

Early-Stage Research on Instruction With the TI-Nspire Handheld

Request for Proposals

Phase I proposals accepted beginning May 1, 2007 for studies in Fall, 2007

Phase II proposals accepted beginning October 1, 2007 for studies in 2008.

TI-*nspire*TM

Overview

In Fall, 2007, Texas Instruments (TI) will ship a new handheld device, called TI-Nspire™. The device goes well beyond the vision of existing graphing calculators, and defines the next generation handheld device for teaching in mathematics and science. TI-Nspire includes a document-centric architecture, the ability to provide simultaneous multiple linked representations, and a display far superior to graphing calculators in size and resolution. Alphanumeric and symbolic algebra input and display (including Cabri Jr. geometry, statistics and optionally CAS algebra), click-and-drag interface, interchangeable keyboards, increased computing power, RAM and classroom networking capabilities qualify the device as a handheld computer optimized for science, technology, mathematics and engineering (STEM) education with applicability to a range of instructional modes. At the same time, the reliability, ease of management, low price and long battery life provide an economical alternative for schools seeking to achieve the benefits of 1:1 computing but at lower total cost of ownership.¹

TI seeks to fund a limited number of researchers who are prepared to advance the state of the art in instruction for STEM education at the secondary (grades 7-12) level through innovative use of TI-Nspire with or without classroom networking. In Phase I, beginning in Fall, 2007, TI seeks to fund short, small-scale seed grants to familiarize research teams with the device, in the context of unit- or lesson-sized trials of instructional effectiveness that may use available sample curriculum materials, or materials adapted by the researchers from other sources. In Phase II, beginning in 2008, TI will fund larger controlled studies of the effectiveness of existing curricula that use the device, as well as studies that involve development and validation of prototype instructional units featuring innovative instructional models for secondary school STEM education, using the device with or without classroom networking. In the past, successful TI-funded projects of this scope have laid the groundwork for larger-scale R&D and evaluation projects funded by third-party governmental and other entities. We hope to continue this precedent.

Proposals will be evaluated based on:

- Likelihood of influencing use of TI-Nspire for teaching and assessment of secondary-level science and mathematics (STEM), world-wide.
- Degree of exploitation of the advantages of TI-Nspire (with or without classroom networking using TI-Navigator™).
- Degree of advancement of the cumulative global knowledge base on teaching mathematics and science with handheld devices including graphing calculators and classroom networks.

¹ More information on TI-Nspire is available at www.TI-Nspire.com

- Methodological soundness and appropriateness of the study design (with preference given to experimental and quasi-experimental designs in Phase II).
- Feasibility of the project plan and budget.
- Capabilities of the research team to execute the proposed study.
- Ability of the researchers to leverage their work to pursue opportunities for larger studies funded by government, foundation and other entities.

Direct costs of phase I projects are expected to be under \$5,000. Phase II projects are expected to be in the range of \$60,000 to \$100,000. In both cases, however, an exceptional proposal may merit a larger grant. In addition, TI will loan individual devices, classroom sets, and networks at no charge for accepted projects. A researcher discount is available for purchase of small quantities of devices, if desired. TI will also provide self-instructional training and phone support for the devices at no charge (in-person training and support is also available for a service fee). In addition, TI will invite its publisher partners to provide their instructional materials to projects as appropriate, at no charge.

Background Discussion

Issues for an Early-Stage Research Agenda for TI-Nspire™

Goal

TI-Nspire represents not only a new generation of graphing calculator technology, but also an advance in the capabilities of a low-cost personal computing device that is reliable and easy-to-use, and inexpensive for schools to manage. It is designed to support a broad range of instructional models and advanced modes of assessment for teaching mathematics and science. It enters the market at a time when the role and value of graphing calculators in mathematics teaching and assessment has been researched and is fairly well understood, and the potential of linking graphing calculators in a classroom network is showing considerable promise^{2,3}.

New research projects should not replicate on TI-Nspire the previous research on mathematics education, graphing calculator or classroom networking. Instead, the goal of early-stage research using TI-Nspire should be to build cumulatively on our existing understanding of teaching secondary mathematics with graphing calculators, by concentrating on instruction and assessment that exploit the advances in the state of the art offered by TI-Nspire as a stand-alone tool. Later research (in Phase II and beyond) then can add TI-Navigator classroom networking to the research agenda and concentrate on developing instructional models. Thus, using this combined technology platform, the early-stage research goal in Phases I, II and beyond should be to develop and validate a full range of models for instruction and their components, such as models of student learning, the structure of instructional materials and learning environments, support for struggling students, models of assessment and instructional management, models for professional development, and the like. The subject matter should be drawn from secondary science and mathematics curricula as defined by state and national curriculum standards.

