Investigating Pre-service Mathematics Teachers' Initial Use of the Next-Generation TI-Nspire Graphing Calculators: A Case Study

Phase I Study: Final Report Submitted to Texas Instrument

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Final Report for Phase I Study Submitted to Texas Instrument by

FCR-STEM TI Group

Learning Systems Institute

Florida State University

Pre-service teachers' education is important because they are tomorrow's teachers and, as such, are future instructional leaders. In order to assume that role, they have to be well prepared for changing learning and instructional environments. Some observers anticipated that new teachers have grown up in a technology-rich environment so that their comfort and skill with technology will lead to increased use of new technology for instruction. In general, however, teacher-training programs do not provide future teachers with the kinds of experiences necessary to prepare them to use technology effectively in their classroom. Research shows that teachers teach the way they are taught (Britzman, 1991; Lortie, 1975). The construction of alternative images of teaching becomes an important goal of teacher education. Engaging pre-service teachers in contexts that exemplify ways of teaching with technology during formal teacher preparation programs becomes central to the preparation and training to use education technology. This becomes a key factor to consider when examining their use of new technology for instructional purposes.

The purpose of this Phase I Study was to make a preliminary investigation into the implementation of TI-Nspire calculators with pre-service middle and high school mathematics teachers. Through this focused case study an emerging model of technological pedagogical content knowledge as it relates to the use of the next generation calculator, the TI-Nspire, was investigated.

Teachers' beliefs and attitudes can be important predictors of nearly all types of technology uses. Specifically, teachers' attitudes and beliefs toward technology can affect their decisions to adopt and frequently use technology in the classroom. Changing teachers' use of technology requires changing their beliefs about technology. It is not surprising that one way to strengthen beliefs is to provide opportunities for teachers to acquire familiarity with technology. This becomes particularly true during pre-service training when teachers can be exposed to a wide variety of technologies and ways to use these technologies to support instructional goals, specifically addressing the use of technology in the classroom for instructional delivery and teacher-directed student use of technology. New teachers may be more comfortable with the technology itself, but they require further training on the value and uses of technology as an instructional tool. Teacher preparation may be enhanced by creating opportunities for teachers in training to see and experience the positive effects of technology on teaching and learning. These stronger beliefs are more likely to translate into more frequent use of technology once a pre-service teacher enters the profession.

TI-Nspire, the next-generation handheld calculator from Texas Instruments, featuring simultaneous multiple linked representations and enhanced interactivity was released in Fall 2007. TI-Nspire offers a new instructional tool to support mathematics instruction and to engage pre-service secondary teachers of mathematics in exploring new ways of mathematics teaching.

As many researchers have studied, calculators may not be appropriate for all educational situations or all mathematical subjects. However, Ellington (2003) reported that the improvement to problem solving skills was most significant when (a) special curriculum materials were designed for use with the calculator and (b) the type of calculator used was the graphing calculator. A meta-analysis also showed that students' attitudes toward mathematics improved as a result of working with calculators. Kastberg and Leatham (2005), in a review of existing literature, found that at the secondary level, the use of graphing calculators is a function of three factors: access, curricular treatment, and pedagogy. They suggest that teacher education program should provide preservice teachers with opportunities to learn with and teach with graphing calculators, and further support their pedagogical decision-making through reflection, experience, and a holistic understanding of graphing calculators.

Under the leadership of Drs. J. Michael Spector and Elizabeth Jakubowski the research team of Lingguo Bu, Lydia Dickey, Hyewon Kim, Nermin Bayazit, Orhan Curaoglu, and Recep Cakir conducted an investigation of the introduction of TI-Nspire calculators with pre-service mathematics teachers at Florida State University. The research questions investigated were

1. How do pre-service middle and secondary mathematics teachers react to the next-generation graphing calculators with respect to the learning and teaching of mathematics?
2. What are the major factors that affect their attitudes toward to the new graphing calculators and the decision-making in their pedagogical practices?

This final report situates the relevant findings to these questions within the current body of knowledge on use of technology in teaching and learning mathematics. Recommendations for additional studies are proposed.

Review of Relevant Literature

Since the advent of graphing calculators in the mid-1980s, there has been a growing volume of literature on the use of graphing calculators in mathematics instruction. In this brief review, we summarize recent research findings and meta-analyses.

Hembree and Dessart (1992) reviewed 79 reports on the use of calculators in mathematics instruction, revealing a scenario of uncertainty and conflicts. On the one hand, there seemed to be large potential benefits from the hand-held devices; while on the other, there had been little actual change in the mathematics curriculum. The authors found strong research evidence in favor of calculator use in instruction. From arithmetic performance, problem solving, to students' attitudes toward mathematics, calculators were found to be playing significant roles. Pedagogically, calculators were used primarily for familiarization, checking, and problem solving in the early grades. In the secondary grades, calculators were more often used as computational tools and reference. However, there were few empirical studies on how to integrate calculators into the learning processes.

The same conflicting scenario may have remained in the 1990s. In a survey study involving 146 middle and high school algebra teachers, Milou (1999) investigated their use of and attitudes toward graphing calculators, finding that the use of graphing calculators was still controversial among algebra teachers and the majority tended to think of graphing calculators as a motivational tool. Adding to the evidence for the use of graphing calculators in algebra classes, Milou's data confirmed that graphing calculators have little negative effect on student performance and do not cause deterioration of students' algebraic skills. Noticeably, algebra teachers are uncertain about the instructional use of graphing calculators. Milou reiterated the need to consider the curricular implications of graphing calculators (cf. Burrill, 1992).

More recent research on the use of graphing calculators has sought to examine students' experience and its impact on the instrumentalization (Trouche, 2005b) of the calculator as well as the social and cultural aspects of such tools (Doerr & Zangor, 2000). In a study of secondary students' conception of variables, Graham and Thomas (2000) found that the graphing calculator helps students construct a versatile view of variables through tool-based mathematical experience. The graphing calculator proved to be an instrument for students' algebraic thinking in terms of variables, which is previously a difficult strand of algebra. Graham and Thomas's study also underlines the significance of redesigning curricular component to provide students with meaningful learning experiences with technology.

Along the social and cultural dimension, Doerr and Zangor (2000) examined the meaning-making process of students and teachers with respect to the use of graphing calculators in mathematics learning in a class-based qualitative study. The researchers studied how the classroom community constructed meaning for the tool and further how the tool assisted students to construct mathematical meaning in learning tasks. Doerr and Zangor identified five themes of graphing calculator use in classroom mathematical practice. The graphing calculators were being used as computational tools, transformational tools, data collection and analysis tools, visualizing tools, and checking tools. Underlying the emerging tool use, the researchers suggested, were teachers' mathematical knowledge and beliefs, their pedagogical role, and the nature of mathematical tasks. Interestingly, they found that the calculator, when used as a personal device, could inhibit communication in small group settings. When used as a shared social device, the calculators tended to support mathematical discourse in the classroom learning community.

In a survey of recent literature related to the use of graphing calculators. Kastberg and Leatham (2005) found that at the secondary level, the use of graphing calculators is a function of three factors--access, curricular treatment, and pedagogy.   Importantly, when using curricular modules designed with graphing calculators as a primary tool, students achieve better mathematical performance. Regarding teacher preparation, the authors suggest that teacher education program should provide preservice teachers with opportunities to learn with and teach with graphing calculators, and further support their pedagogical decision-making through reflection, experience, and a holistic understanding of graphing calculators.

Teachers' beliefs about mathematics and mathematics instruction are fundamentally related to their teaching practice, including their use of new technology. New ideas and technologies tend to be shaped and reshaped by teachers' beliefs and established practices (Thompson, 1992). Based on a survey of 800 mathematics teachers across the elementary, middle and high school levels, Brown and colleagues (2007) identified four factors that account for teachers' belief and practices regarding their calculator use: catalyst beliefs, teacher knowledge, crutch beliefs, and teacher practices. The researchers suggest that mathematics teachers at all levels should be provided intellectual and technical support, with the focus on influencing their beliefs, mathematical knowledge, and pedagogical skills. In particular, "pre-service teachers could be more effectively supported in the integration of calculators in their mathematics instruction through the methods courses for preservice teachers" (p. 113).

In summary, there is substantial research evidence for the use of graphing calculators in mathematics instruction, in spite of the fact that teaching with technology is a complex process involving a range of social, cultural, and technical variables. There has been a repeated theme in the research findings that the mere addition of calculators to the existing curriculum will not fully realize the potentials of the new technology, and the integration of calculators as well as other technologies in mathematics instruction calls for the reconsideration of the whole mathematics curriculum (Burrill, 1992; Heid, 1997).

Further, there has been a consensus that preservice mathematics teachers should be provided with rich experiences in the use of new technology in a mathematics education program in order for them to develop technology-related pedagogical content knowledge (Mishra & Koehler, 2006).

Methods

The purpose of the study was to investigate secondary preservice mathematics teachers' use of the new TI-Nspire calculator with respect to their understanding of the subject matter and their pedagogical use of the technology. It was implemented first with an undergraduate method class in secondary mathematics education during Fall 2007 and, based on lessons developed from the first implementation, was replicated with a second class during Spring 2008 in the Department of Middle and Secondary Education at a major university in southeast US. This study included both quantitative and qualitative methods of data collection and analysis in order to incorporate a greater diversity of views on the integration of technology in the teaching and learning of mathematics.

Context

Participants in the study were pre-service mathematics teachers taking MAE4657 (Using Technology to Teach Mathematics) in Fall 2007 (n=23) and Spring 2008 (n=12). MAE4657 is a required methods course for the middle grades mathematics and secondary mathematics tracks in teacher preparation. While the course is intended to be taken in the first semester of the teacher preparation program (junior year) the pre-service teachers were at various stages in their preparation (e.g., some juniors and others seniors). There was also considerable variation in their mathematics knowledge and technology fluency. Participants in the course are engaged in exploring a comprehensive list of topics in algebra, geometry, probability and data analysis, discrete mathematics, and calculus using a variety of technologies, including graphing calculators. The course has a component that addresses new technologies. Thus, the TI-Nspire project was incorporated into the course as an integral component with the approval of the program coordinator. An initial survey on participants' background, particularly, their attitude toward calculator use in teaching and learning mathematics and their attitude toward mathematics was administered early in each semester.

Procedure

Team members attended summer workshops to become familiar with TI-Nspire, the newest graphing calculator from Texas Instruments. Following the workshops lessons were conceptualized that would be developed and taught with the class over a period of four weeks for eight 75-minute class periods. Based on their review of the computational and pedagogical features of TI-Nspire, the project team decided to focus on a few big ideas of secondary mathematics as opposed to tackling traditional problems using the new technology. Operating under the theoretical framework of Model-Facilitated Learning (MFL) (Milrad, Spector, & Davidsen, 2003), the team developed a series of six instructional units to engage pre-service mathematics teachers to readdress their own mathematics content knowledge, to learn about the new graphing handheld, and to further reflect on its implication for mathematics teaching and learning. Specifically, the project was designed in a way to foster the development of preservice mathematics teachers' technological pedagogical content knowledge or TPACK (e.g., Mishra & Koehler, 2006) while promoting deep understanding of big ideas of mathematics as opposed to re-addressing routine problems using new technology.

The research team selected six worthwhile topics from number theory, financial literary, trigonometry, statistics, and physics, and developed instructional tasks for each topic, taking advantage of the multiple representations and manipulative tools of TI-Nspire. Each lesson started with a realistic scenario that was deemed familiar and interesting to the participants. The informal scenario was further mathematized through small group work and whole-class discussion under guidance of the instructor, and investigated by participants at an increasing level of complexity using resources of the TI-Nspire. The mathematical models developed on the TI-Nspire were ultimately used by participants for holistic reasoning and judgments with respect to the initial situations. The instructional purpose of these lessons was to engage preservice mathematics teachers in reconnecting and expanding their own existing mathematical knowledge, and mindfully reflecting on the implications of the new technology for their pedagogical methods. Lessons are provided in Appendix A of the report.

From the onset, the research team chose to focus on integrating the exploration of mathematical ideas with the introduction of the new technology. Instead of teaching the use of TI-Nspire first and then using it for problem solving, they treated the new technology as a way to tackle challenging mathematical problems, each feature of the new technology being introduced wherever and whenever they came in handy. This proved to be an effective strategy in that many of the participants could navigate through the TI-Nspire menu system, search for tools, and discover their own way of using TI-Nspire with no prior keyboard training. What made the key combinations meaningful was, in fact, the mathematical situations, although certain just-in-time support from the instructor was constantly provided.

For each lesson, the class was divided into five groups of four or five students according to the instructor's perception of their performance in the class. All of the students were loaned a TI-Nspire for use inside and outside the classroom. While the instructor was implementing each lesson, two research team members observed target group activities and their interactions. After each class period, participants were asked to leave on the university's online course site their reflections regarding the mathematics content, the use of technology, and the relevance of the lesson to their future job as a mathematics teacher.

Toward the end of each semester, participants were asked to design their own lesson plans featuring the use of TI-Nspire, which led to a collection of over 30 lesson plans. They also were asked to write their responses to an imaginary teaching scenario in which they were offered the new technology and were required by their future employer to incorporate it into their mathematics teaching. These responses led to 35 essays, each about 300 words. Selected participants were also interviewed by the research team members about their month-long experience using TI-Nspire.

Data Sources

Data were gathered from students' lesson plans, interviews, discussion threads (through online course website), an initial questionnaire, and response to a hypothetical teaching scenario. The team analyzed students' journals, homework assignments, lesson plans, and field notes in search of repeated themes regarding participants' learning experience using the new TI-Nspire graphing calculator.

Interviews: As the Nspire was the final unit of the course, these interviews were administered at the end of the semester for both the fall and spring semesters. During the fall semester, students were interviewed in groups by two team members. During the spring semester the students answered the interview questions by participating in a Blackboard discussion group, where each pre-service teacher was asked to answer the interview questions as well as to respond to other student's posted comments. The same interview questions were used for both groups.

1. State your demographic background: major, grade, experience of teaching, internship.
2. What is your prior experience related to calculator use (class or high school, calculator version)?
3. How and what was helpful to understanding mathematics problems when you used TI-*N*spire?
4. How and what was not helpful to understanding mathematics problems when you used TI-*N*spire?
5. If you have struggled with using TI-*N*spire, what and why was the problem?
6. What do you think about technology integration for math education?
7. As a pre-service teacher, will you use the calculator for your teaching in the future?
8. What do you think about the instruction which presents a problem scenario first?
9. How can this course be improved?

Discussion board threads: Discussion board threads focused the pre-service teachers' experience with the TI-Nspire in the three areas of technical issues, personal beliefs, and content knowledge

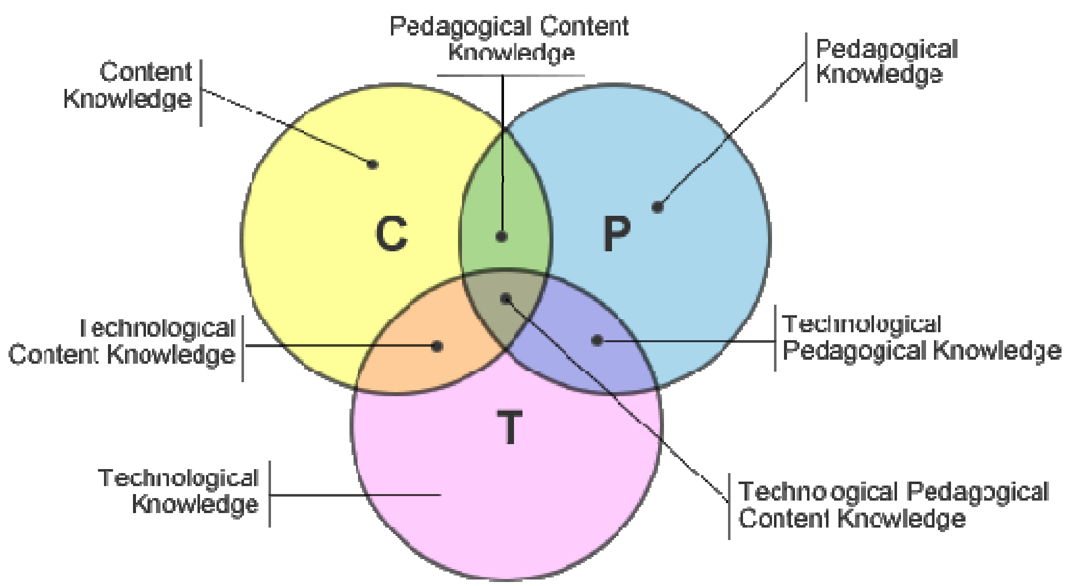
Essays: Toward the end of the TI-Nspire sessions both in Fall 2007 and Spring 2008, all participants were asked to respond to a hypothetical teaching scenario that involved the use of the TI-Nspire. The purpose was to gather data about their holistic instructional inclinations when TI-Nspire was available for classroom use.

Observations: Team members were participant observers within the classes taking field notes. When appropriate following class sessions team members would use data from observations to make informed decisions regarding instruction for subsequent classes.

