Issue 33, February 2014

HP Solve

Education solutions powered by HP

A new approach to teaching transformations in the plane

G.T. Springer

There's a new way students can be taught about transformations in the plane, including translations and reflections. Instead of the geometric approach, the HP Prime Advanced Graphing app allows us to take an algebraic approach.

Start graphing

Put the focus back on the students

Christi Cole

Teachers are redistributing the responsibility for learning and teaching to focus more on the student. Changing to a mix of formative and summative instruction can allow students to become more self-aware and in charge of their own learning.

Read more

HP Prime Connectivity Kit: Better engagement with students

Chris Olley

Engaging students in mathematical conversations is one thing, being aware of what students are doing and thinking while it's happening is another. HP Prime has a full suite of mathematical software to make this possible.

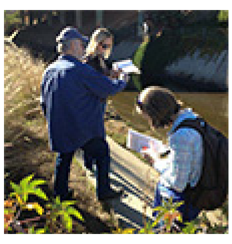
Engage

Incubators for Innovation: How the arts can foster collaboration

Laura Berlin

The arts can be accelerators of learning and innovation. Even among strangers from diverse backgrounds, arts-based learning strategies have the ability to develop amazing innovations.

Read more



Think strategically about teaching, learning and technology

Jim Vanides

For educators using technology, it's time to stop learning about apps and start learning with apps. Powerful learning experiences are not possible without the combination of great teaching and the right technology.

Learn more

Meet Namir Shammas

Customer corner takes a closer look at Namir Shammas. A native of Baghdad, currently residing in Virginia, Namir has a background in chemical engineering, programing and technical writing. He also enjoys collecting vintage models of HP calculators.

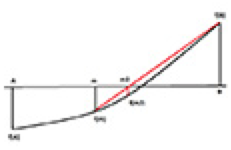
Read more

Seeking roots with the Bisection method

Namir Shammas

For centuries, solving for the roots of nonlinear functions and polynomials has been one of the cornerstones of numerical analysis. The Bisection method remains one of the simplest and slowest root-seeking methods.

See why



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A Prime Graphed Rose For You

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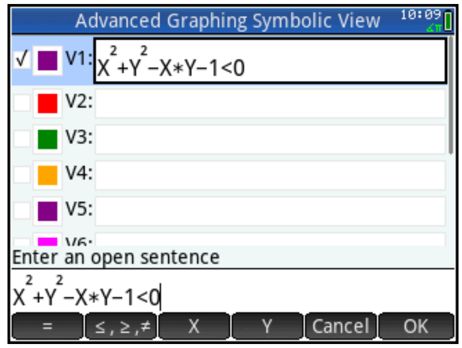
A Prime Graphed Rose For You

G.T. Springer

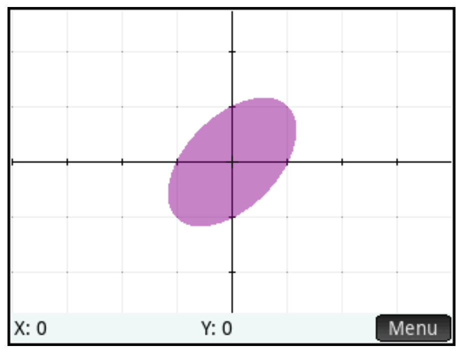
In this short article, we discuss how to use the HP Prime Advanced Graphing app to teach students about transformations in the plane, including translations and reflections. But instead of a geometric approach, the app allows us to take an algebraic approach. We start with a generic shape, which we then transform in various ways to build a picture of a rose.

We start by defining our generic shape, a filled ellipse, given by $x^2 + y^2 - x \cdot y - 1 < 0$.