Of particular research interest are two new capabilities of TI-Nspire: document-based content and the ability to display multiple representations that are dynamically connected and in a single plane. The document-based content system is an organized presentation of multiple screens of mathematics and text that can be saved, shared, annotated, and revisited. The multiple representation capability dynamically links graphical curves, axes,

² Research reviews and meta-analyses are available from <http://education.ti.com/research>.

³ In the spirit of open content, a master bibliographic data base of research on teaching with graphing calculators and classroom networks is in development, as a resource for the research community. The first version of the data base (using EndNote) is expected to be available to interested researchers in late 2007 on request to Dr. Foshay.

equations and tables in simultaneous displays, such that a change in one representation is carried through to the others.⁴

At this early stage, we believe the cumulative goal of research should be to develop and/or validate instructional models which exploit the advanced capabilities of TI-Nspire in unique and innovative ways, using the full range of instructional strategies (such as guided inquiry, modeling and simulation, direct instruction, etc.). The research should examine the innovations against the criteria of improved achievement and faster mastery. Any lesson using technology can be thought of as having three content “layers: a “tool” layer (operating the technology), a “procedure” layer (emphasizing low-level procedures and declarative knowledge), and a “deep understanding” layer (emphasizing context, connections and strategies). It is our hope that the design of TI-Nspire makes it possible (and more likely) to spend more time on the highest layer of content.

It is equally important to examine the impact on teachers and students’ thinking about math (and, in future work, science) content, teaching/learning processes, and personal confidence/motivation. Available research shows that teacher understanding of math or science content, beliefs about learning and instruction, and confidence in new teaching techniques, all play a vital role in influencing what students actually learn and how they feel about their learning ability and about math or science in general. Add to these multiple layers of pedagogical learning the imperative to master the technologies of TI-Nspire and TI-Navigator, and a research focus on patterns and strategies for professional development becomes particularly important.

Some Examples of Potential Early Research Issues

Following are examples of early TI-Nspire issues that may bear examination through research. The list is not meant to be exhaustive, nor does it necessarily imply the funding priorities of TI or other agencies. It is only meant to exemplify a few of the state-of-the-art research issues relevant to our current understanding of TI-Nspire. Researchers are encouraged to suggest other issues for research.

1) *Instructional Models*. An instructional model is at its base an instructional strategy for teaching a particular knowledge type, or combination of knowledge types, operationalized as one or more activities for teaching, learning and assessment, which are appropriate for a particular context and student type. Among the critical features of instructional models are techniques for presentation, questioning or other activities and feedback, all in a defined sequence. Unfortunately, there is no commonly-recognized taxonomy of these models⁵. We are hoping that over time, the models we define and research will become a common frame of reference for the community of practice surrounding TI-Nspire.⁶ By developing a common framework of instructional models, we will better be able to build knowledge cumulatively and facilitate the dialog among researchers and teachers. Over time, we hope that these models will stimulate the user community and content developers to develop TI-Nspire documents and associated activities that teach and

⁴ The research basis underlying these capabilities is discussed in a review paper by SRI International, available at http://www.ti-nspire.com/tools/nspire/resources/tinspire_research.pdf

⁵ For a promising framework, see Merrill, M. D. (2006). First principles of instruction: a synthesis. In R. A. Reiser and J. V. Dempsey (Eds.) Trends and Issues in Instructional Design and Technology. Columbus: Ohio, Merrill Prentice Hall. Download from <http://cito.byuh.edu/merrill/text/papers/Reiser%20First%20Principles%20Synthesis%201st%20Revision.pdf>

⁶ TI is defining a framework of instructional models which takes into account knowledge types and cognitive demand. The framework embraces direct instruction, modeling and simulation, and guided inquiry, and includes principles for differentiated instruction. Researchers may choose to situate their work within this framework, or use other alternatives. Working papers on the TI-Nspire instructional activity framework will be available to researchers on request to Dr. Foshay as they are developed.

assess contextualized and "higher-order" understanding and problem solving in new, more powerful ways than is possible with current platforms.

2) *Content Creation.* A large issue centers on the degree to which teachers and students will be able to use TI-Nspire capabilities to create or customize their own content as part of the teaching/learning process. As we understand the abilities, time and processes here, we are hoping it will be possible to provide support/scaffolding via templated TI-Nspire documents and/or other learning objects. It may be that there is a simple-to-complex progression of content creation tasks, which depends on the skill level and instructional intent of the teacher as well as the students.