Lesson plans: At the end of each TI-Nspire project, participants were requested to develop a complete lesson plan on a mathematical topic of their own choice that incorporates the use of TI-Nspire. A set of 30 lesson plans were collected on a variety of mathematical ideas ranging from algebra, geometry, dada analysis and probability, and financial literacy with the use of TI-Nspire at various levels.

Data Analysis

Interview, discussion threads, essay data, and lesson plans were qualitatively analyzed by the research team in the context of the TI-Nspire study in search of recurring themes, informed by the Technological Pedagogical Content Knowledge (TPCK) framework (Niess, 2008). TPCK builds on Shulman's idea of PCK and attempts to capture some of the essential qualities of knowledge required by teachers for technology integration in their teaching, while addressing the complex, multifaceted and situated nature of teacher knowledge. At the heart of the TPCK framework, is the complex interplay of three primary forms of knowledge: Content (CK), Pedagogy (PK), and Technology (TK).



Using WEFT software for qualitative data analysis, data sets were entered and categorized as informed by the TPCK framework. To ensure credibility of data coding, team members independently coded passages and then compared the codes. Discrepancies between the code assignments were discussed until consensus was reached. Major themes were triangulated through multiple data sources. Through team discussions, the researchers refined and clarified the categories, which further contributed to the emergence of subcategories.

Findings

Across the data sources there were five major themes identified in the participants' responses: TI-Nspire as a pedagogical tool, the tension between textbook constraints and teacher's design initiatives, the tension between traditions and innovations, teachers as learners, and personal beliefs and experiences. For the data sources a description of the findings as they relate to the evident themes are provided.

Discussion Board

After each class session students were asked to post reflections on the Discussion Board regarding the mathematics content, the use of technology, and the relevance of the lesson to their future job as a mathematics teacher as these related to the class experience. From the threads three themes emerged from their experiences with the TI-Nspire: technical issues, personal beliefs, and content knowledge

Technical Issues

Preservice mathematics teachers made both positive and negative comments on the same features of the calculator mostly depending on their familiarity with the calculator. For example, some students were fascinated with having two different graphs on the same screen while on the other hand, for some the feature was a source of frustration.

> "I really liked how the TI-Nspire allowed us to split the screen in order to compare box and whisker plots"
>
> "The important thing to remember is setting the window to the same dimensions for both plots. Otherwise, as I could see before setting the window, the two box plots can look almost the same if the window is automatically fitted to the data"

Similarly, screenshot application of the calculator had both sides. Some said that it is very helpful to follow the steps you went through on the other hand, some said it is a lot of work and can give students an excuse to cheat on the tests.

But it should be noted that positive comments outnumbered the negative ones for most of the features such as user-friendly interface, spreadsheet application, coloring the screen, visualization of data, use of different pages at the same time and ease in moving between the pages, defining piecewise functions, transition to other quantitative software, programming different functions and supporting multiple representations.

One of the most emphasized useful applications of the new generation calculator is the spreadsheet application. A majority of the students stressed that its similarity to Microsoft excel made it a lot easier and efficient to use in data storage and manipulation.

One of the major complains about this new technology was the contrast level of the screen which was asserted as a drawback for the people who had trouble eyesight difficulties, and the placement of the numbers and letters. Some suggested that "it would be really neat if the letters were put on perpendicularly to the numbers and the keypad swiveled out and the letters were aligned like a keyboard".

It was observed that most of the complaints resulted from not having enough experience with the calculator. As the preservice teachers became more familiar with the features of the calculator with increasing use of with it, their frustration tend to disappear.

Personal Belief

Pre-service teachers aligned themselves in one of two camps about the new calculator: full support for the use of it in class recognizing its benefits for students' learning and concern about students loosing focus of the topic whereby the focus becomes more on a procedural use of the calculator.

On the first side, preservice mathematics teachers refer to the new calculator as a valuable asset. They stressed that the new calculator provides "great visual demonstrations." It also saves time and shows that mathematics can be "fun and applicable in their lives." In addition, they highlighted that easiness of transition between documents in the solution of complex problems making it easier to follow and understand. Lastly, they also focused on the positive motivation effect of keeping up with the currency in technology.

On the other hand, there is also a group who has concerns about possible negative effect of calculators in students learning. They argued that first students should be taught the theory and learn the mathematical concepts then they can use the calculator as a supplement if time allows and most of the time it does not. They claim that calculators may reduce students' conceptual understanding. Some also suggested that more advanced technologies are better for advance classes. One even stated that the TI-Nspire was more suitable for engineers or computer science people.

Content Knowledge

In discussion threads, students reflected on certain activities focusing on gravitational force, central tendency of a data set, piecewise function, integral applications, prime numbers and Fibonacci sequence. The discussions provided enough evidence that preservice teachers were familiar with the concepts mentioned above. Some students' lack of understanding of piecewise functions' domains was striking. One said that

> It struck me odd that when defining the piecewise function, the first piece was used in respect to "less than or equal to." I have always used simply "equal to."

On the other hand, their confidence with certain statistical terms such as mean, median, Poisson distribution or moment-generating functions were impressive. Some suggested scatterplot activities for students to explore mean, median, mode and range. Moreover, one criticized the use of box plots due to its dependence on median and continued stating that "median has a relatively low resistance to outliers, thus the data can become skewed very easily."

Interviews

The pre-service teachers were interviewed at the end of the *N*spire component of the course, *Using Technology in Teaching Mathematics*. As the *N*spire was the final unit of the course, these interviews were administered at the end of the semester for both the fall and spring semesters. During the fall semester, students were interviewed in groups by Hyewon Kim and Lydia Dickey. During the spring semester the students answered the interview questions by participating in a Blackboard discussion group, where each pre-service teacher was asked to answer the interview questions as well as to respond to other student's posted comments. The same interview questions were used for both groups (see attached). The results from the interviews were surprisingly consistent across both semesters.

Technical Issues

There were four themes related to technical issues which were widespread among the students. The first was their positive reaction to the graph and spreadsheet programs. The pre-service teachers found that both of these programs enabled them to visualize and work with data in multiple ways, and they specifically liked the way the two programs were interrelated. In other words, they appreciated how easy it was to use the information in a spreadsheet to create a variety of visual representations such as graphs, scatter plots, or box plots. The second technical issue which multiple students voiced was their criticism of the keys on the *N*spire, which included two separate complaints. The first complaint some students had was that the letters keys were too small and encroaching, and in general they often pushed a button they didn't mean to push or even two buttons at once. The other complaint regarding the keys was that they often did not know where to find the key they needed. A third recurring theme, which was also a negative reaction to the technology, was that there were too many applications on the *N*spire, and they often were overwhelmed, neither knowing what application or command to use nor how to find it. A final response frequently posited by the students was the benefit of being able to save documents. Multiple students were impressed and pleased by this feature.

Content Knowledge

In the interviews, when the pre-service teachers were asked if they would use the calculator in their future teaching, they generally shirked from discussing the *N*spire in relation to any specific content. They had broad ideas of whether technology and specifically calculators were helpful, and they stuck to asserting only these general principles. Two students did allude to the fact that it would be better not to introduce the *N*spire to middle school students as they thought it would be too complicated for those students.

Personal Beliefs

The interview responses evinced that similar beliefs were prevalent among the pre-service teachers. First, multiple students believed that the calculator should only be used after students have learned "by hand". They believed that calculators made mathematics easier and more interesting, but were tools that should be supplements to learning, and therefore should be added after proficiency has already been demonstrated by the student.

Central to this is the fear that technology and the use of calculators will take the place of learning. This fear is represented in several student responses. A final belief which had fair representation in the interviews was that students needed to know how to use the calculator. Because technology in the classroom is becoming more customary, some pre-service teachers did not discuss the usefulness of the calculators as mathematical aids, but simply as technology that should be learned.

Hypothetical TI-Nspire Scenario

Toward the end of the TI-*N*spire sessions both in Fall 2007 and Spring 2008, all participants were asked to respond to a hypothetical teaching scenario that involved the use of the TI-*N*spire. The purpose was to gather data about their overall instructional inclinations when TI-Nspire was available for classroom use. The prompt and questions are as follows:

> Imagine the following situation. You have been just hired by a high school, and the school has been awarded a grant from a generous company for you to teach Algebra I/II using TI-Nspire or similar technologies. All of your students will have access to a TI-Nspire at home and in class. Further, you have the full support of the principal. Work out a plan to teach mathematics using the technology you are offered. Please address as many as you can of the following questions:
>
> 1. How are you going to use the current textbook, which is not written for the use of the new technology?
> 2. How are you going to plan classroom learning activities?
> 3. How are you going to assign homework?
> 4. How are you going to assess students' performance?
> 5. How are you going to deal with unexpected questions and other issues in the classroom?
> 6. Why are you teaching the way you propose to teach?
> 7. Other thoughts you may have regarding your assignment.

A total of 35 participants responded to the hypothetical scenario, contributing 35 essays to the data set.

TI-Nspire as a pedagogical tool

When technology is used for the purposes of facilitating student-teacher and student-student communication, enhancing mathematical understanding, and complex problem solving, it is used primarily as a pedagogical tool. More than half of the participants perceived TI-Nspire as a technological tool that has pedagogical implications. One participant wrote,

> Using a new technology is a learning experience for everyone. It is great to have open discussions and to have cooperative learning … If I don't know an answer, which am sure will happen, especially with technology, the class can solve it together. I can turn the question into a classroom task.

Another participant wrote,

> With this technology, classroom activities will be group focused. This is a new technology, therefore there is a learning curve involved, so we will all help each other and learn together. The students will receive written homework which can be assisted with the new calculators. These calculators will not replace written work, but is there to help and encourage learning.

A third participant went even further,

> I would not be set in old ways like some of the other teachers that had been teaching for a long time. If the out dated textbook was the only book I had available then I would most likely try to go onto the TI website to see if they have any resource that can help with creating new great mathematics problems. I would try to use these to encourage the students, teach them math is fun!

A majority of the participants recognized the powerful features of the TI-Nspire and presumed that their future students would be able to accomplish much without their intensive lectures, thus opening the door to cooperative learning, open-ended discussion, and whole-class activities. The multiple representations and the hands-on manipulations of them would help reach out to more students. Some students mentioned the document-based content of TI-Nspire and wish to use that to encourage student participation,

> I would assign homework by giving less amounts of problems with the expectations of them being able to save their work to the TI- Nspire and being able to upload it the next day if called on to do so. This way, credit will be given not only for the completion of homework but also in participation in class activities as well.

The tension between textbook constraints and the teacher's design initiatives

The textbook plays an important role in mathematics instruction. When asked how they would use an existing textbook when teaching with the new TI-Nspire technology, about half of the participants reported that they would closely follow the textbook in planning instructional activities and assigning homework. One participant wrote, "I will continue using the content and sequence of materials from the current text." Another said, “I will assign homework according to the book.” When the textbook (not written for the use of the new technology) is given priority, the technology might be more likely used as supplement or instructional alternative. One participant wrote, “I would probably use the new technology after the students have been introduced to a particular topic.” Another participant responded,

> I would teach them all of the essential concepts and ideas that they need to know without the use of the calculator. I want them to have a solid foundation before integrating what we are doing with the calculator. After I feel that my students have a firm grasp of the material then I would integrate the calculator into my lesson.

Instead of following the existing textbook, about one third of the participants indicated that they would need to create their own lessons to integrate the new technology into their teaching, recognizing the interactions between content, pedagogy, and technology. One participant wrote,

> Even though the textbook I am given will probably have at least some graphing calculator snapshots, they will not be from the TI-Nspire. Therefore, I will have to do some homework myself and transpose the calculator processes presented in the book (most likely from a TI-83) to TI-Nspire formats.

Another participant shared a similar view about the need to create one’s own version of the lesson,

> If I had a set of TI-Nspire graphing calculators but a textbook that was not written for it I would have to adapt the lesson plans from the book to the use of this technology. …. I would bring the students away from the book and have them explore the new information with this technology. A teacher does not have to teach exactly by a book, especially if there are ways for the students to interact with the lesson better.

Given the hypothetical situation, there seems to be a tension perceived by the participants between the textbook constraints and their awareness of the need for teachers to be lesson designers. Individual participants’ responses were frequently inconsistent about the roles of textbook and the need for adaptation, reflecting the underlying tension or uncertainty.

The tension between traditions and innovations

A second type of tension exists in the participants reactions to the new technology. On the one hand, the participants had been taught in a mostly traditional environment. They seemed to value the "paper-and-pencil" way of learning and teaching mathematics. Six participants specifically mentioned the importance of paper and pencil math. One participant, for example, wrote, "I prefer to teach primarily with paper and pencil mathematics and only to use the calculators as an aid instead of a crutch or vital tool." On the other hand, they recognized the implications of the powerful features of the new technology in manipulating mathematical ideas. The result is that they were inclined to see a balance between traditional approaches and innovative ones. One participant wrote,

> For activities in my classroom I plan to do a mixture of both technology-enhanced lessons and regular paper and pencil lessons as well. I feel that there should be an equal mixture between both types of teaching styles because some students might have problems using certain devices and become frustrated and discouraged from learning. Instruction should only use technology when it only helps the learning of the students.

Another participant proposed to test students in both ways,

> I would propose that they send in their work through the calculator so I know that they are learning to use it. But I'd also make them do work on paper and pencil so I know they can do the work without the technology as well.

Faced with the affordances of the new technology, many participants seemed to have experienced a pedagogical dissonance, when they would sway back and forth between the traditional approaches (they had personally been affected by) and the innovative ones. As far as preservice teacher education is concerned, this pedagogical dissonance may be the starting point for the long-term development of a teacher of TPCK.

Teachers as learners

Toward the end of the TI-Nspire project, many participants expressed their willingness to learn more about the technology and mathematics and highlight the need to learn with students. Some regarded it as part of their teaching career to be fluent with the new technology; others acknowledged that they had learned much about mathematics and teaching mathematics within the course of the TI-Nspire project. One participant wrote,

> Implementing a new technology such as this into the classroom will keep classroom learning current. We are a fast paced society, making advancements everyday. Students need to stay motivated to learn, and if given a new means, such as this or any new technology, they will not only be kept interested but will be kept up-to-date as well.

Another participant was positive about his own learning on the project,

> I know we hardly ever used any type of technology in the math classes I took in high school ... or at [the university] for that matter! But in this class this semester I have learned so much and I have realized that I want to definitely include as much technology as I can when I become a teacher. I think it will help students understand the concepts and ideas so much better, because I know that it has helped me!

A third participant emphasized the need to learn with her students,

> The reason I am going to teach this way is because I feel this is going to be a learning experience not only for the students, but for me as the teacher as well. Teaching in this manner will help me better understand where the students are coming from because the use of the TI-Nspire will be new to me as well.

Through their own learning experience on the TI-Nspire project, many participants came to recognize the alternative ways of mathematical learning and teaching. Not only did they find that they themselves need to learn about the mathematics, but they could also learn from and with their future students. As one participant wrote, "we are all going to work together to solve problems, whether it literally be math problems or problems that will arise while using technology. Hopefully, this technology will inspire a greater and higher thinking."

Nine participants specifically pointed out the need for training and support including (online) tutorials regarding the use of the new technology. On participant wrote,

> I am going to have to have my handbook ready, and have a few contacts who know how to work the calculators well. Also, I would go through as many online tutorials as I could and any other organized events to learn how to use the calculators to ensure that I am mastering the skills and techniques.

Another participant thought that she learned a lot in the class and expressed her need for more support,

> The assignments that we did in class regarding the TI-Nspire were very helpful. I learned a lot using this new advanced technology. However, I did find the use of the calculator to be very difficult to adapt to only because it is new and something I have never seen before.

In brief, the new technology and the lessons created provided participants an opportunity to look into the richness of mathematical ideas and the pedagogical alternatives, leading, to some extent, to their awareness and willingness to learn and pursue professional training.

Personal beliefs and experiences

Personal beliefs and experiences with learning played a major role in shaping the participants' responses to the hypothetical scenario and the affordances of the new technology. About one third of the participants acknowledged that they would teach in the way they proposed because of their personal beliefs and previous learning experience. One participant wrote,

> I feel that the way I propose to teach is directly related to my personal experiences in mathematics and educational information I have been given. I've experienced some amazing mathematics teachers and classes, and the direct inverse of that as well.

Another was more concerned about calculators being used as a crutch, and he wrote,

> I feel a calculator is a crutch for students. They routinely [do] not know what they are typing in to get the answer. They just know what buttons to push. This is sad to me; I believe a calculator should just be an aide, not an answer key.

A third participant wished to teach differently than she was taught and she wrote,

> I've experienced the boring, never-ending lectures and unplanned lessons. They do not interest me, and they do not help me. I've had many wonderful teachers, and many teachers who need to go back to school and re-learn how to teach. I do not want to be one of those teachers that slacks off or is uninterested in my students' work.

Finally, some participants thought what they did on the TI-Nspire was different than their previous experience and wanted to adopt some of the strategies. One participant wrote,

> I will probably do TI-Nspire activities like we did in class, several groups of 4 or so students. I thought this worked well. I was able to ask a neighbor how to get

> to a certain point without slowing the teacher down and disturbing the entire class. I like this method. I will also try other methods, so I see how my students work best. Example: entire class, individually, and pairs.