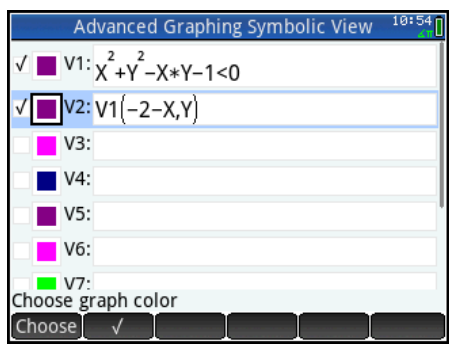
- Press Apps (Info) and tap the *Advanced Graphing* icon
- Enter the expression above into V1, using X and Y to help you
- Tap on the color picker for V1 and choose purple



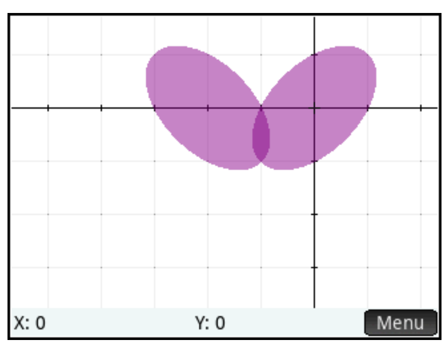
Press Plot (Setup) to see the graph of our ellipse. Press + to zoom in. This is the first "petal" of our rose.



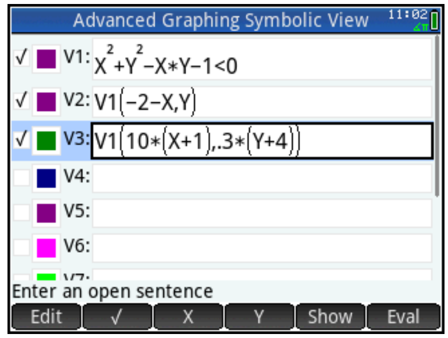
A reflection over the vertical line x=-1 is a mapping such that *x*→-2-*x* and *y*→*y*. So we define V2 to be V1(-2-x, y), as shown in the figure to the right. We use the same color (purple) for our reflection.



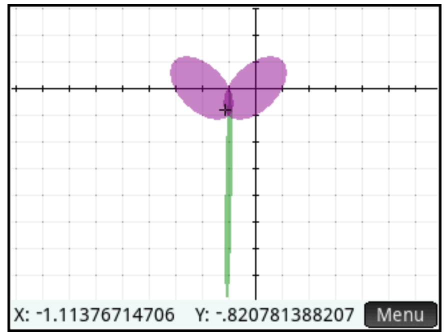
Press Plot (Setup) to see the second "petal"; tap and drag to scroll the view.



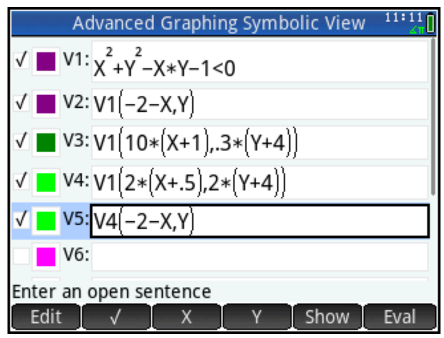
We need a stem for our rose. Creating a stem takes some experimentation. Students will learn to stretch the base shape first, then translate it into its final position. We defined V3 to be V1(10*(X+1),0.3*(Y+4)), as shown to the right. Do not forget to change the color to dark green!



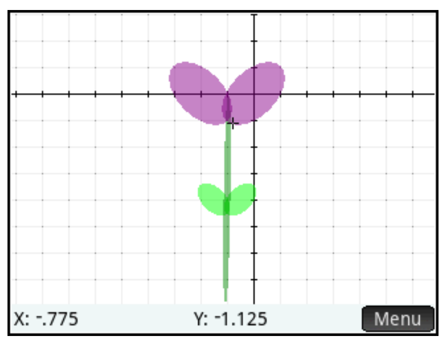
Again, press  to see the rose starting to take shape. Press w to zoom out and drag to scroll until you get the view you want.