3) *Scaffolding the teacher as well as the student.* We need to understand how TI-Nspire can be used as an affordance for scaffolding the math understanding and teaching skills of the teacher. Our early studies of TI-Navigator suggests that it is a powerful affordance for stimulating high-quality classroom discussion and teaching, but the "learning curve" for these techniques typically spans many semesters. This is true for guided inquiry, but may also be true for simulation/modeling and even for high-quality direct instruction. It may be that there is a predictable pattern to the teacher's learning curve, and it may even be possible to design teacher scaffolding to accelerate this learning curve. It may be that the degree and type of scaffolding teachers (and students) need changes according to their skill and knowledge profile. It may be that there is a skill hierarchy for mastery of TI-Nspire and TI-Navigator in classroom instruction. Research on these issues will allow us to refine the professional development system supporting TI-Nspire and TI-Navigator in scalable, sustainable ways.

4) *Assessment of deep understanding and problem solving.* TI-Nspire has the ability to capture a progression of documents that might represent stages in a student's thinking about a problem-solving task. It also has the ability to support free-form answer entry using alphanumeric and algebraic notation, instead of being confined to multiple-choice formats. TI-Navigator can store data from classroom sessions. We need to discover how to exploit these capabilities for formative and summative assessment, with particular attention to deep understanding and "doing real work" (ill-structured problem solving), in both mathematics and science.

5) *Barriers to CAS.* Effective utilization of CAS often is difficult to achieve. The user interface improvements in TI-Nspire should help, in particular its use of standard mathematics notation. We need to know how it has helped and what issues remain to be addressed by professional development and future product development. We also need to examine ways in which CAS enhances learning and provides new opportunities for students to do more mathematics in more meaningful ways.

6) *Probeware and beyond.* A rich variety of probes are available for graphing calculators in science and mathematics, and TI-Nspire will support current-generation probes. However, the computational and display capabilities of TI-Nspire creates a great many options in science for simulation, modeling, and support of most parts of the inquiry process (such as hypothesis formation, experimental design, and argumentation). We need to develop and evaluate models of these types.

Three additional study topics require availability or creation of content at scale, and thus may be possible only in 2008 or later:

7) *Learning Object Management.* A fully networked classroom TI-Nspire system eventually will include literally thousands of TI-Nspire documents, emanating from students, teachers, and published/ downloaded content. Understanding use cases here will help us create a learning object management strategy that is intuitive and easy to use.

8) *Differentiated Instruction*. With TI-Navigator providing classroom networking to TI-Nspire,⁷ teachers will need practical models for real-time formative assessment to support differentiated instruction. In addition, the document structure of TI-Nspire might provide supports for differentiated instruction in classroom networks. These models carry implications for assessment designs as well as teacher and student scaffolding and professional development.

⁷ Available late 2007

Potential Study Designs

Depending on the study goals, researchers may choose to use a design experiment strategy which emphasizes early learner trials and rapid prototyping, or they can employ a standard experimental or quasi-experimental design to test previously designed instructional applications.

Phase I studies are likely to be descriptive studies of learning processes and learning outcomes (or perhaps learning gains), in a small group of students or teachers over a fairly short period of time. Phase II studies are likely to use comparison group (experimental, quasi experimental) or regression discontinuity designs, with student learning as the main outcome under study. Future, larger studies may wish to use more complex experimental designs.

Number of subjects is likely to vary, as well. In Phase I, studies of learning outcomes probably will not exceed a single class. Studies which emphasize qualitative methodologies to analyze teaching/learning processes and the like could easily require only a few teachers or students. In a phase II study of learning outcomes, the sample of teachers, classes and students should be large enough to provide adequate statistical power to address the research question, using the intended learning measures. Qualitative studies of teaching or learning processes are likely to need a smaller sample of teachers, classes and students. Any secondary age level (grades 7-12) is appropriate, and any of the full range of contexts, ability levels and student profiles is appropriate for study.

Design Considerations

1) *Duration*. For Phase I and II studies, the amount of content included in the treatment should be small, and it may provided to researchers or developed by them. In phase I studies, content could be as little as a single unit covering a few weeks of teaching (assuming teacher and students have previously developed their skills with TI-Nspire, and the teaching methodology has already been mastered). In phase II studies, content could span as little as a segment of a semester (after learning to use TI-Nspire and mastering the pedagogy required), or as much as a full year's course. Future studies may wish to scale to a full semester or full year of content.

2) *Content*. Applications may already be available from TI or its publisher partners⁸, which researchers can use "as is" or adapt (with permission of the publisher). Or, researchers may choose to develop their own. The scope of studies, especially in Phase I, can be very small, involving trials of a single unit. Phase II content can be as little as a segment of a semester, to as much as a full year's course.

⁸ Early content is expected to be available in pre-Algebra, Algebra I, and Geometry. Content for the full secondary math and science curricula eventually will be available. Contact Dr. Foshay for details relevant to your proposal.