A similar response came from another participant,

> I really enjoy mathematics and the technology to enhance students learning. This class was perfect for my interest and the career I want to pursue. I plan to use all the technological knowledge I have gained to become a better teacher.

In short, participants brought their own beliefs and experiences to the TI-Nspire project, which affects the instructional flow and the classroom interactions. However, their experience with the TI-Nspire and the activities also affected their beliefs and decision-making or, at least, created dissonance in their belief system. Therefore, careful planning and design seem to be essential in taking full advantage of the features of TI-Nspire in future endeavors, including strategies to address their prior knowledge and attitudes.

Lesson Plans

Each semester the pre-service teachers enrolled in MAE 4657 created lesson plans as one of their final projects. Although these lesson plans incorporated the use of the *N*spire, most students did not take full advantage of the capabilities of the calculator. Across both semesters, a large portion of the lessons could be completed on any graphing calculator, or in some cases with a spreadsheet program such as excel, or a dynamic geometry program. However, some lessons stood out from the rest, making use of unique aspects of the *N*spire. One such lesson, which is based on NBA players' salaries, makes use of multiple pages to analyze spreadsheets, box plots, dot plots, and concludes by utilizing the split screen feature to compare two plots of data. This was not the only lesson plan to showcase the exceptional capabilities of the *N*spire, but in general these types of lessons were in the minority. Example lessons are included in Appendix A.

Conclusions

First, the effective use of TI-Nspire lies in the resequencing and reorganization of traditional mathematical topics, i.e., it is essentially an instructional design issue. Under sound instructional principles such as those of MFL, the new technology affords students opportunity to model and explore a variety of mathematical ideas at increasingly complex level and ultimately develop a holistic view of the mathematics in terms of their multiple connections and representation (NCTM, 2000, 2003). Second, the new technology plays the roles of cognitive amplifiers and organizers (Heid, 1997) in support of students' mathematical problem solving. Third, the new technology stands as a challenge to collaborative learning in small group. The project team's initial findings are consistent with those of Doerr and Zangor (2000).

Through multiple experiences including a hypothetical teaching scenario involving TI-Nspire, class reflections, and lesson plans participants responded to a variety of aspects of teaching with technology. The initial analysis of their responses unveiled five major themes. First, the new technology served as a tool or stimulator in fostering pedagogical reflection among the participants. Second, faced with the challenges and alternatives of the new technology, participants experienced the tension between traditional curricular materials (e.g., the textbook) and the need to recreate their instructional tasks. Third, the new technology stands as a challenge to the traditional paper-n-pencil approach to school mathematics, causing a tension or, at times conflicts between participants' traditional view of mathematics teaching and their awareness of innovative alternatives. Fourth, the new technology stimulated among the participants a willingness to learn on their own and with their students. There is evidence that the new technology might have fostered the emergence of certain openness in their approach to teaching. They explicitly identified the need for further support, training and peer assistance. Fifth, participants' beliefs and prior experience played an important role in their justification of their proposed ways of teaching and assessment. Their beliefs shaped their learning experiences on the TI-Nspire project, which further challenged their beliefs.

Teachers in general are not well prepared to take advantage of technologies such as the graphing calculator to support mathematics education. Deficiencies are not easily categorized and seem to involve what is now being called *technological pedagogical content knowledge* (TPCK) (AACTE Committee on Innovation and Technology, 2008). Deficiencies with regard to TPCK have not been addressed by traditional teacher preparation or professional development. Rather than support teachers, the graphing calculator in many cases makes it evident that teachers lack the appropriate TPCK.

According to Mishra and Koehler (2006) effective technology integration for pedagogy around specific subject matter requires developing sensitivity to the dynamic, transactional relationship between all three components. The expertise demonstrated by a teacher capable of negotiating these relationships represents a form of expertise different from, and greater than, the knowledge of a disciplinary expert (say a mathematician or a scientist), a technology expert (a computer scientist) and a pedagogical expert (an experienced educator). Furthermore, the incorporation of a new technology (e.g., TI-Nspire calculator) suddenly forces teachers to confront basic educational issues because this new technology reconstructs the dynamic equilibrium among the elements of technology, pedagogy and content. Through the design of effective learning tasks utilizing technology integration teachers are confronted with new decisions about the content and pedagogy.

Future studies need to further examine the dynamic interplay between elements such as connections, interactions, and constraints between and among content, pedagogy, and technology. The identification of centrally held beliefs about the nature of mathematics and the learning of mathematics in contexts involving the use of technology for teaching mathematics is another area that merits further examination. Finally, curriculum development leading to units of content that are supported by NSpire are needed to examine the effectiveness of the use of the calculator learning different levels of mathematics and the interplay of multiple representations in the learning process.

References

AACTE Committee on Innovation and Technology (2008). *Handbook of technological pedagogical content knowledge (TPCK) for educators.* New York: Routledge.

Britzman, D. (1991). Practice makes practice: A critical study of learning to teach. Albany: State University of New York Press.

Brown, E. T., Karp, K., Petrosko, J. M., Jones, J., Beswick, G., Howe, C., et al. (2007). Crutch or catalyst: Teachers' beliefs and practices regarding calculator use in mathematics instruction. *School Science and Mathematics, 107*, 102-116.

Burrill, G. (1992). The graphing calculator: A tool for change. In J. T. Fey & C. R. Hirsch (Eds.), *Calculators in mathematics education, 1992 yearbook* (pp. 14-22). Reston, VA: National Council of Teachers of Mathematics.

Doerr, H. M., & Zangor, R. (2000). Creating meaning for and with the graphing calculator. *Educational Studies in Mathematics, 41,* 143-163.

Ellington, A. (2003). A meta-analysis of the effects of calculators on students' achievement and attitude levels in precollege mathematics classes. *Journal for Research in Mathematics Education, 34*(5), 433 – 463.

Graham, A. T., & Thomas, M. O. J. (2000). Building a versatile understanding of algebraic variables with a graphic calculator. *Educational Studies in Mathematics, 41*, 265-282.

Heid, M. K. (1997). The technological revolution and the reform of school mathematics. *American Journal of Education, 106*, 5-61.

Hembree, R., & Dessart, D. J. (1992). Research on calculators in mathematics education. In J. T. Fey & C. R. Hirsch (Eds.), *Calculators in mathematics education, 1992 yearbook* (pp. 23-32). Reston, VA: National Council of Teachers of Mathematics.

Kastberg, S., & Leatham, K. (2005). Research on graphying calculators at the secondary level: Implications for mathematics teacher education [Electronic Version]. *Contemporary Issues in Technology and Teacher Education*, 5(1), 25-37. Retrieved July 25, 2007 from http://www.citejournal.org/vol5/iss1/mathematics/article1.cfm.

Lortie, D. (1975). *Schoolteacher: A sociological study.* Chicago: University of Chicago Press.

Milou, E. (1999). The graphing calculator: A survey of classroom use. *School Science and Mathematics, 99*, 133-140.

Milrad, M., Spector, M., & Davidsen, P. (2003). Model facilitated learning. In S. Naidu (Ed.), *Learning & teaching with technology: Principles and practices* (pp. 13-27). London Kogan Page.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108,* 1017-1054.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

NCTM. (2003). *Position statement on the use of technology in the learning and teaching of mathematics*. Retrieved December 10, 2005, from http://www.nctm.org/about/pdfs/position/technology.pdf

Neiss, M. L. (2008). Guiding preservice teachers in developing TPCK. In AACTE (Ed.), *Handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 223-250). New York: Routledge.

Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 127-146). New York: Macmillan.

Trouche, L. (2005). An instrumental approach to mathematics learning in symbolic calculators environments. In D. Guin, K. Ruthven & L. Trouche (Eds.), *The didactical challenge of symbolic calculators: Turning a computational device into a mathematical instrument* (pp. 137-162). New York: Springer.

Appendix A

Lesson Plans Developed for the TI-Nspire Preservice Mathematics Teachers Project

With samples of student work

Preface

These lessons were developed in Fall 2007 and Spring 2008 at the Florida Center for Research in Science, Technology, Engineering, and Mathematics (FCR-STEM) as part of an exploratory study on secondary preservice mathematics teachers' use of the TI-Nspire handheld. The topics include a series of important ideas in number theory, discrete mathematics, data analysis, financial literacy, and calculus. In developing the lesson, the research teams were guided by the instructional design framework of Model-Facilitated Learning (Milrad, Spector, & Davidsen, 2003) and the TPCK framework for fostering preservice mathematics teachers' technological pedagogical content knowledge (e.g., Niess, 2008).

These lessons represent our initial endeavor to provide mathematics teachers and their students with conceptually enriched and technology-supported instructional tasks. The underlying instructional model contributes to the ongoing STEM research and development, in general, and the use of TI-Nspire handheld, in particular, in bringing meaningful mathematics in powerful ways into mathematics teacher preparation programs and further into school mathematics.

Milrad, M., Spector, M., & Davidsen, P. (2003). Model faciliated learning. In S. Naidu (Ed.), *Learning & teaching with technology: principles and practices* (pp. 13-27). London: Kogan Page.

Niess, M. L. (2008). Guiding preservice teachers in developing TPCK. In AACTE (Ed.), *Handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 223-250). New York: Routledge.

Table of Contents

LESSON PLANS DEVELOPED FOR TI-NSPIRE PRESERVICE PROJECT

Getting Started with TI-Nspire: Number Theory

The expanding role of the Internet will ultimately lead to each of us being uniquely identified by our very own prime numbers.

--- Marcus Du Sautoy, 2003

Overview

This lesson provides a few number theoretic activities for students to get familiar with the TI-Nspire user interface and some important mathematical functions. Starting with the basic idea of prime numbers, students will visit a few built-in functions on TI-Nspire such as *factor()*, *gcd()*, *mod()* , and further write a program *PowerMod()* to implement the idea of "raising a number to a certain power and then applying a mod operation." With the user-defined function *PowerMod()*, this lesson further engages students in implementing the well-known public-key cryptosystem RSA. Originally designed by Rivest, Shamir, and Adleman (1978), the RSA cryptosystem makes use of two large prime numbers in constructing the algorithm for data encryption and decryption. The two prime numbers are kept secret, but their product N and a corresponding encryption key E are made public. Typically, it is the recipient of information who publishes his/her N and E for the public to send his/her encrypted information. Anybody can send him/her information, but only the recipient, who has the decryption key, can retrieve the original information. Both encryption and decryption make use of the *PowerMod()* function. The RSA mechanism is shown in Figure 1. In reality, the two prime numbers are several hundred digits long. However, for the purposes of this lesson, students will be using relatively small prime numbers.

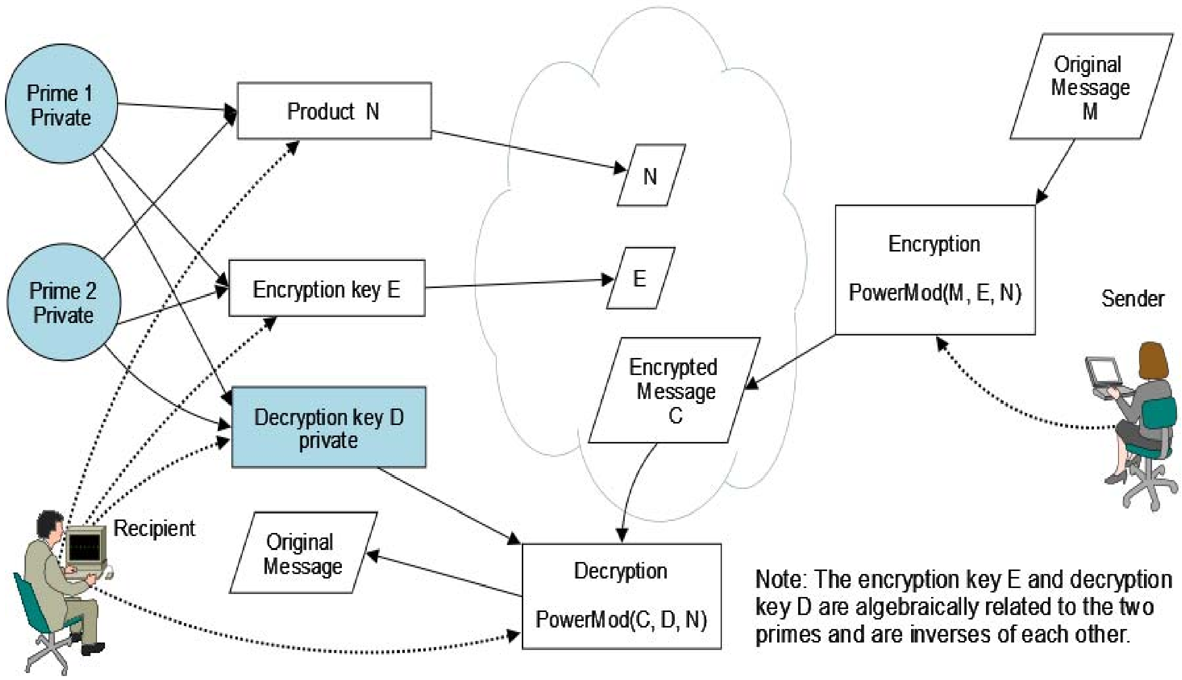


Figure 1. The RSA mechanism.

Mathematical Concepts

Prime numbers, factorization, relatively prime numbers, modular arithmetic, public key cryptography

Procedure

1. Revisit a few number theoretic concepts.
    a. Is it prime? [isprime()]
    b. Factoring integers using the 'factor()" function.
    c. Are they relatively prime numbers? [gcd(a, b)]
    d. Modular arithmetic using "mod(x, m)"
2. Write a little program to do "powermod(x, e, m)".
3. Send me a message using RSA.

Discussions:

How do you think such built-in functions like "factor()", "gcd()", and "mod()" can be used to engage middle grades students in exploring patterns with integers and solving realistic problems?

Assignment

Participate in the online TI-Nspire discussion, specifically addressing: (1) the mathematics content, (2) the use of the calculator, and (3) how it might be relevant to your job as a teacher.

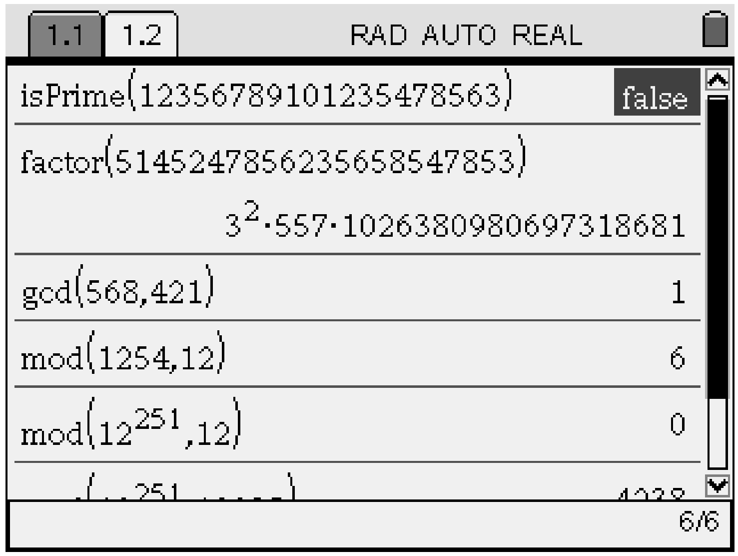
Extensions

As interest grows among the public in protecting their information online (such as emails), students should be encouraged to explore the mathematical algorithms involved in public key systems (such as RSA) and further make use of their mathematical understanding in protecting one's privacy online. For example, there is an NPR discussion on encrypting and decrypting one's email content using a public key algorithm (Kaste, June 19, 2008) available at http://www.npr.org/templates/story/story.php?storyId=91666556 . Another reference is Sarah Flannery's (2001) book *In Code: A Young Woman's Mathematical Journey*, which documented the author's personal encounters with RSA and her creation of a new public key algorithm.

Worksheet

Directions: Create a new document and add a *calculator application*. When you want to add a new page, you can always use "Ctrl-I".

1. Think of <u>three</u> numbers in the 500s, and determine if they are prime using the *isprime()* function. Record your finding below.



2. Using the *factor()* function, factor two or three large integers (at least 15 to 20 digits). Also try factoring the following RSA Numbers. Pay attention to the behavior of the calculator.

   R1 = 3444795763618669143 89

   What if you change the last digit to 5 and try factoring the number again?

   R2 = 3579483042721878633 97

   What if you change the last digit to 8 or 4 and try factoring the number again?

