-service training. Rather, only in-service training of current teachers can hope to offer a chance of reaching the goal. This makes sense, given the obstacles of attracting new teachers to the field, while offering AP CS opportunities to current teachers û math and otherwise û who would be attracted to extending their capabilities and making themselves valuable in their current position.

A stated goal is broadening the opportunities for minority participation by reaching out to underserved communities in Georgia. This reach is going to be assisted by their partnership with Disciplinary Commons in Computing Education, which will help reach teachers not yet involved with ICE@GT.

If successful in fashioning new pedagogies for in-service training in CS, this project might add to the research base of effective strategies for streamlining in-service training in CS. Its methods might also be used in other related subjects. The team will be partnering with Georgia Computes!, a program at Georgia Tech. A possible outcome would be new strategies and interventions in in-service teaching of current teachers of math.

A possible weakness is that the project is too broad, i.e. too many methodologies are tackled at once. Perhaps a unifying principle might overcome that.

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**Review #2**

**Proposal Number:** 1138378  
**NSF Program:** Computing Education for the 21st Century (CE21)  
**Principal Investigator:** Guzdial, Mark  
**Proposal Title:** Type 1: Using Instructional Design Techniques to Create Distance CS Education to Support In-Service Teachers
**REVIEW:**

What is the intellectual merit of the proposed activity?

The proposed project will be using multimedia and a combination of methods to help train teachers to teach computing through distance learning modalities.

What are the broader impacts of the proposed activity?

Since the mode of learning is distance learning, the teaching materials created should be able to reach a broad audience of teachers. Further, there is a mechanism for transferring the method of instruction to students down the road, which is very attractive.

Summary Statement

The proposed project will contribute to the research base of effective teaching and learning (by teachers) of computing. The project is forging partnerships amongst teacher organizations, but there is no guarantee that the results of the project will trickle down to the K-14 students. New instructional materials are being created for this project (enhanced from prior projects) that do have a TREMENDOUS opportunity for reaching a large audience of teachers. The online model provides teachers with great flexibility to do the coursework, but they must be motivated, or it is easy to forget about online coursework. This new model for teacher training should enhance teaching expertise on computing education. This project should scale well, since it is online.

Review #3

**Proposal Number:** 1138378  
**NSF Program:** Computing Education for the 21st Century (CE21)  
**Principal Investigator:** Guzdial, Mark  
**Proposal Title:** Type 1: Using Instructional Design Techniques to Create Distance CS Education to Support In-Service Teachers  
**Rating:** Excellent
REVIEW:

What is the intellectual merit of the proposed activity?

Authors are well qualified to carry out the research. The PI has been awarded five grants by NSF. All the grants are focused on enhancing CS teaching to various populations including teachers and minorities.

The proposed work will develop new best practices in computing education especially for distance learning and self-study.

What are the broader impacts of the proposed activity?

Techniques developed could be used by other high-school teachers or CS students. The evaluation of the instructional design principles applied in local high-schools will inform the computing education research community of their impact and applicability nationwide. The goal is for the project to become a model that can be used anywhere since it is distance-based.

Broadening Participation: The population targeted in this project is mostly high-school teachers of under-represented groups teaching in ‘majority-minority’ schools who have been taking workshops through ‘Georgia Computes’. This is a project funded by NSF under the BPC initiative. The data presented clearly shows that the PIs know their population and how to address the potential challenges and concerns that could arise during the development of the research project.

Summary Statement

The work proposed is to use instructional design and educational psychology research findings to develop improved CS teaching materials for CS concepts and programming. Teach more effectively CS concepts that do not require programming, and make programming activity more efficient. Efforts focused on high school teachers learning CS.

Novel approach to teach CS based on research-driven examples+practice. Approach will be evaluated against the following measures: 1.) Do teachers learn CS using this model of examples plus practice? 2) Do teachers become more efficient at programming tasks after using this model? 3. How to apply and adapt instructional design practices for CS using a design-based research approach? Outcome: guidelines on creating effective distance materials for CS based on instructional design and educational psychology literature.

Contributions: language independent assessment for CS concepts, application of the structure-behavior-function model of knowledge, use of mixed modality and skillmeters.

Extend partnerships across Georgia through the Disciplinary Commons in Computing Education (DCCE) effort and the Georgia chapter of Computer Science Teachers Association (CSTA). Other collaborators: Dr. Wayne Summers at Columbus State University, Dr. Tiffany Barnes of U. North Carolina at Charlotte and Dr. Beth Simon of the University of California at San Diego.

Design-based research model focus on five key design areas: worked examples, practice, SBF, use of mixed modality, and awareness via skillmeters. During each design iteration the model will be evaluated with two teachers using the materials developed to see how they are being used. Factors to be evaluated are the following: satisfaction, quality of materials, and learning effectiveness. Finally, surveys will be conducted will all participants to measure these factors.