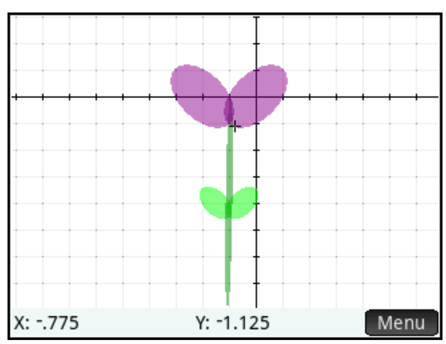
Next, we add some leaves. For the first leaf (in V4), we experiment as we did for the stem, first dilating and then translating to get what we want. Then the second leaf is the reflection of the first leaf, using the same method we used for the petals. We chose light green as the color for both leaves.



And now you have a simple rose!



For extra credit, we added two fancy petals and some thorns. The expressions are shown on the next page in case you want to work them out for yourself first!



Be sure to save your new app. Press Apps Info to go to the App Library; the Advanced Graphing app should already be highlighted. Tap Save, enter a name for your new app (we used ARose4You), and tap OK twice. The new app now appears in your App Library.

Getting the most out of your HP Prime Virtual Calculator for the PC.

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If you are using the HP Virtual Prime for the PC (it is on the product CD that came with your HP Prime), you can just copy and paste the expressions below into the virtual calculator. Then you can send the app from the virtual calculator to your physical HP Prime. The steps are listed below.

Advanced Graphing app expressions for the rose

V1: X^2+Y^2-X*Y-1<0
V2: V1(-2-X,Y)
V3: V1(10*(X+1),.3*(Y+4))
V4: V1(2*(X+.5),2*(Y+4))
V5: V4(-2-X,Y)
V6: Y+1>(X+1)^2 AND Y<1+COS(2*X+3)
V7: V6(-2-X,Y)
V8: V1(20*(X+.8),10*(Y+3))
V9: V8(-2-X,Y)

To copy the rose expressions to your HP Prime Virtual Calculator

1. Select and copy the expression named V1. Note: select and copy everything <u>after</u> "V1:"
2. On the HP Prime Virtual Calculator, go to the Rose app Symbolic view and select the field **V1**
3. In the menu bar, click on *Edit* and select *Paste*. The expression will be pasted into the V1 field.
4. Tap OK to accept the expression. It will now graph properly.
5. Repeat Steps 2-4 for the other expressions (V2-V9)

To send the Advanced Graphing app from your virtual calculator to a physical HP Prime

1. Connect your physical HP Prime to your PC using the USB cable
2. Turn on your HP Prime and launch the HP Prime Virtual Calculator for the PC
3. On the virtual Prime menu bar, click *Calculator*, then click *Connect To* and select your physical Prime
4. Go to the App Library, select the Rose app, and tap Send
5. The Rose app is now on your physical Prime and ready for viewing!

Formative Assessment in the Math Classroom

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Formative Assessment in the Math Classroom

Encouraging students to invest in their own learning

Christi Cole

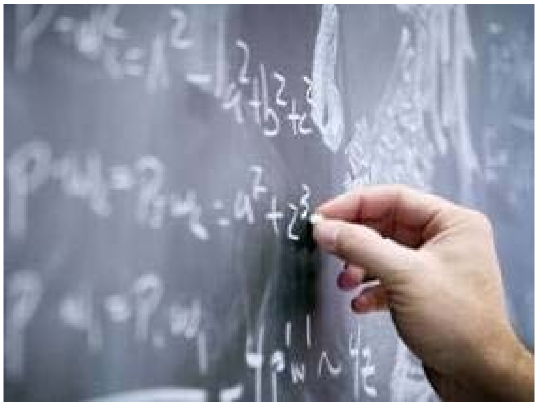

Fig. 1 – Math problem solving.

One of the most frustrating things a student can do in my class is receive a returned paper, look at the grade, and throw it in the recycling. Perhaps the learning is in the doing, so the returned paper is inconsequential, but if there are errors, the returned paper is a learning opportunity. What I really want students to understand is that math involves editing and revision, it's rarely perfect on the first try. In my search to motivate students to explore this revision process I have delved into the current trend of formative assessment.