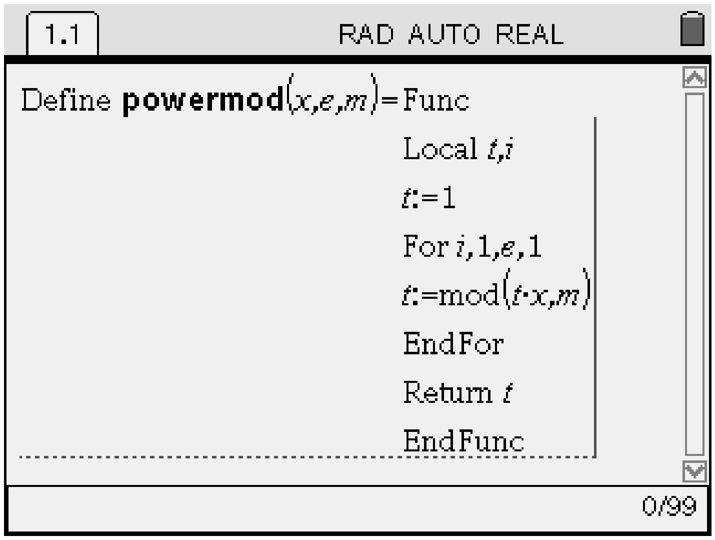
3. Find three pairs of relatively prime numbers in the range (2 -100) using the *gcd()* function. Recall that two integers are relatively primes if they do not share any common factor except for one, such as 8 and 15.

4. TI-nspire has a built-in *mod()* function, which functions like this: *mod(17, 12) = 5*. Using the *Mod()* function, find the day of the week after 1557 days [say, today is Thursday].

   Also try the following:
   mod(5^5, 12)
   mod(5^200, 12)

mod(5^2000, 12)

5. Define a new function *PowerMod(x, e, m*) as follows. Discuss why it might solve the problem you encountered in mod(5^2000, 12).



6. Test your *PowerMod()* function. The instructor's public keys are**:** *N= 52326809, E = 3541.* Please send him the last four digits of your social security number (just make one up!), using *PowerMod(ssn, E, N)*. Just write the encrypted message on the board!

7. To decrypt the encrypted SSN, you would need to know the instructor's *private* decryption key. Suppose his private decryption key is D, you could do *PowerMod(encryptedSSN, D, N)* to retrieve the original information.

The Fibonacci Sequence and Piecewise Functions

Overview

The Fibonacci sequence has rich historical and natural connections. Examples include the well-known rabbit population problem, numerous objects in nature, and the floor tiling problem ( ). In a Fibonacci sequence, the value of any term (for n>2) is the sum of the two terms that come before it. In the floor tiling scenario, for instance, the side length of each square (starting from the third) is the sum of the side lengths of the previous two squares (see Figure 2). Hence the sequence: 1, 1, 2, 3, 5, 8, 13, 21, …. Equally interesting is the ratio of adjacent terms in the Fibonacci sequence: 1, ½, 2/3, 3/5, 5/8, 8/13, 13/21, …, which approaches the golden ratio. There is a great deal of information on the Internet about the Fibonacci sequence and its applications. Students should be encouraged to conduct an Internet search for relevant aspects about the Fibonacci sequence and share with each other about their findings and questions.

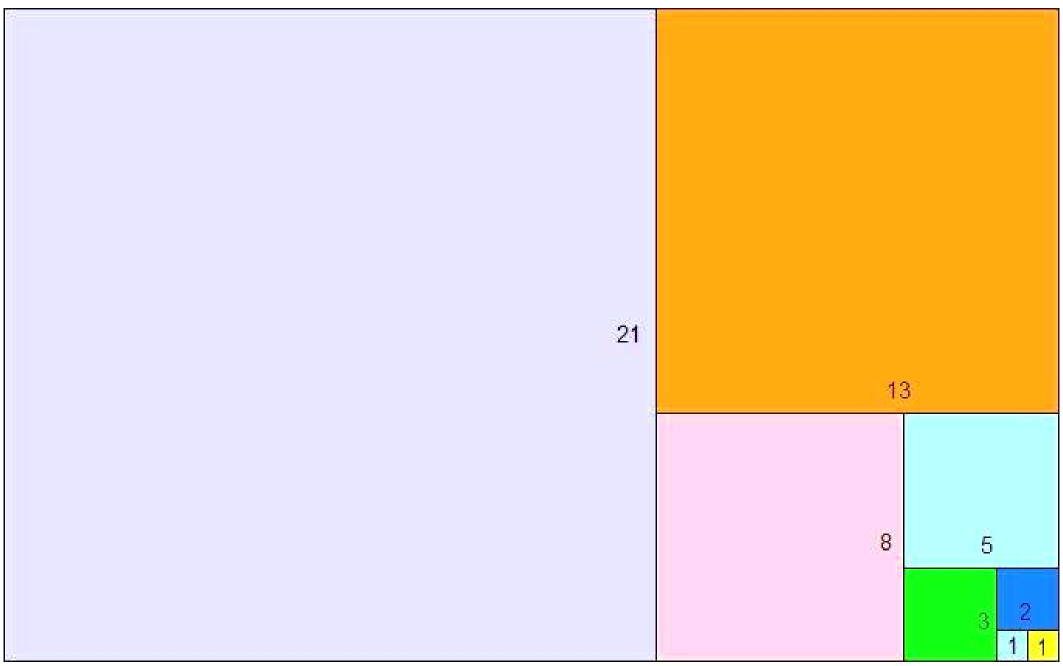


Figure 2. The floor tiling problem and the Fibonacci sequence.

Mathematical Concepts

Recursive function, piecewise function, algorithmic complexity, the golden ratio

TI-Nspire Features Used

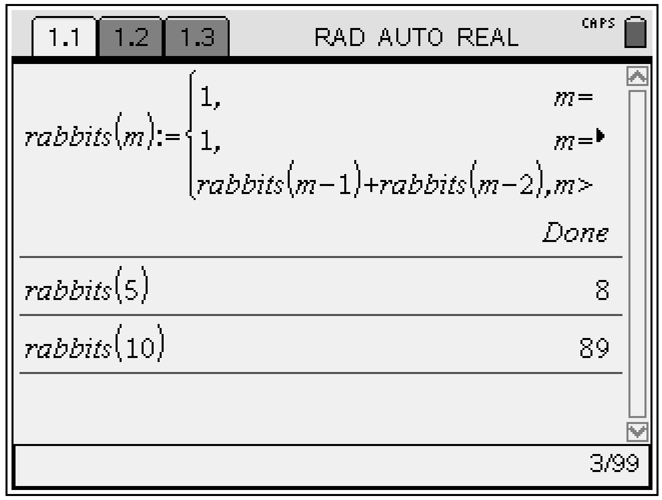
Calculator [function definition], spreadsheet, scatter plot

Procedure

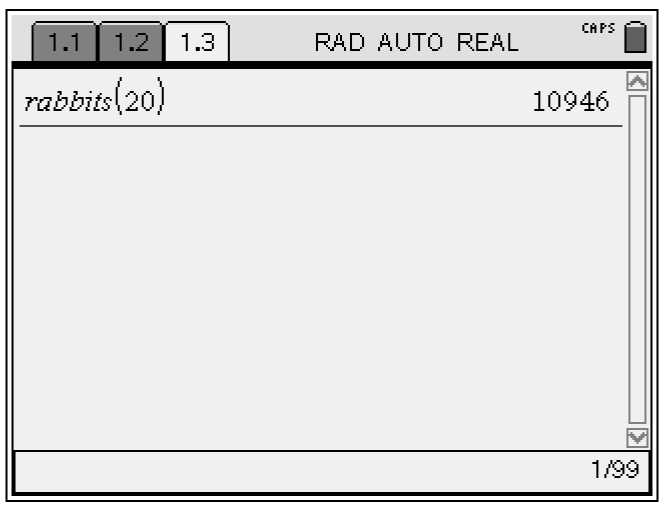
1. Start the lesson with a general discussion of the Fibonacci sequence, inviting students to share their findings on the Internet and their own mathematical description of the sequence.

2. Using the rabbit problem as a starting point, define a rabbits() function.

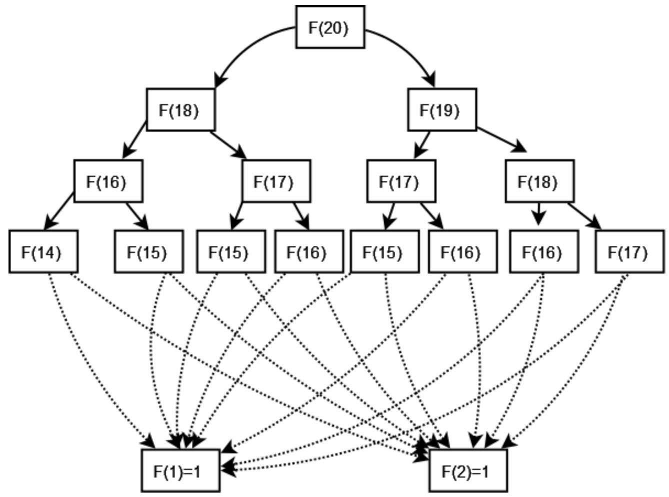
Find the population of rabbit at the 5th and 10th month, starting with some smaller number.



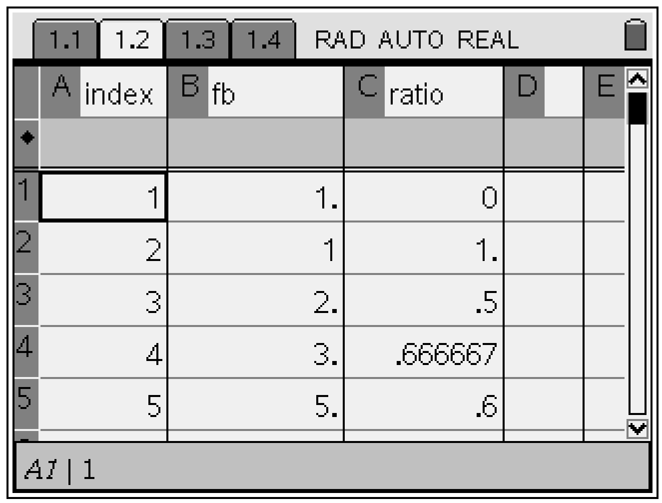
3. Try to find the rabbit population for the 20th month or 25th month. Discuss the behavior of the calculator.



4. Ask students to trace the calculator's evaluation of rabbits(20) in small groups and try to explain why it takes so long find rabbits(20).



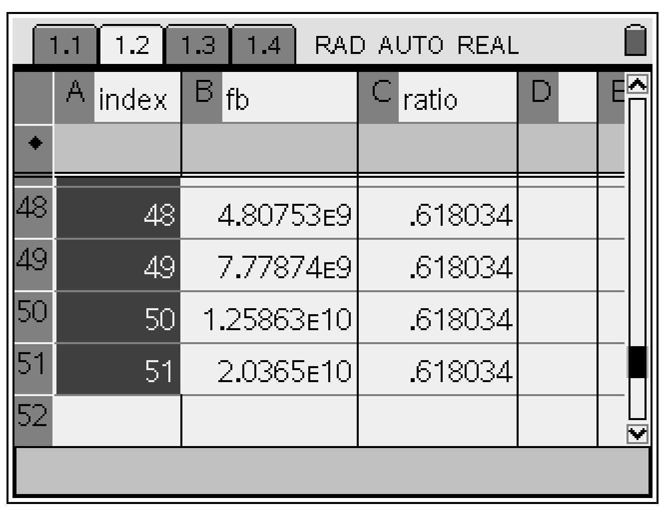
5. Open a new page, and construct spreadsheet model for the rabbit population, and further explore the ratio of adjacent terms.



	A index	B fb	C ratio	D	E
◆					
1	1	1.	0		
2	2	1	1.		
3	3	2.	.5		
4	4	3.	.666667		
5	5	5.	.6		

6. Replicate the spreadsheet pattern and explain why it can easily reach the 50th month and what might be the differences between the rabbits() function and the spreadsheet model?

Further, make observations of the ratio.

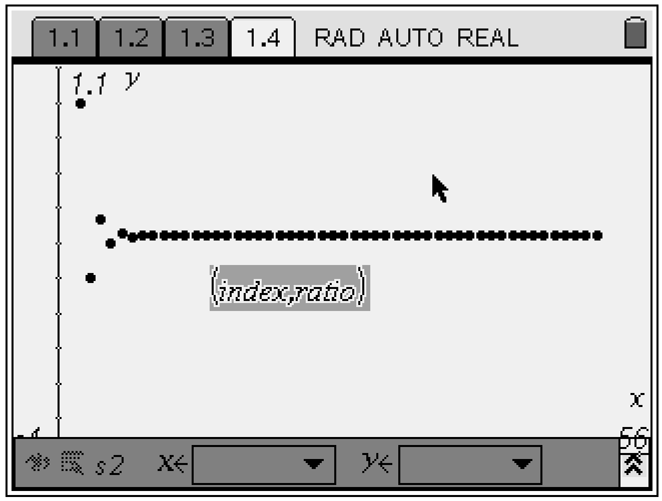


	A index	B fb	C ratio	D	E
◆					
48	48	4.80753E9	.618034		
49	49	7.77874E9	.618034		
50	50	1.25863E10	.618034		
51	51	2.0365E10	.618034		
52					

7. What if we change the initial terms to, say rabbits(1)= 5, rabbits(2)=12. Does it affect on the long-term tendency of the ratio? What if you use negative numbers for the initial numbers?

Make a few conjectures about the change of the ratio.

8. Open a new page, and graph (index, ratio) data in a scatter plot. What is happening to the ratio?



9. Allow time for students to make modification to the rabbits problem and investigate the consequences of their modifications.

Extensions

There are many possible extensions to the Fibonacci sequence. Of particular interest is the manipulation of the initial terms. What if they are negative? What if they are big numbers? What if they are fractions (decimals)? Do they actually matter at all? Is there an explicit rule that can be used to find a specific term of the sequence without going through the involved solution tree? If the initial conditions do not matter, what makes a Fibonacci sequence (the underlying algebraic structure)? Using features of TI-Nspire, these questions could be readily addressed.

Money Matters

Experience modifies human beliefs. … I address myself to all interested students of mathematics of all grades and I say: Certainly, let us learn proving, but also let us learn guessing. … Mathematics in the making resembles any other human knowledge in the making. You have to guess a mathematical theorem before you prove it; you have to guess the idea of the proof before you carry through the details. You have to combine observations and follow analogies; you have to try and try again.

--- G. Polya, 1954

Overview

From credit cards to loans and investments, people deal with money matters all the time! Behind the scene of many money-related scenarios, there usually exists a simple cycle repeating itself over an extended period of time. Simple as it is on a local scale, the cycle ultimately leads to serious consequences or benefits. This lesson invites students to imagine a realistic scenario (credit card loan, car loan, or long-term investment), simulate the unfolding of situation, understand its underlying mathematical structure, and further make informed decisions about real-life money matters.

Specifically, students are to build recursive and piecewise functions by taking advantage of the TI-Nspire features and subsequently look into the nature of recursion, developing a first understanding the interconnected applications on TI-Nspire and investigating problems involving loans and investments using a variety of mathematical representations.

Mathematical Concepts

Compounded Interest, amortization, recursive function, piecewise function, exponential functions

New Florida Mathematics Standards (2007)
MA.912.F.1.2 Solve problems involving compound interest
MA.912.F.1.4 Demonstrate the relationship between compound interest and exponential growth
MA.912.F.4.4 Establish a plan to pay off debt

Procedure

The problem: On January 1, 2008, Vera is going to invest $1000 on the market (say certain mutual funds) which is estimated to generate 8% annual yield. From then on, she will invest $600 on the first day of every year. Assuming the market is stable (for our purpose), please analyze how Vera's account balance (in dollars) will change over time.

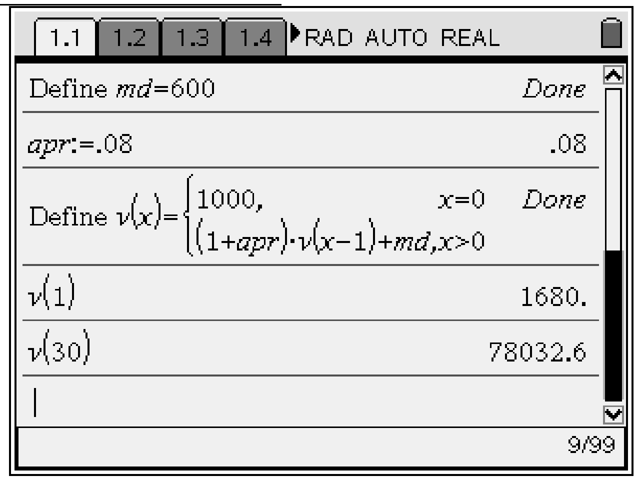
Let

v(x) be Vera's account balance at beginning of the x-th year, and
md be the annual investment.

Then: *v(0)* =_________________, *md* =______________
v(x) =_____________________________________.

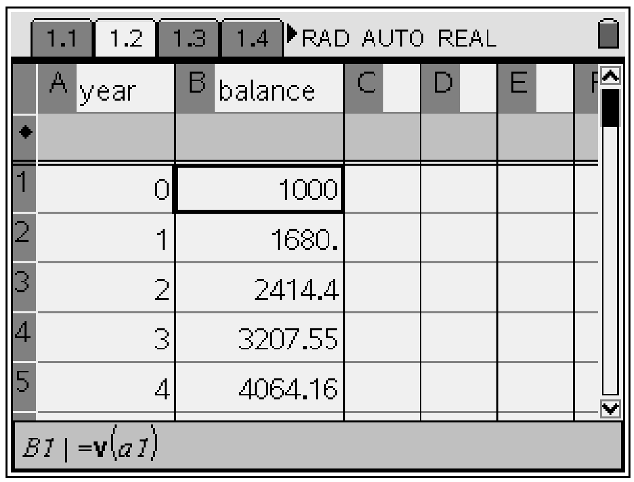
1. **[New calculator page]** Define v(x), including all constants and variables involved.