Review #4
**REVIEW:**

What is the intellectual merit of the proposed activity?

The proposed activities reflect compelling and current research related to instructional design and educational psychology that have yet to be tested in the field of computer science. Existing research informs questions that will guide this inquiry; questions, outcomes, and proposed methods/assessments are closely aligned and have the potential to lead to efficient and economical alternatives to use of cognitive tutors and evidence related to the promise of using (this) new approach not yet tested for use to teach teachers.

What are the broader impacts of the proposed activity?

The proposed project will generate published guidelines that can be used to design effective instructional materials and supports for other content domains, for use to support informal and online learning. Furthermore, the creation and use of the teacher dashboard seamlessly integrates implementation and assessment with potential to enhance teaching effectiveness given its suitability as a structure for accessing real-time formative assessment data. Leveraging use of existing instruments, the proposed project has a high likelihood of developing language independent assessments of computer science concepts which have potential for broad application.

**Summary Statement**

The PI has a long track record of success and scholarship in this area and has well-established alliances and support from key stakeholders as well as experts in the areas upon which the proposal is based. The rationale for the project is grounded in recent/relevant research; project goals are clearly stated and are aligned with proposed outcomes and assessments. The project is situated within a context likely to broaden participation by ethnic minorities and acknowledges the practical demands on in-service teachers while at the same time engaging teachers as key informants in the cycle for innovation and learning described in the solicitation.
REVIEW:

What is the intellectual merit of the proposed activity?

Development of materials that in-service teachers can use to learn CS. Will incorporate distance learning and self-study.

What are the broader impacts of the proposed activity?

Techniques developed can be used by other teachers or CS students. Also will establish models and design guidelines that can be used for the creation of other learning materials. Because the proposed activity focuses on teachers, can potentially have broad impact by demonstrating strategies for bringing new CS teachers online. Published design guidelines for creating effective distance learning materials for CS.

Summary Statement

Development of improved CS teaching materials in order to better teach CS concepts that don't require programming, and improve programming activities. Will focus on high school teachers. Direct connection to CS10K goal of increasing number of qualified CS high school teachers. Based on education paradigms that have not been applied to CS. Will be useful to know if they work, and whether they work for teachers, who are basically a different kind of student.

Hypothesis: ideas from instructional design and educational psychology have not yet been tried in computing education (this is more of an assertion than a hypothesis). I think it's fair to say the PIs hypothesize that new materials that build on instructional design and educational psychology will improve educational practice.

Broadening Participation: The PIs have good understanding of the demographics of Georgia based on their prior work in the state. Even more important, they are aware of the flow from Georgia high schools into Georgia public universities, and the demographics of that student body. They make a clear argument that reaching high school teachers in Georgia will have significant impact on the women and minorities in the student body. The proposed project addresses the demographics of both the teacher community and the student population.

Are those issues of underrepresentation adequately addressed in the proposed work?
Is the project likely to be successful for the diverse population that it is designed to serve?

Yes, because it will engage many teachers from majority-minority schools, who should in turn have significant impact on their students.

Required CE21 components:

The evaluation of the proposed activities will contribute to an understanding of how to teach teachers, and whether the same approach can be used for students.

Draw on partnerships among the computing and teaching and learning communities, institutions of learning, including primary, secondary and post-secondary institutions and organization, and other stakeholders.

Yes, since it heavily involves high school teachers.

Design, develop and study the effectiveness of new instructional materials and interventions

Application of learning/teaching approaches that have not been applied before in CS. Specifically application of instructional design and educational psychology to CS education in the form of worked examples; structure, behavior, and functions; multiple modalities; supporting communications when distance learning is used.

Study and evaluate each of these new methods for efficacy.

Design, develop and evaluate the impact of pre-service and in-service efforts and strategies that enhance K-14 teaching expertise in computing.

Because the project is focused on teaching teachers, it directly addresses this CE-21 goal. If successful, it will highlight an approach that can be used nationwide to help develop new CS teachers at the high school level.

Evaluation Plan

Measure learning outcomes of CS content, satisfaction with instructional media, efficiency during programming for assignments. Will provide the community with information about the impact of applying instructional design principles to computing education. Will evaluate whether teachers actually learn CS, whether they become more efficient at programming, and whether the instructional design practices are adequately applied and adapted to CS.

Partnership Plan

Tried and true team of Guzdial and Ericson, supplemented with research scientist, and an advisory board that brings educational psychology and education model knowledge. Also has connection to people who have been offering the CS Principles course so that the new materials can be developed in a way that matches the requirements of the CS Principles course.

General Comments

This is a strong proposal that addresses the broadening participation goals, as well as the required and additional components of the CS-21 solicitation.