3) *Sample*. Phase I studies can use convenience samples of a single class or a small group of students, or groups with various demographic profiles. We expect Phase II studies will be somewhat larger, including perhaps one or more classes of one to four teachers each, in a quasi-experimental design or other control group strategy. These studies will set the stage for larger and longer experimental ones, if prior experience justifies the investment of resources.

4) *Measures*. For Phase I and II studies, researchers will need to take care in selection or design of appropriate learning outcome measures for pre- and post-testing. Standardized tests typically do not have the sensitivity needed to detect learning gains in small treatments, and may be vulnerable to validity issues when measuring deep understanding and high-level problem solving. Furthermore, the tasks included in either standardized tests or locally developed tests often are not “graphing calculator sensitive:” the items do not require solution strategies which presume a graphing calculator; often the items test only for simple fact or algorithmic procedural knowledge, and allow for low cognitive complexity. On the other hand, stakeholders value results on their high-stakes tests, so Phase II studies may need to consider a dual-measurement strategy.

Both Phase I and II studies are likely to include substantial qualitative analysis components appropriate to the research goals.

4) *Fidelity of Implementation*. For a treatment to be a valid test of an instructional strategy, three layers of interaction need to operate simultaneously and successfully in the classroom:

- The instructional strategy layer (presentation, question, feedback, other activities, processes, sequence, etc.)
- The problem structure layer (content knowledge type and procedural structure)
- The “tool” layer (keystroke-level procedures for each task)

Getting a successful implementation of all three layers, by teachers and students, is often difficult, especially in situations involving short-term treatments. Researchers are cautioned to design their studies with adequate provisions to ensure that their treatment is actually implemented as planned. Furthermore, researchers are urged to measure fidelity of implementation, and take this into account as an outcome or interaction effect when analyzing results.

Suggested Proposal Format

Suggested Organization of the Phase I Proposal

A phase I proposal can be very simple: 5 pages or so. Probable headings include:

1. Cover sheet

Study name/goal

Subject area & grade level

Study location/context

Number of TI-Nspire devices needed & when

Content to be provided by TI source (if any)

Principal investigator & contact information

Study start & end dates

Report deadline

Total budget requested

2. Introduction

Research question

Theoretical context and key references – no need for a full literature review section

Study significance if continued to Phase II and beyond

3. Study design & Project Plan

Independent & Dependent variable(s) & measures

Treatment description

Subjects (teacher(s), student(s))

Method of assignment (if comparison group study)

Teacher & student training plan for the treatment and for the technology

Study schedule with dates, & data collection plan

Analysis plan

Project team & qualifications

Letter of support from the participating school(s), if any.

IRB permissions and letters of commitment from school(s), if required before submission by your institution or the school(s) involved. Otherwise may be addressed after approval.

4. Proposed budget

TI – provided materials (no cost): specify how many & when:

TI-Nspire devices

Self-instructional training

Telephone hotline support (no need to quantify)

Instructional materials (if desired)

Fees & supplies (budget & when payable. We prefer 50% at the start and 50% upon delivery of the report. Our policy is to allow up to 20% university overhead, but this is not recommended for so small a budget.)

In-kind support you will provide, if any (simple list, no need to quantify)

Suggested Organization for a Phase II Proposal

A Phase II proposal will often follow a successful Phase I project which has demonstrated proficiency with TI-Nspire (with or without TI-Navigator). Expected length of the proposal is 5 -10 pages, with supporting appendices as needed.

1. Cover sheet

Study name/goal

Subject area & grade level

Study location/context

Number of TI-Nspire devices needed & when

Number of TI-Navigator systems needed & when

Content to be provided by TI source (if any)

Principal investigator & contact information

Study start & end dates

Report deadline

Total budget requested

2. Introduction

Research question

Relevant research and theoretical framework discussion with key references – brief, no need for a full literature review section

Study significance if continued to larger scale studies

3. Study design & Project Plan

Independent & Dependent variable(s) & measures

Treatment description

Subjects (teacher(s), student(s))

Study design (treatment, controls, sampling plan, method of assignment, treatment plan)

Teacher & student training plan for the treatment & precautions to ensure fidelity of implementation

Study schedule with dates, & data collection plan (qualitative & quantitative)

Analysis plan (qualitative & quantitative) & discussion of power/sensitivity in quantitative analyses

Project team & qualifications

IRB permissions, if required by your institution or the school(s) involved before submission. Otherwise may be addressed after award.

4. Proposed budget & timeline

TI – provided materials (no cost): specify how many & when:

TI-Nspire devices

TI-Navigator systems

Self-instructional training

Telephone hotline support

Instructional materials (if desired, pending agreement with publisher)

Fees & supplies (budget & when payable. We prefer 50% at the start and 50% upon delivery of the report. Our policy is to allow up to 20% university overhead, if required.)

In-kind support, if any (simple list, no need to quantify)

Letter of support from the participating school(s), if any.