   - What is Vera's account balance at the beginning of the 8-th year?
   - What is *v(27)*? What does it mean to Vera?
   - What is v(60)?

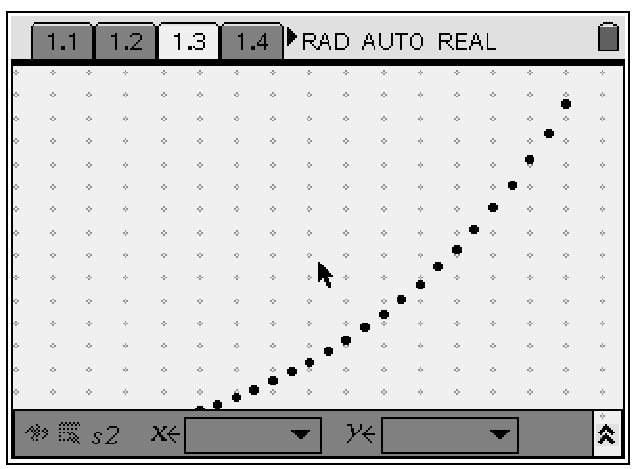


2. [**New List/Spreadsheet page**] Make a table to show how **v(x)** changes on a yearly basis. <u>To save time, do not allow x to go beyond 30 for the moment</u>. [do not use the function v(x)]

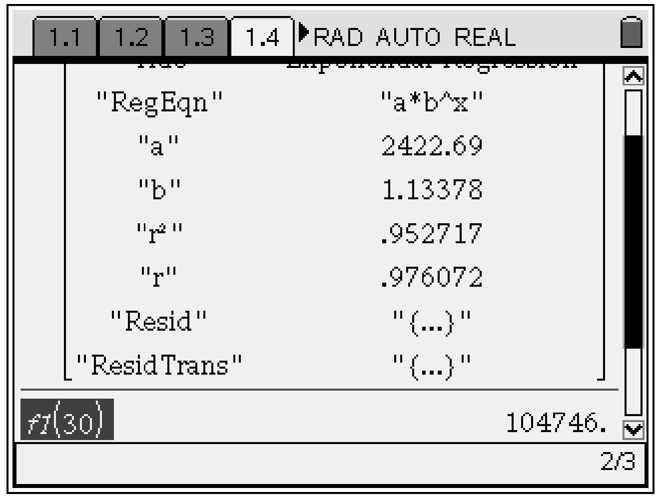
   In B2, you need to type " **=(1+apr)*B1 +md** "



3. [**New Graph & Geometry page**] Make a scatter-plot of the data in the table. Does it look like linear growth?

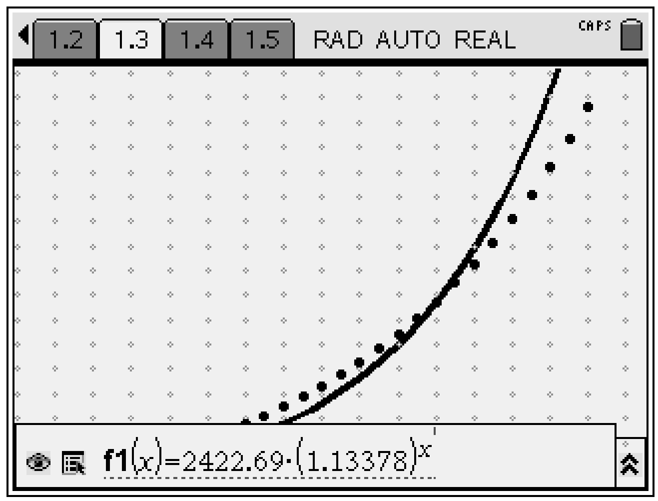


4. [**New Calculator page**] Based on the data in the table [*balance* over *year*], conduct an exponential regression and store the resulting function in ***f1***.



What is the meaning of ***f1(5)***?

5. [**Go back to the Scatter-plot page**] graph ***f1()*** on the same page as the scatter plot, and comment on the two graphs.



Discussion

1. There are a variety of ways to analyze the investment problems covered in the lesson, such as a piecewise function, a table, a scatter-plot, and the regression model. What are the disadvantages and advantages of one compared with the others? How would you start the lesson if you were the teacher? How would you assess students learning?
2. What do you think of the *connectedness* within the TI-Nspire? How do you think middle or high school students might respond to its features?
3. Think of some *what-if* questions you might ask about Vera's investment scenario?

Extension

Money issues are part of our every life. Students should be encouraged to look into a variety of problem situations that are relevant to them. More importantly, students should look into the mathematical nature of the problems and make further recommendations/decisions regarding the use of credit cards and high-interest-rate loans.

Assignment

Paying off a Car Loan

Peter has just purchased a gas-saver car on a loan of $25000 with $0 down payment. The loan carries an APR of 6.84%. Peter plans to make a monthly payment of $450 until the loan is paid off. Please analyze how his account balance (debt) is going to change on a monthly basis.

Let ***papr=.0684***, and ***pmp=$450***, and

Let ***p(x)*** be the balance at the x-th **month**. Then,

p(0) = _______;

p(x) =(1+papr/12)* p(x-1) – pmp.

Analyze p(x) according to the steps in the investment activity. On the spreadsheet page, extend the list as far as it is necessary for the balance to be less than $450.

Write a two-page report of your work, including a problem description, summary of the procedures, and your reflections on both the mathematical ideas and your experience with TI-Nspire. Feel free to provide a few hand-drawn screen displays as evidence.

Student Reactions

- The TI-*N*spire is a perfect way to show students that learning about math is fun and applicable in their lives. – Student LM
- I enjoy the ease and user-friendly interface that the TI-*N*spire offers, especially with respect to piece-wise functions. I've been decently impressed with Texas Instruments' new line of mathematical technology, and I applaud the ease and simplicity that the TI-*N*spire offers students. – Student CT
- I really enjoyed using the TI-*N*spire calculator when viewing the investment problems. I really liked how I could define the variables on one page, make a table of the data on another page and then make a scatter-plot graph from the data on another page. –Student CD

A Free Fall Experiment

I know not what I appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell, whilest the great ocean of truth lay all undiscovered before me.

--- Isaac Newton http://www-history.mcs.st-and.ac.uk/Quotations/Newton.html

Overview

The free fall phenomenon is familiar to all students. If air resistance is not considered, an object in free fall accelerates at a rate of the gravity. In this lesson, students will model the free fall, relating gravity to speed and distance, and further realistic problems. Technically, they will look at the integral (area) and data capture tools of TI-Nspire. Mathematically, they will build a model to describe the behavior of a fee falling object. Pedagogically, they will discuss how to integrate important mathematical ideas in everyday (motivating) physics and other sciences.

Mathematical Concepts

Linear function, integral (area), quadratic function, and scatter plot

Procedure

Kendra's Free Fall Experiment. The Sears Tower is Chicago is 1450ft tall from its roof to the ground. Kendra takes a baseball to the roof, and somehow gets of out of the window with no force imposed on it. Now the ball falls freely toward the ground. Assuming the air has insignificant influence on the baseball and the gravitational acceleration in Chicago is 32ft/s2, Kendra wonders 1) How fast is ball falling? 2) How does the distance from the roof to the ball change over time? 3) When the ball hits on the ground, how fast is it moving at the moment? [Does it hurt if it happens to drop on someone's foot?]

1. What kind of problem is Kendra's experiment?

2. What are the major variables involved?

3. How could we build a mathematical model to answer Stacy's questions?

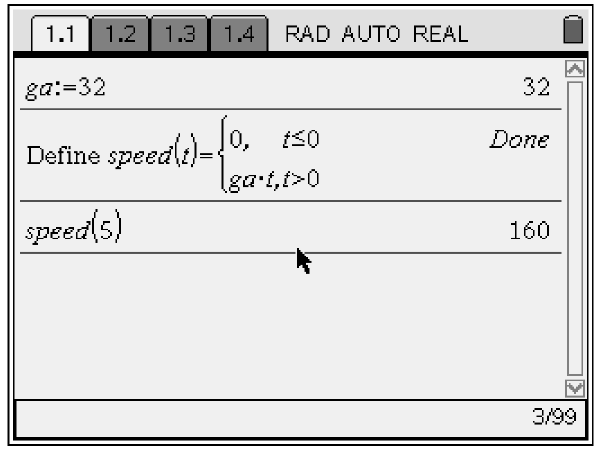
1. Open a new document and create a new "calculator" page.

Define the constant ga:=32

Define the speed function

speed(t)= …

Do think it is necessary to let speed(t)=0 for t<=0?

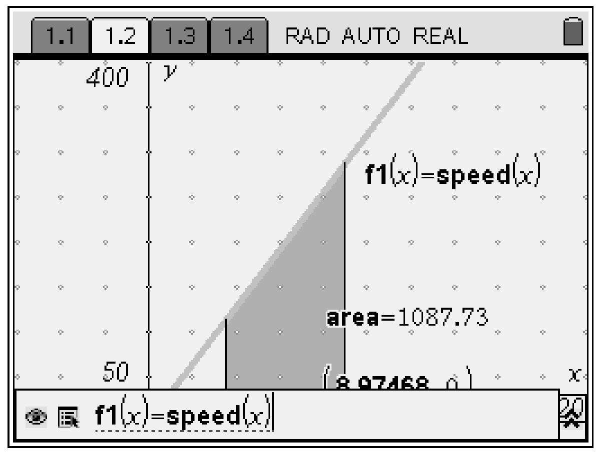


2. Create new "graph" page [page 1.2]

Graph the function speed(t)

Set the windows initially to

Xmin=-5, xmax=25
Ymin=-20, ymax=450



3. On page 1.2, select two arbitrary points to define the integral region.

Menu->Measurement->integral

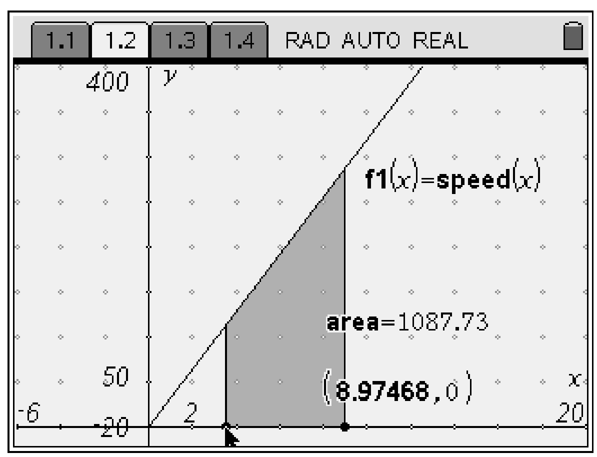
Experiment with the "Click" button to select the upper and lower boundaries.

Move the left point to (0, 0).

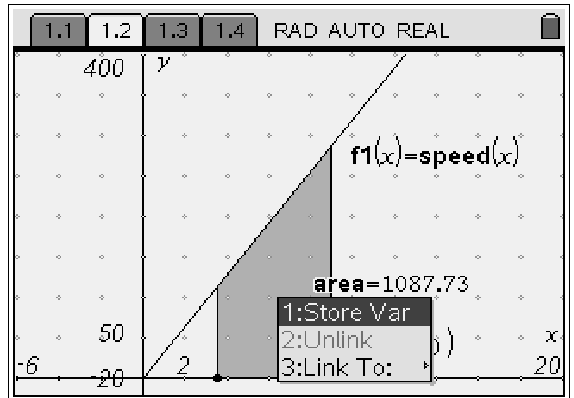
4. Now drag the right point and watch the change of the area. When does the ball hit the ground? How fast is it moving?

5. On Page 1.2, show the coordinates of the right point.

Tools->Coordinates and Equations

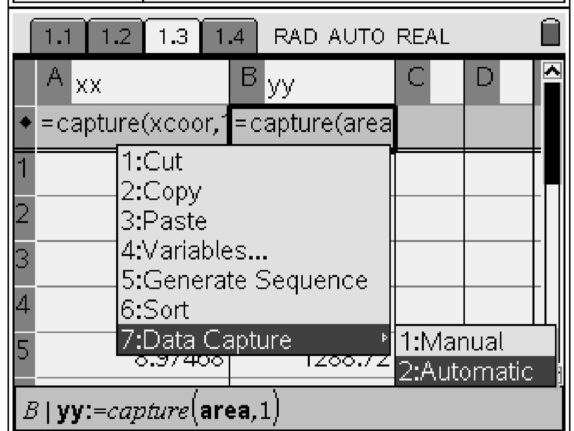


6. Name the area “area”, and further name the x-coordinate of the right point “xcoor”.

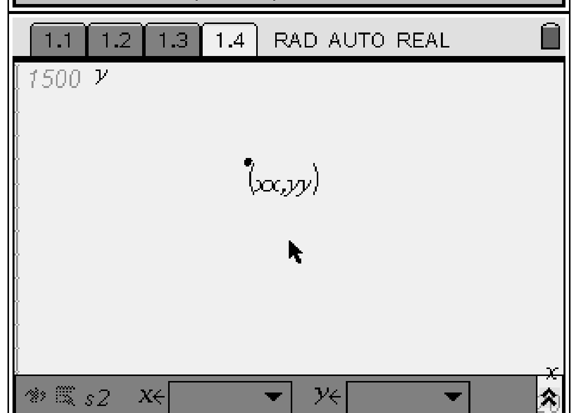


7. Create a new “spreadsheet” page, and define two columns “xx”, “yy”.

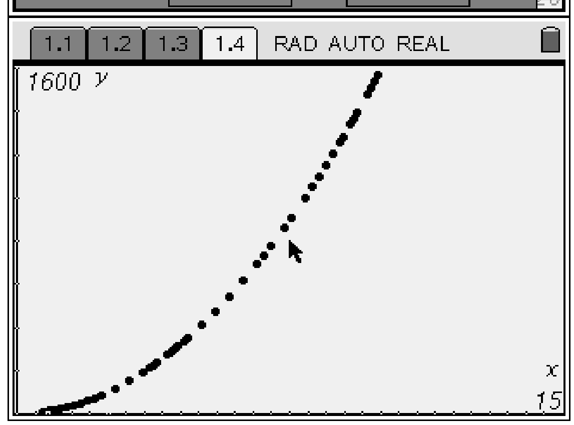
Let column xx capture the value of “xcoor”, and column yy capture the value of “area”



8. Create a new “graph” page, and make a scatter plot of (xx, yy).
Adjust the windows settings in a similar way as described above. You might only see one dot here.



9. Now go back to page 1.2 (the speed graph), select and drag the right point slowly. Observe what happens to the spreadsheet and scatter plot. What is the meaning of the scatter plot? What does it look like?
Feel free to do a quadratic regression on (xx, yy) if you want to.



Extension

In reality, air resistance can not be neglected, especially when the object is falling at higher speed. Some students may be interested in considering the effect of air resistance on a free falling object. Further, it may be useful to introduce the vector-based concept of velocity and distinguish it from the scalar concept of speed.

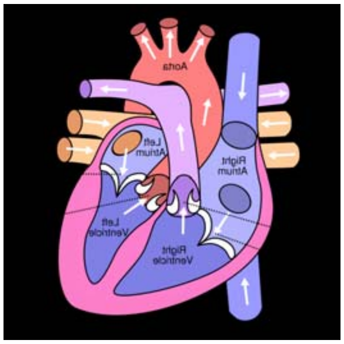
Discussions

How do you think a mathematics teacher could help students build connections between mathematics and sciences? What are the consequences? When is it important to distinguish between velocity (directional) and speed (scalar)?

A Hearty Dose of Statistics

Statistics sway public opinion on issues and represent--or misrepresent--the quality and effectiveness of commercial products. Through experiences with the collection and analysis of data, students learn how to interpret such information.

NCTM from http://standards.nctm.org/document/chapter3/data.htm



Lesson Overview

In this lesson students gather and make sense of personally relevant data. They record their heart rates before and after engaging in physical activity, and each student shares their individual heart rate data with the class. Once all students have compiled a complete spreadsheet with data from the entire class, the data is used to create a box plot. The students learn and discuss key ideas regarding data analysis and statistics.

Mathematical Concepts

Concepts include data collection, data analysis, and making use of appropriate data displays including box plots. This lesson also lends itself to an examination of outliers, mean, median, and mode.

TI-*N*spire Features Used

This lesson makes use of the data analysis tools of the TI-Nspire. This includes inputting data into a spreadsheet, using the data to create a box plot, and splitting the screen to observe two box plots concurrently.