Education as a whole, and math in particular, has been moving toward a more student-centered approach. Lorrie Shepard in her article "The Role of Assessment in a Learning Culture," wrote that there is an "emergent, constructivist paradigm in which teachers' close assessment of students' understandings, feedback from peers, and student self-assessments would be a central part of the social processes that mediate the development of intellectual abilities, construction of knowledge, and formation of student identities." In other words, teachers are redistributing the responsibility for learning and teaching to focus more on the student, allowing the student to have a role in both how they are taught and how they are evaluated. Two years ago, professional development at my school centered around formative assessment, focusing on just this principle. And, just as all good PD should, it started me thinking about how I organize my classroom. I examined my grading, my grade book and my feedback to students, and I made some changes.

If you talk to multiple people, including education researchers, you may find multiple definitions of formative assessment. For the purposes of my classroom, I identify formative assessment as anything that helps me to observe student learning and informs my instruction and improves their learning. Formative assessments help students to identify their strengths and weaknesses and target areas that need improvement. In addition, they help me to see where students are struggling and adapt my teaching to address problems immediately. Formative assessments are generally not graded, or have very low grade impact.

In contrast, summative assessment is used to evaluate student learning at the end of a unit or time period. It is usually attached to a point value. For years, In my classroom I used primarily summative assessment. Daily assignments were given a grade by me, projects were evaluated by me, quizzes were given a grade by me and exams were graded by me. Although students participated in the doing of the work, they never evaluated their own work. This has changed as I've moved to a combination of formative and summative assessment.

Therefore my students still have unit exams, and submit their assignments to be evaluated at the end of a unit. However, I wanted to find a way to encourage students in the revision process. First, I completely changed my grade book to reflect a student's progress per unit, organizing my grading categories by content, congruent triangles and parallel lines for example, rather than more general categories like homework, classwork and tests. Students could then see how they were progressing in a topic versus testing or homework. Then I went to work on my daily assignments.

I believe in daily practice in math. Currently, instruction and discussion of new topics take place in the classroom and assignments, perhaps begun in class, are completed subsequently outside of class. When students bring their assignments in on the day they are due, they take a few minutes at the beginning of class to ask questions, check solutions with a collaborative group and then self-evaluate their homework.

At the top of every assignment is a space to mark which problems they need to correct. To evaluate their

work, they use a rubric that includes the following terms: exceeding expectations, meeting expectations, approaching expectations and not meeting expectations.

It's been interesting for me to be able to see how students self-assess their understanding versus how I assess their understanding on a daily basis. Middle school students generally do not have a good ability to evaluate themselves. We spend a few days at the beginning of the year assessing sample work, deciding how you can assess your understanding, looking at the difference between conceptual and arithmetic errors and giving feedback. It's generally easier for students to do this for someone else, than do it for themselves. It takes practice, but it's a useful skill and one that allows them to find their areas of weakness and hopefully strengthen them.

One of my students reflected on their ability to self-evaluate, "At first, I didn't understand how to check my own work. I thought things were either right or wrong. Now I'm able to tell if I just made an arithmetic error and actually understand the concept or if I need help understanding the concepts." I believe the use of formative assessment has allowed me to encourage this self-evaluation, which is creating a more self-aware student, someone who can figure out how to build their understanding without having to always seek my evaluation.

After their evaluation, I collect it, examine their work and either record their self-evaluation or change it and add to problems they need to fix if necessary. This examination allows me to see if there are topics on which the entire group is struggling, or if an individual is struggling with a particular topic. This informs my teaching for the following day. I return the work the next day and students have until the end of the unit to revise their work, seeking help if they need it.

The expectation is that students will then take the assignment and revise it before turning it in at the end of the unit for a summative assessment. I have found that my students no longer check their grade when the paper is returned, because it was self-assigned. However, they do look at the problems that were missed, knowing that they can revise their work and increase their understanding. Before this system, I had very few students who revised their assignments, now, I have very few who do not.