Procedures

1. Everybody takes a deep breadth, and count her/his heart beat for one minute.
2. . [Page 1] Put the class heart rate data into a list (spreadsheet), and name the column HR1

3. [Page 2] Create a new page for Data and statistics, and explore a couple of ways to make sense of the data.

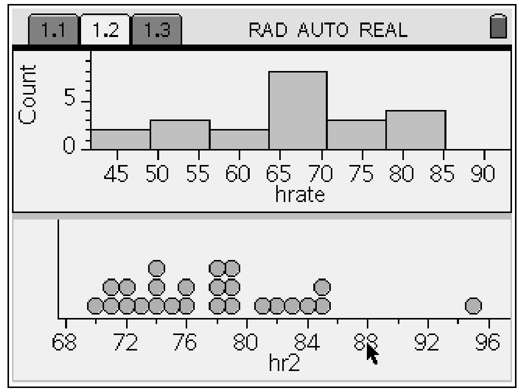
4. [Page 2] Create a **box-plot** of the data and discuss what you see.

5. All go outside and run to a designated point and come back as fast as you can. Feel free to do a few jumps and stretches! But be careful not to hurt yourself!

6. Collect second round of heart beat data.

7. [Page 1] Enter the new data in a new column of the spreadsheet page. Name the column HR2.

8. [Page 2] Change the page layout: horizontally divide the display into two parts. [Use Ctrl-Tab to switch windows]. In the second one, plot HR2.



9. [Page 3] Set both windows to [xmin=50, xmax=150] and compare the two box-plots.

Discussion

What happened to the heart rates after 10 minutes of exercise? What sense can you make of the width the boxes? Why is the second one wider than the first one?

Extensions

What is helpful when trying to make sense of the data that is around us?
How are graphing calculators and other graphing utilities helpful in this kind of exploration?

Student's Reactions

- I enjoyed seeing the heart rate statistics displayed over so many types of applications. It was easier to visualize and understand what was happening to the heart rates of everyone. – Student RB
- Like I say all the time, I don't usually like calculators, but today's lesson was made so easy because of the calculator. It is so easy to move data to a graph or plotting system of choice that the Ti-Nspire has definitely won my heart today. – Student AM
- The ability to engage the class as whole was very fun and I believe it kept a higher portion of the class interested. The split-screen effect that the TI-Nspire possesses proved to be very useful. I like the idea of having two graphical representations of data, side-by-side and at a student's disposal. – Student CT

Heart Rate Data Worksheet

First Set of Data

<u>Strategies for making sense of the data</u>

1. ___
2. ___
3. ___

Second Set of Data [After running downstairs and coming back]

Strategies for making sense of the data

4. ___
5. ___
6. ___

7. ___

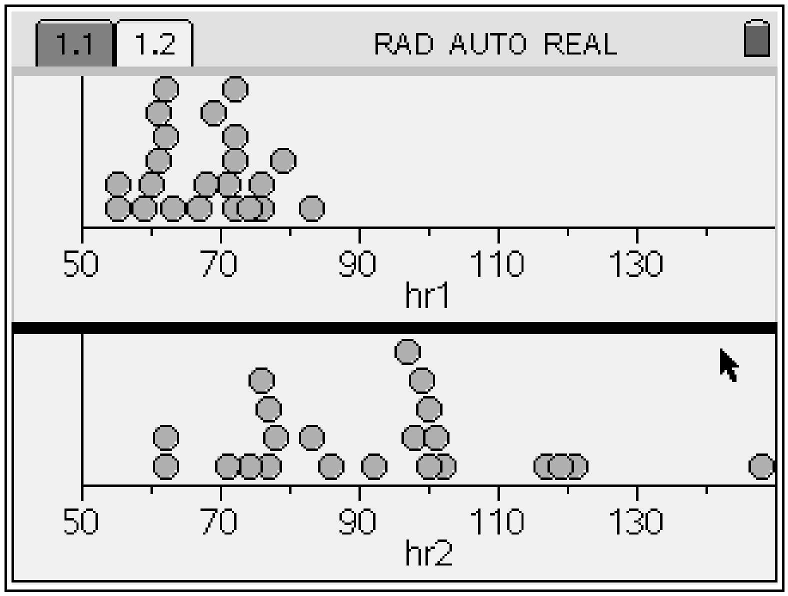
Actual Data Collected (N=22)

After collecting the first set of heart rate data, all participants ran downstairs, reached a landmark structure near the classroom building, and rushed back in about 10 minutes. No strict rules were implemented. The second set of data was collected once all participants were back in the classroom.

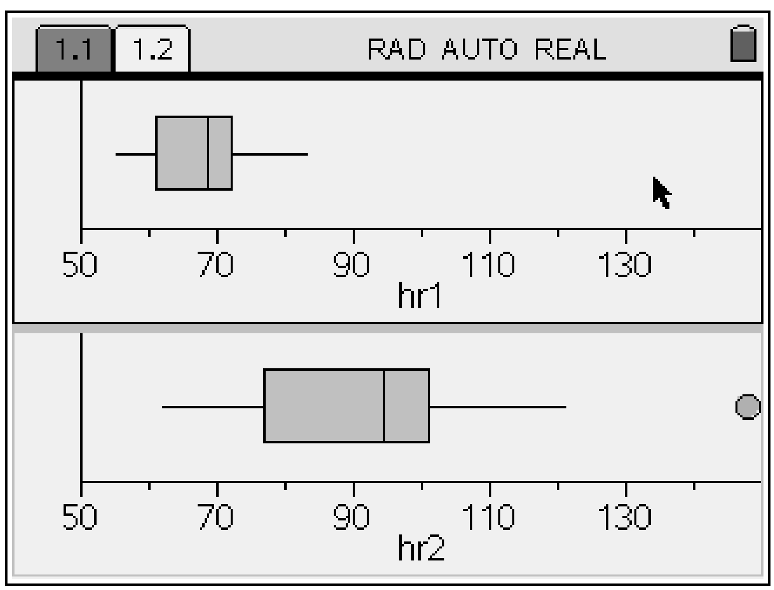
HR1	HR2
83	102
72	100
76	98
71	100
63	77
67	78
55	86
72	77
55	74
72	117
69	99
59	97
60	71
61	148
76	101
62	62
79	121
68	83
61	76
62	62
74	92
72	119

TI-Nspire Screenshots

Dot Plots



Box Plots



The Shapes of Sound: AM and FM Signals

Mathematicians may flatter themselves that they possess new ideas which mere human language is as yet unable to express. Let them make the effort to express these ideas in appropriate words without the aid of symbols, and if they succeed they will not only lay us laymen under a lasting obligation, but, we venture to say, they will find themselves very much enlightened during the process, and will even be doubtful whether the ideas as expressed in symbols had ever quite found their way out of the equations into their minds.

--- James C. Maxwell
from http://www-history.mcs.st-and.ac.uk/Quotations/Maxwell.html

Overview

Trigonometric functions describe the properties of angles. They are essential in modeling a wide variety of cyclic phenomena in nature and physics. Imagine that you are spinning a coil of wire in a magnet field, or a magnet within a coil of wire at a certain speed (turns per second or frequency). The signal thus generated is a function of time and can be modeled using a sine or cosine function. In this lesson, students will have opportunities to investigate the properties of such functions, and see how they can be manipulated to create AM (amplitude modulation) and FM (frequency modulation) signals. Haven't you already noticed that they are in your car stereo?

Technically, we will take advantage of the high-resolution LCD of the TI-Nspire and its ability to handle complex function manipulations. Mathematically, we will look at function composition and present an extended view of trigonometric functions in the context of sounds and radio signals. Pedagogically, we will reflect on the role of context and the use of technology in framing our conception of important mathematical ideas.

Mathematical Concepts

Function, function composition, trigonometric functions and their applications.

New FL Mathematics Standards (2007)

MA.912.A.2.7 Perform operations (addition, subtraction, division and multiplication) of functions algebraically, numerically, and graphically

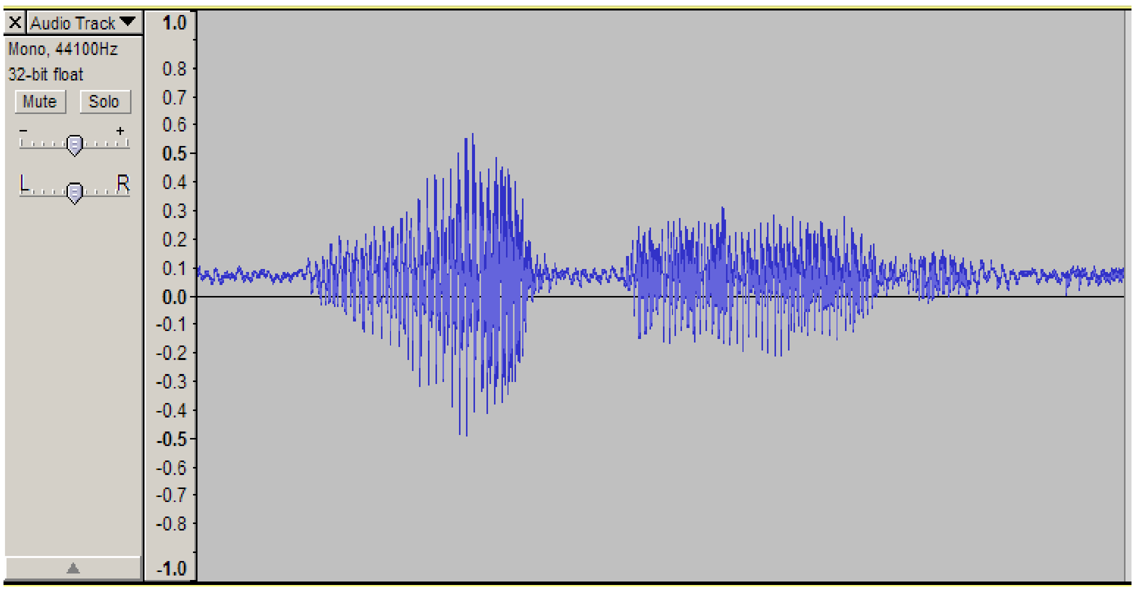
MA.912.A.2.8 Determine the composition of functions

MA.912.T.1.8 Solve real-world problems involving applications of trigonometric functions using graphing technology when appropriate

Procedure

1. Introduction: The Shape of Sound

The following is the shape of the sound "mathematics". Using the open source utility, **audacity** (http://audacity.sourceforge.net/), you could capture your voice, music, or anything audible in high quality and make your own MP3s if you wish.



2. Function Composition

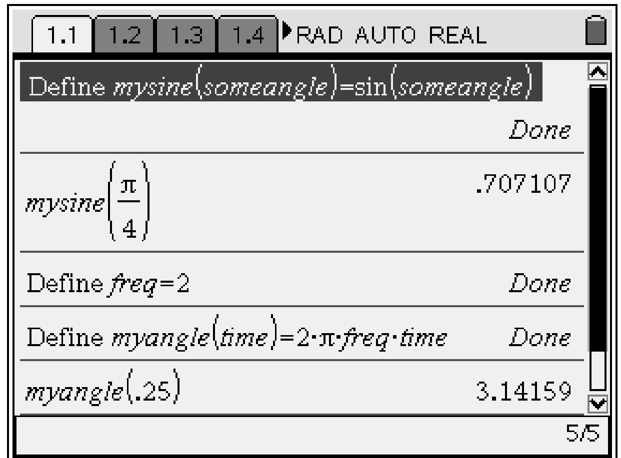
1. Graph 5 * sin(x) in a graph application and comment on what you see.

2.

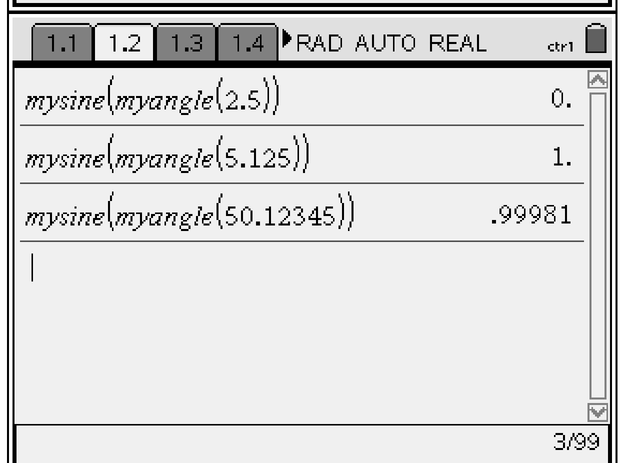
Define

mysine(someangle)   and **myangle(time)**

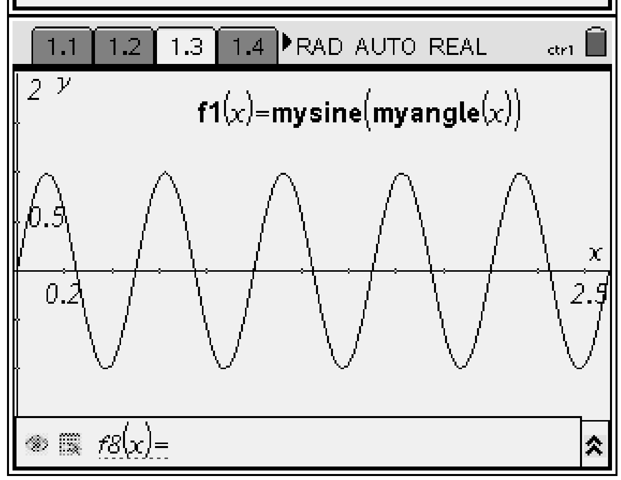
freq is a constant for the frequency of spinning!



3. What is the value of mysine at time =7.186 seconds?

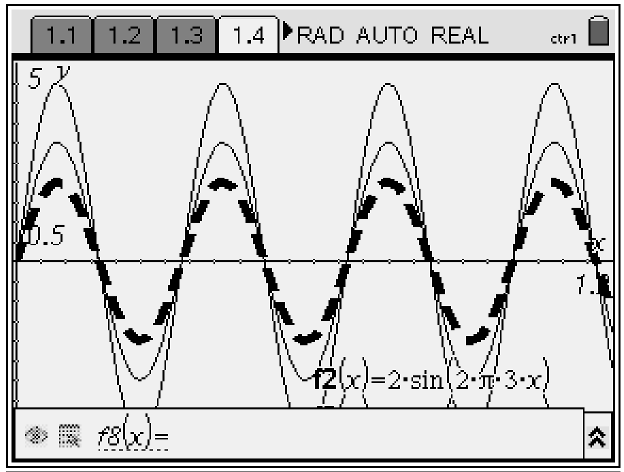


4. How does mysine behave over time? It might be necessary to set the windows to a proper scale to see the details. Try xmin=0, xmax=2, ymin=-5, ymax=5.



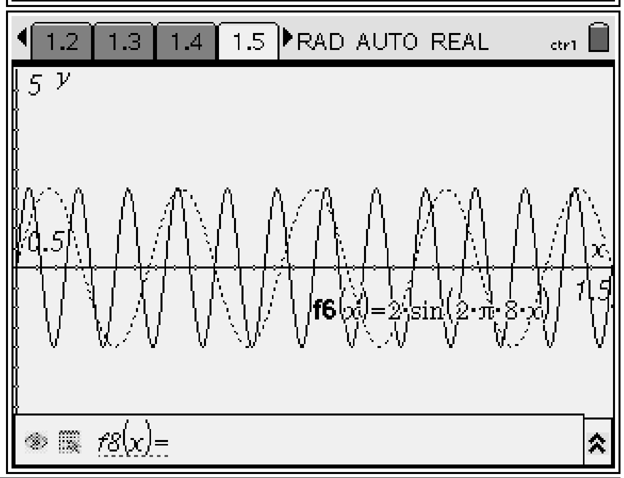
3. AM Radio Signals

Now we have related the sine function to time with the introduction of "frequency". Let's look at the various components of a function like f(x)= A* sin(2π*f*t)



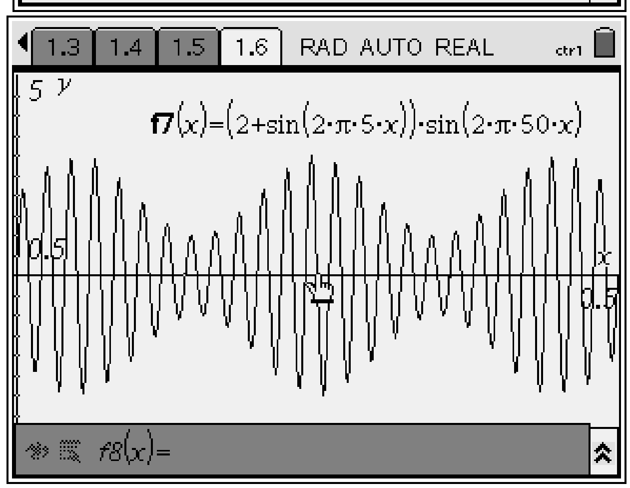
1. On a new page, graph the following functions

    a. 2*sin(2π*3*x)
    b. 3*sin(2π*3*x)
    c. 4.5*sin(2π*3*x)



2. On a new page, graph the following functions

    a. 2*sin(2π*3*x)
    b. 2*sin(2π*8*x)



3. Graph the product of the following two functions.

    a. 2+sin(2π*5*x)

    b. sin(2π*50*x)

What is the difference between the two above? What are they doing to each other?

Discussion

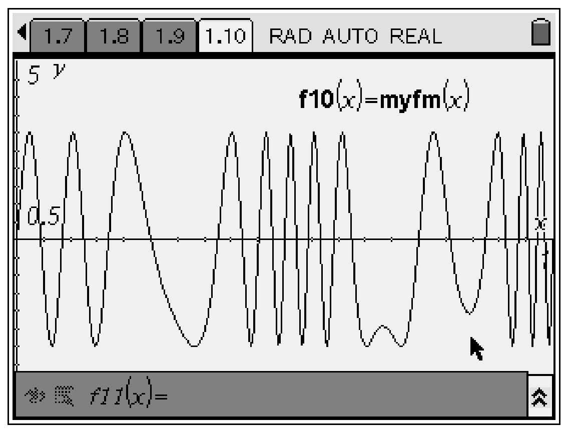
How do you think the “sound-point-of-view” of the sine (or cosine) function might (or not) be helpful in teaching trig function in high school? What other natural phenomena could be approached as a scenario to engage students in appreciating the value of trig functions?

Extension

Some students may be curious about the “decoding” process within a radio receiver. There are circuits that do the job. In the case of AM signals, it is relatively easy—just chop off the upper or lower part of the AM signals. FM signals are decoded using a circuit that responds to the change of frequency.

Assignment

Open-ended exploration. Create a new TI-Nspire document for the following problem and be prepared to share your functions and graphs with the class.



Making Sense of FM

Set the window to (xmin=0, xmax=1, ymin=-5, ymax=5) initially for all the steps, but feel free to adjust them.

— Define ***myCarrier(t)=3*sin(2*π*10*t)*** and further let ***f1(x)=myCarrier(x)***.

— Graph ***f1(x)***. Relate what you see on TI-Nspire to the components of ***myCarrier()***. What if you change 10 to 20, to 50? You could zoom in and look at the graph in detail.

— What if you replace that “**10**” in ***myCarrier()*** with the following: 10+2*sin(2*π*2*t)? For convenience, define another function

Define ***freq(t)= 10+2*sin(2*π*2*t)***

Define ***myFM(t)= 3*sin(2*π* freq(t)* t)***

— Now graph ***myFM(t)***. You could let ***f2(x)=myFM(x)*** to graph it. What do you see in the graph? Explain why. You might adjust the numbers in ***freq(t)*** to see if the graph changes.

SAMPLES OF STUDENT WORK

Paying off a Car Loan

[This is a report submitted by one preservice student teacher]

Problem description

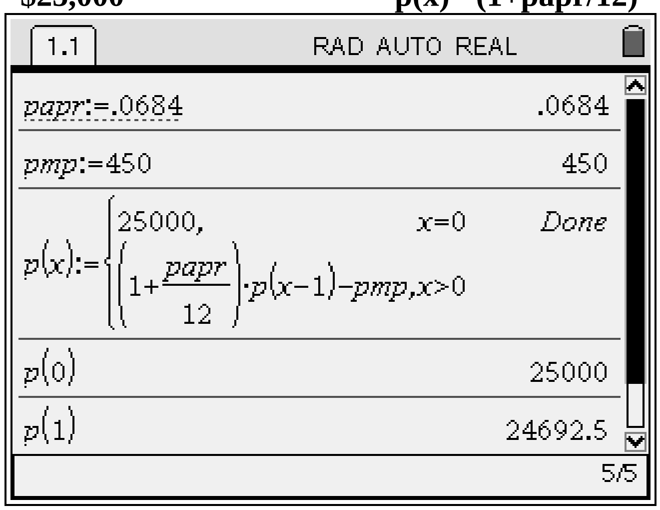
Patrick has just purchased a gas-saver car on a loan of $25,000 with $0 down payment. The loan carries an APR of 6.84%. Patrick plans to make a monthly payment of $450 until the loan is paid off. Please analyze how his account balance (debt) is going to change on a monthly basis.

Procedure

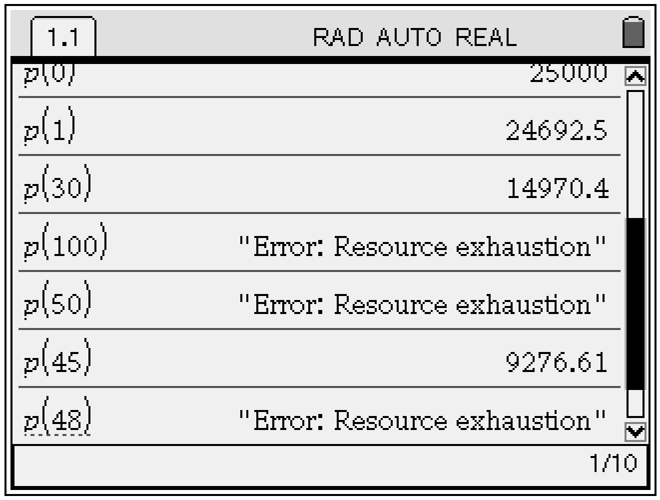
1. I created a new calculator page and defined the variables and constants.

   Let **papr=*.0684***, and **pmp=*$450*** and Let ***p(x)*** be the balance at the x-th **month**.

   Then, **p(0) = $25,000** **p(x) =(1+papr/12)* p(x-1) – pmp**



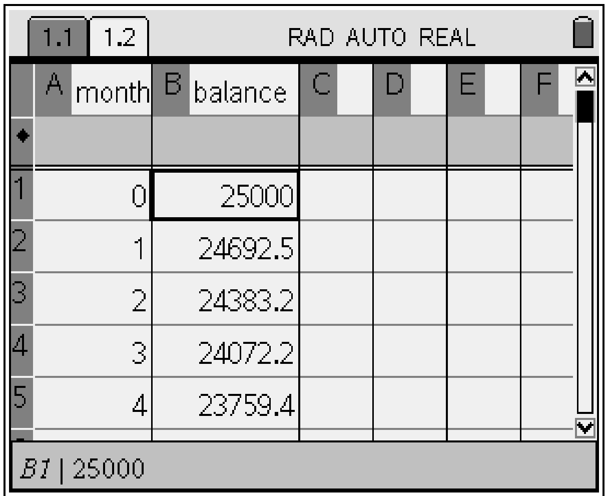
I checked Patrick's balance at the beginning, **for *p(0), p(1), p(30), p(100), p(50), p(45),*** and ***p(48)***.

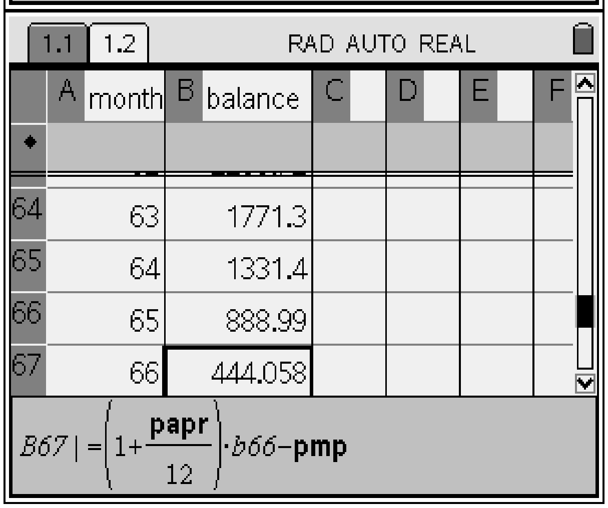


It seems to be that by ***p(48)*** the calculator is unable to calculate the balance; the calculator displayed "Error: Resource Exhaustion"

2. I then created a new List/Spreadsheet page. I made a table to show how ***p(x)*** changes on a monthly basis.

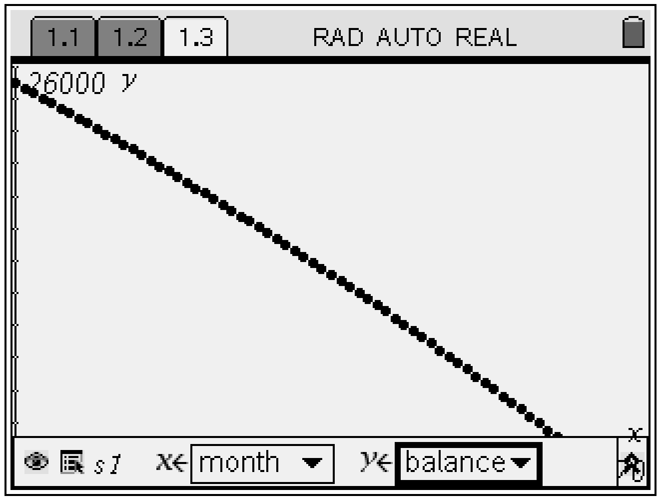
    - I labeled the column A, *month*, and column B, *balance*. Then I resized the columns so I could see the whole word.
    - In cells a1-a3, I put the numbers 0, 1 and 2. Then dragged it down to the 67th cell.
    - In B1, I typed 25000.
    - In B2, I typed "= **(1+papr/12)* B1 – pmp**. Then I dragged it down until the balance was below the monthly payment of $450, during the 66th month.



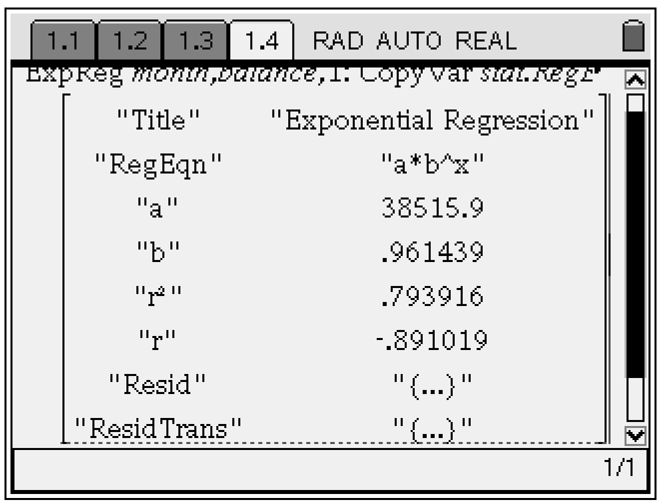


3. I created a new Graph & Geometry page to make a scatter-plot of the data in the table.

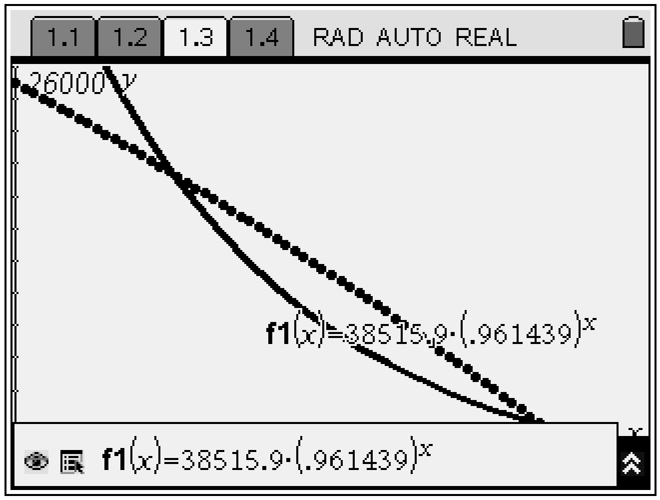
   - x = *month*, y = *balance*
   - I set the window settings: x min = 0; x max = 70; y min = 0; y max = 26000
   - The graph does look linear with a constant negative slope.



4. I created a New Calculator page. Based on the data in the table [*balance* over *month*], I conducted an exponential regression and stored the resulting function in ***f1***.



5. I went back to the Scatter-plot page and graphed ***f1(x)*** on the same page as the scatter plot.



The function does not look like the display of the data from the scatter plot at all. However both are still exponential functions.

Reflections

Time plays an important role when looking at exponential functions, especially when graphing. The shorter the time span the more linear the function will appear.

My experience with TI-*N*spire was good. For the most part I remembered the steps to solve the problem, except towards the end when I needed to do a statistical calculation of exponential regression, which made it hard for me to graph the line from that equation onto the scatter plot. That was basically because on the spreadsheet the balance went below the monthly balance which was at the 67^{th} month. However, to do the statistical test I should have only gone to the 66^{th} month when the balance was less $450.

Compared to the example in class, when it came down to plotting the line from the regression equation it did not look much like the scatter plot. But I believe I did everything correctly.

Solving this equation on this new piece of technology did have me stumbling through the problem for the simple fact that I'm not used to the device and sometimes need an explanation as to why something happens the way it does rather than it just being a simplistic command or operation that can solve problems.

Creating Various Graphing Representations using NBA Statistics

[This is a lesson plan developed by a preservice student teacher]

Overview

In this lesson, students use information from NBA statistics to make and compare different representations of the information provided in a box plot and histogram.

The data provided in the lesson come from the NBA, but you could apply the lesson to data from the WNBA or any other sports teams or leagues for which player statistics are available. You can also make comparisons between something other than salaries, such as weight, height, average baskets per game, etc.

Usually students are asked to analyze data by hand or use the graphing calculators to make computations. Using the TI-*N*spire Graphing Calculator students will be able to input the data and have the calculator construct various types of graphs using the data.

Topic

Mathematics: Data Analysis and Probability (6-8)

Standards Addressed

Data Analysis & Probability 6-8

1. Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.
2. Select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatter plots.
3. Discuss and understand the correspondence between data sets and their graphical representations, especially histograms, stem-and-leaf plots, box plots, and scatter plots.

Goals

Provide opportunities for students to use various forms of representation to analyze statistics

Specific Objectives

Students will:

- Collect data on the Top 20 NBA players' salaries
- Create a box plot
- Create a histogram
- Compare and analyze different representations of the data

Materials

1. Roster and salaries of the top 20 NBA players
2. TI-*N*spire Graphing Calculator

Prior Knowledge

Students should be familiar with interpreting and constructing a box plot. The concepts of minimum, maximum, median, upper quartile and lower quartile may need to be reviewed.

Students should know that a histogram graphically shows the center of the data, spread of the data, the skew of the data, presence of outliers and presence of multiple modes in the data.
The histogram differs from a bar chart in that it is the *area* of the bar that denotes the value, not the height, a crucial distinction when the categories are not of uniform width.

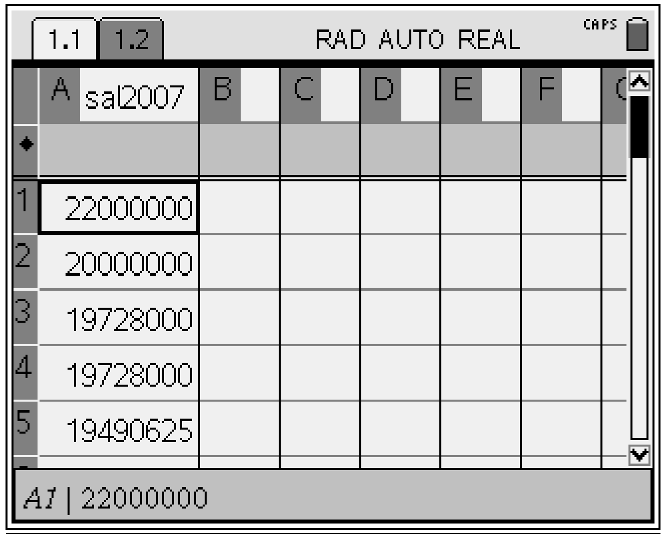
Procedure

1. Students will be given the information about the NBA players for 2007
http://www.insidehoops.com/nbasalaries.shtml

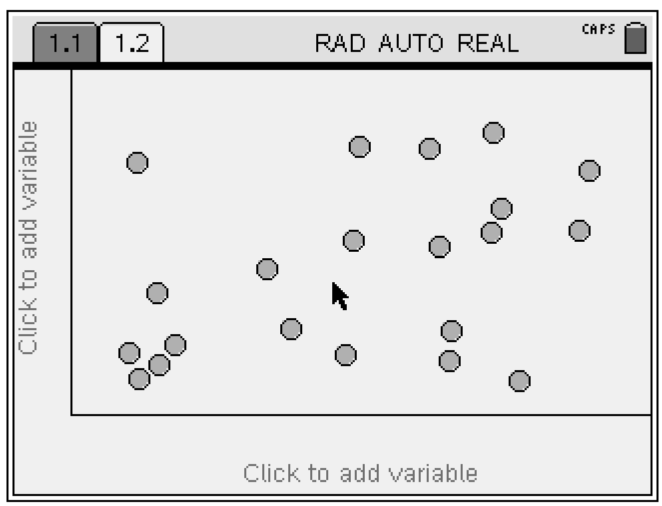
1) Kevin Garnett $22,000,000
2) Shaquille O'Neal $20,000,000
3tie) Jermaine O'Neal $19,728,000
3tie) Jason Kidd $19,728,000
5) Kobe Bryant $19,490,625
6tie) Allen Iverson $19,195,312
6tie) Stephon Marbury $19,195,312
8) Tim Duncan $19,014,188
9) Tracy McGrady $19,014,187
10tie) Baron Davis $16,440,000
10tie) Shawn Marion $16,440,000
12tie) Antawn Jamison $16,360,090
12tie) Dirk Nowitzki $16,360,090
12tie) Paul Pierce $16,360,090
15) Ray Allen $16,000,000
16) Ben Wallace $15,500,000
17) Sam Cassell $15,344,000
18) Rashard Lewis $14,884,951
19) Michael Redd $14,520,000
20tie) Amare Stoudemire $13,762,775
20tie) Yao Ming $13,762,775

SIDE NOTE: Students can work in groups or pairs throughout this activity, but make sure that they all use their calculators throughout the activity.