One of my students said, "it takes the pressure off math homework. I try every problem but know that I will have time to fix my mistakes before I get a grade on it. It helps me to learn the material." I was concerned at first that I would have more students who did not turn in their work because it wasn't "worth" anything. However, I actually have more students who submit their work and I think it's due to exactly what the student above said: some of the pressure surrounding the assignments has been relieved. I believe that students better understand that the assignments are for their learning benefit, and not just for a grade and not just for me to get a grade in the grade book.

Fig. 2 – Engaged students as teachers want to see them.

In addition I feel that students have a better understanding of the material at the end of a unit. They've corrected homework along the way, solidifying the concepts and learning from their mistakes. One of my students explained, "I feel like I have a better understanding than I used to. I actually take the time to look over my work so that I don't make the same mistakes on the unit exam."

Changing my instruction from primarily summative assessment to a mix of formative and summative has allowed my students to become more self-aware and in charge of their own learning. I believe that they see more purpose in the daily work they are doing and engage more in the revision process. One of my students summed it up for me, "I like doing the math homework because it's fun to try out the problems. I'm not worried about the grade I'm going to get on the assignment the first time so I may take more risks." If I have a student telling me that they like doing the math homework, I think my experimentation with formative assessment is successful.

Dialogic Teaching with HP Prime Connectivity Kit

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Dialogic Teaching with the HP Prime Connectivity Kit

Advanced Pedagogy with the HP Prime

Chris Olley

In my classroom, I want to engage my students in mathematical conversations. I want to listen to their responses, take full account of them and react and respond accordingly. In my work in teacher training, I am struck by how often I watch a beginning teacher engage with their class and a student says something deep and insightful. Capturing that moment requires skill and knowledge, but it also requires an activity setting in which there is the opportunity to think deeply. Really good mathematical software provides the means to construct the dynamic and open activities that allow for deep thinking. The difficulty is for the teacher to be aware of what students are doing and thinking while it is happening.

HP Prime has a full suite of mathematical software to make the activities possible. Now with the HP Prime Connectivity Kit, the teacher can see the screen of all connected student machines updating regularly. The teacher is on the lookout for what Martin Gardiner referred to as Aha! moments. Those key break through points of mathematical insight. Now there is a choice, open a one-to-one discussion asking the student to describe or explain their thinking or maybe the whole class could benefit from seeing the student's screen and hearing their thoughts.

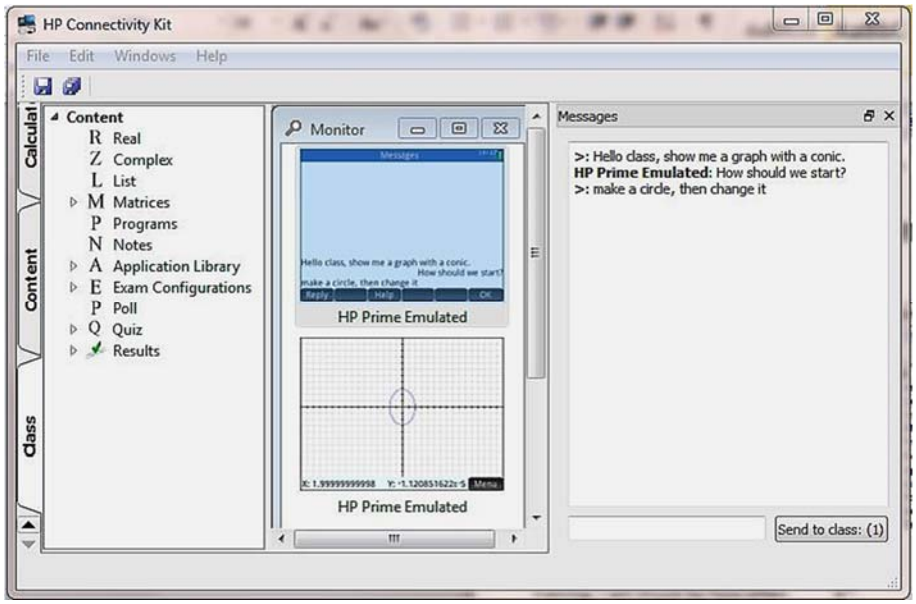

Fig. 1 – HP Connectivity kit screen.