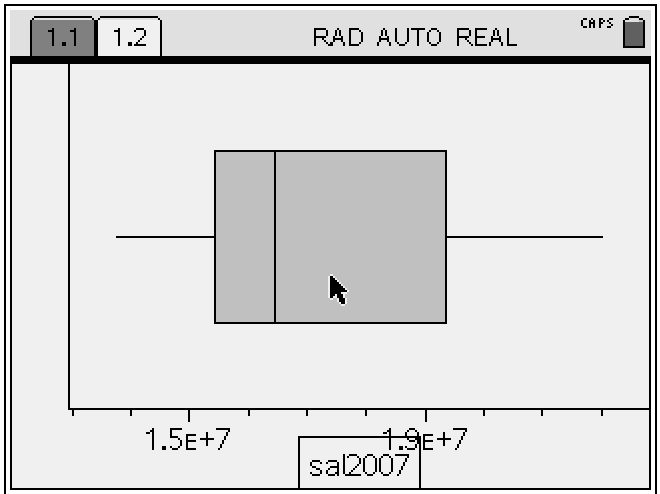
2. Students will then be asked to enter all the salaries into a list (spreadsheet) using the TI-*n*spire Graphing Calculator. Name column A, sal2007

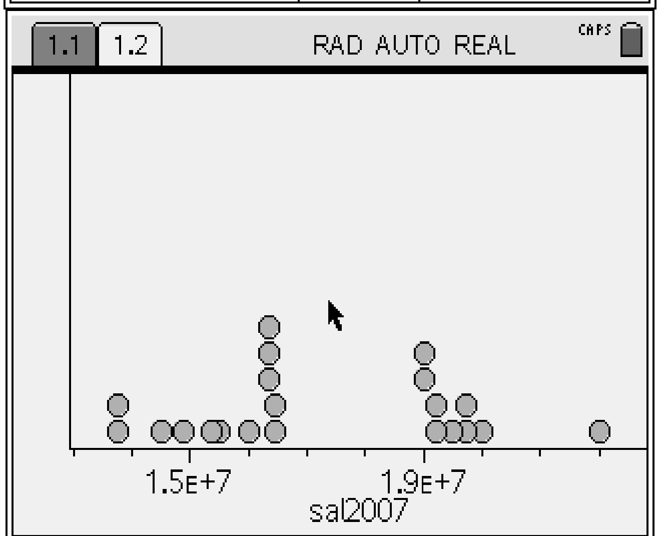


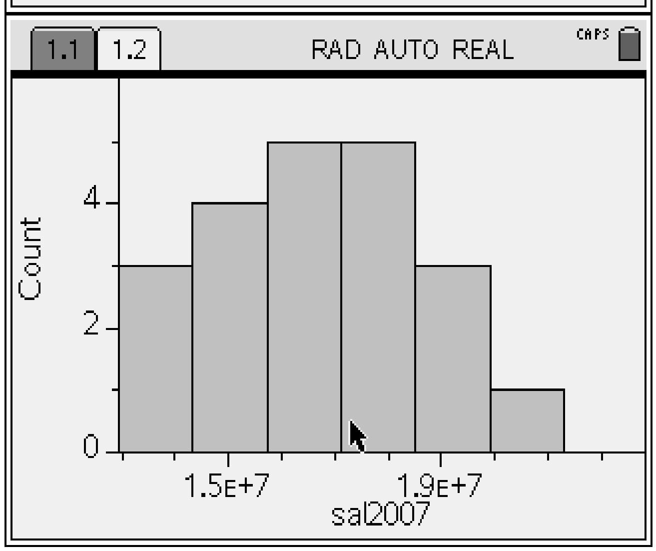
3. Create a new page for Data and Statistics.



4. Create a box plot, dot plot, and histogram for the top 20 NBA players' salaries for the year 2007.

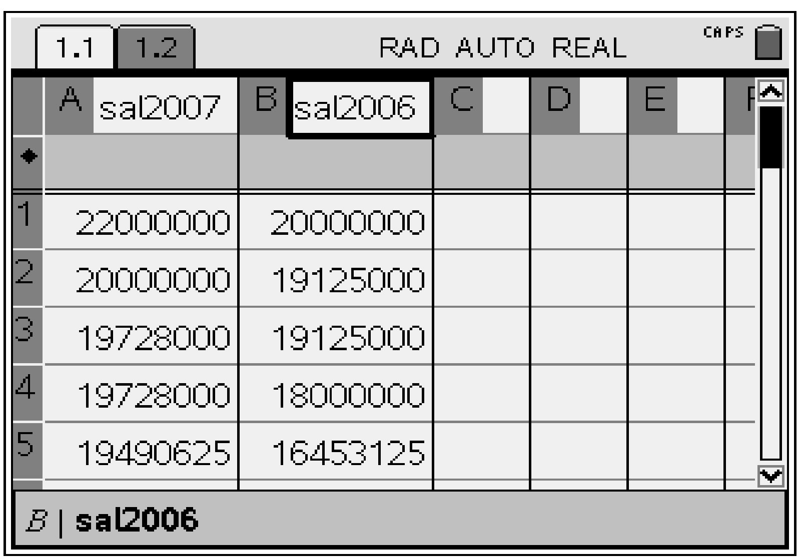

1.1
1.2
RAD AUTO REAL
CAPS
1.5E+7
1.9E+7
sal2007


1.1
1.2
RAD AUTO REAL
CAPS
1.5E+7
1.9E+7
sal2007

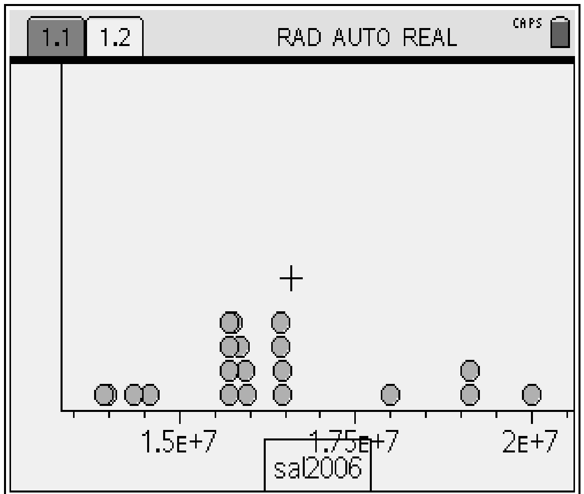

1.1
1.2
RAD AUTO REAL
CAPS
Count
0
2
4
1.5E+7
1.9E+7
sal2007

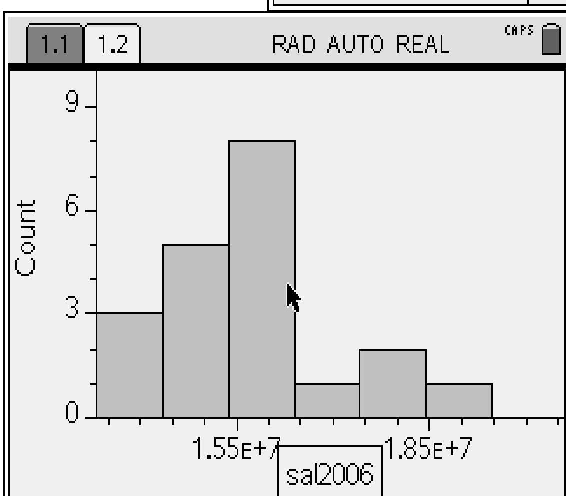
5. Enter the statistics in a new column. Name column B, sal2006.
http://www.eskimo.com/~pbender/misc/salaries06.txt

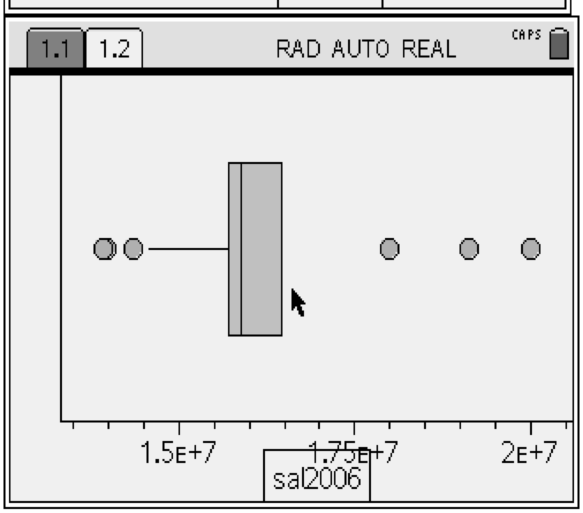
1. Shaquille O'Neal (Mia) $20,000,000
2. Allan Houston (NY) $19,125,000
2. Chris Webber (Phi) $19,125,000
4. Kevin Garnett (Min) $18,000,000
5. Allen Iverson (Phi) $16,453,125
5. Stephon Marbury (NY) $16,453,125
7. Jason Kidd (NJ) $16,440,000
7. Jermaine O'Neal (Ind) $16,440,000
9. Kobe Bryant (LAL) $15,946,875
10. Michael Finley (Dal) $15,937,500
11. Tim Duncan (SA) $15,845,156
12. Anfernee Hardaway (NY) $15,750,000
13. Grant Hill (Orl) $15,694,250
13. Tracy McGrady (Hou) $15,694,250
13. Jalen Rose (Tor) $15,694,250
13. Keith Van Horn (Dal) $15,694,250
17. Eddie Jones (Mem) $14,576,250
18. Brian Grant (LAL) $14,336,220
19. Tim Thomas (Chi) $13,975,000
20. Antonio Davis (NY) $13,925,000



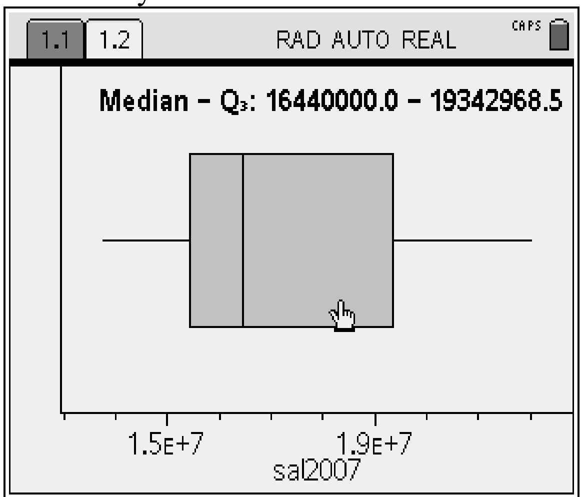
6. Create a dot plot, histogram and box plot of the NBA players' salaries for 2006.

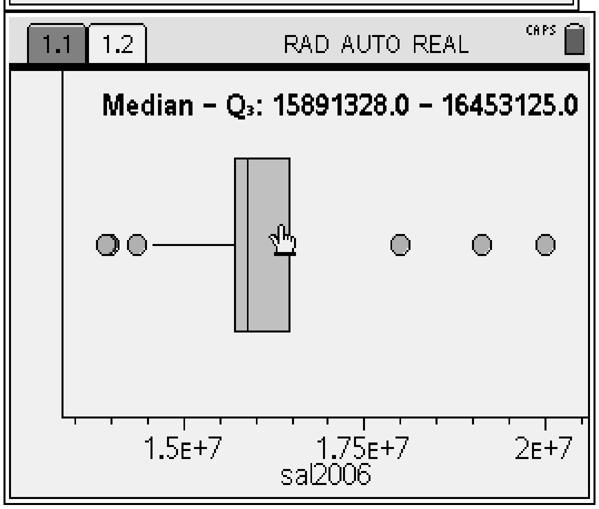




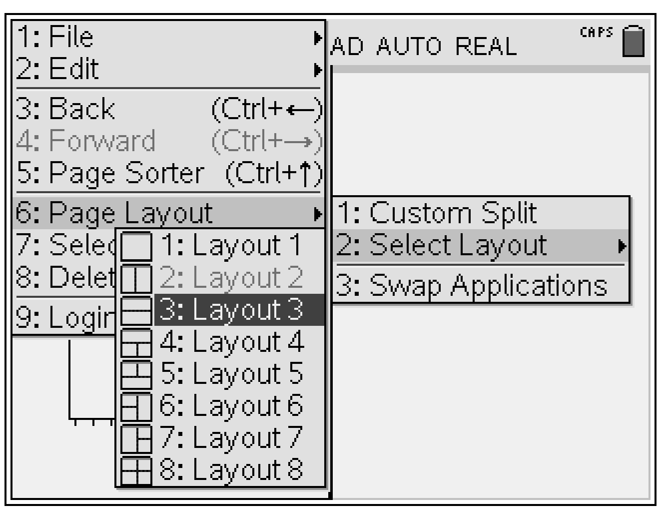


7. Identify the median for both data sets.

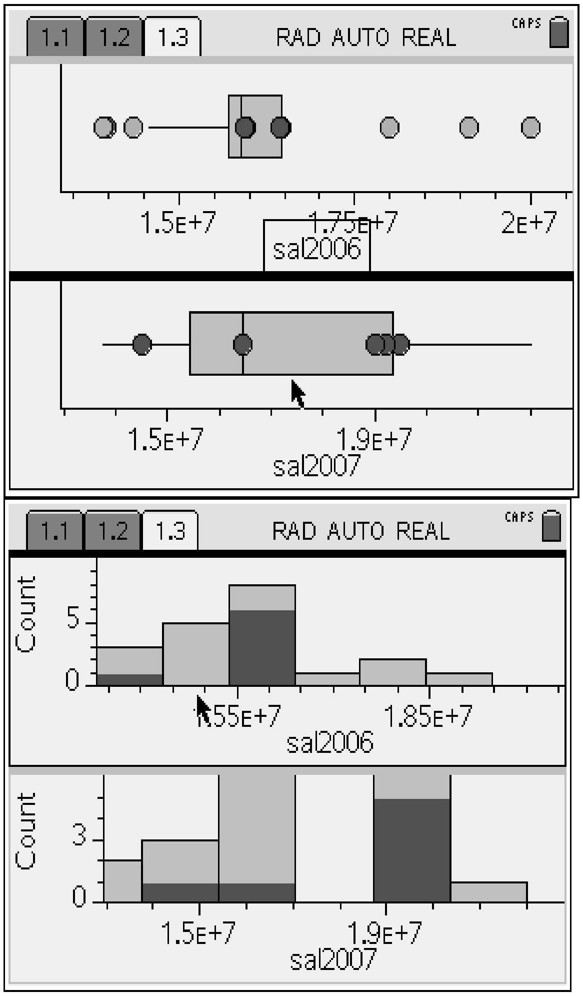




8. Change the page layout.



9. Have the students create a split screen for the box plots and histograms of the data.



Discussion

Have students draw comparisons between the 2 sets of graphs, regarding the mean, outliers, pros and cons for each type of graphical representations, etc.

Have students make predictions for the year 2007-2008.

Ask students about their experience using TI-*N*spire Graphing Calculator: useful, time-consuming, easy to adjust to, etc?

Assessment

Assessment is through informal observations throughout the lesson. Students will be assessed as they verbally answer questions during the class discussion. Students will then be asked to write a reflection on this lesson: creating and analyzing different graphical representations, as well as on the use of TI-*N*spire Graphing Calculator.

Accommodations

The lesson will be inclusive of all students by varying the settings in which students learn, calling on students' existing knowledge, observations, and experience, making the most of recurring problems and mathematical experiences, requiring students to learn through hands-on investigation, emphasizing how students' mathematics and language skills will benefit them in the future, allowing students to work as a whole group to understand new concepts and vocabulary and integrating technology.

LEP, IEP, ESE, ESOL students will be allowed more time to answer questions during the discussion and will be given extra time to complete their individual seatwork and their homework problems.

Teacher Reflection

Creating a lesson seemed difficult at first just because I did not know what topic I wanted to focus on, that could also incorporate the fascinating functions of the TI-*N*spire Graphing Calculator. I was inspired by a lesson that my own class had with the use of the calculator. I was actually fascinated with the split screen feature of the calculator so I figured I could create a lesson that included that feature of the calculator. I chose data statistics that I figured would be interesting to the students – basketball and money. By representing data in various ways you are able to organize, record, and communicate a mathematical idea, which makes it easier, at times, to solve problems. It is a way of modeling and interpreting data. Starting off the lesson was this hardest part. But once I got started I had fun creating the lesson plan. I have fun inputting the screen shots. Those would be so beneficial for others who would be using my lesson plan – just because they would know what to expect from the students throughout the lesson.