To achieve this effect with other technologies has proved hard because of the enormous hardware and set up overheads. With the Connectivity Kit, you install software on the PC, connect HP Prime to the PC and that's it. The handheld is registered in the class and an updating screen shot appears. As of now, this works through USB cable connection. By the start of 2014, with the addition of a low cost dongle to plug in to the top of the HP prime, and a corresponding adapter for the PC (much like those used in wireless mouse and keyboard sets), the whole system will be fully wireless, with absolutely no set up.

I'm running two versions of the emulator so you can see my class of two students! We have a content pane which allows for the creation and sharing of content. We have the monitor pane showing the handheld screenshots and we have a pane to show messages between teacher and students, either individually or collectively.

I can send a task to the class and monitor the responses. No names are shown, so students are comfortable for their work to be on view. Students can send a reply or ask a question and I can respond personally to them.

Now use a 'Poll' to get feedback – see Fig. 2.

You can see that the handhelds all receive the question and can send back a response – see Fig. 3.

All of the responses are collected – see Fig. 4.

The student responses may be analyzed – see Fig. 5.

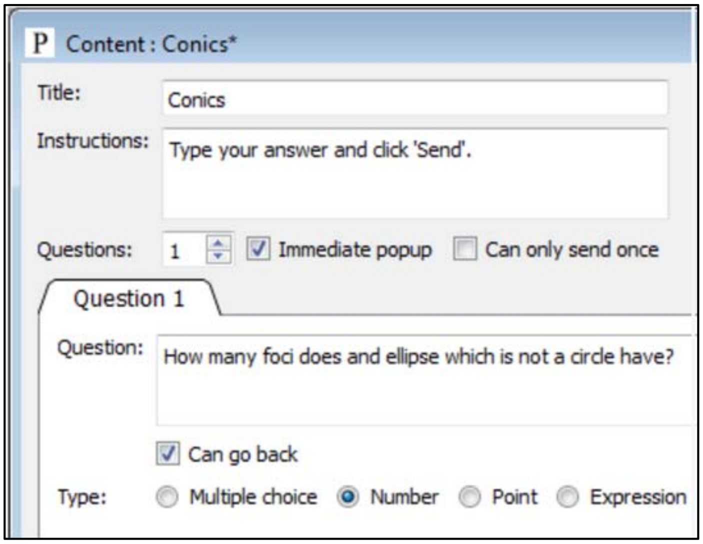

Fig. 2 – Sending a pole to the students

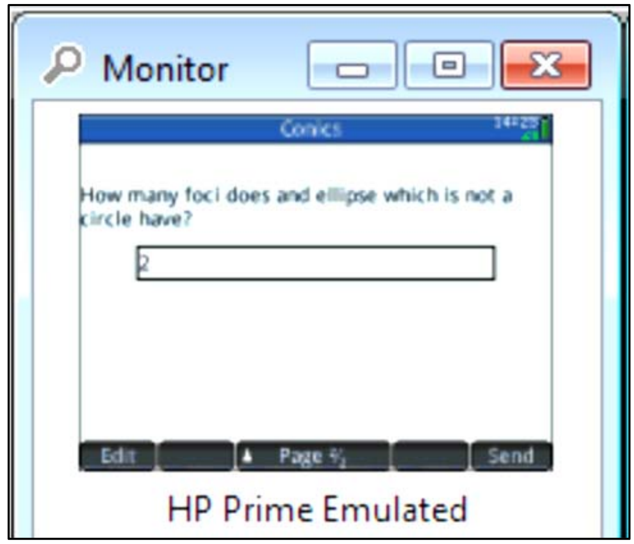

Fig. 3 – All student's machines received the pole

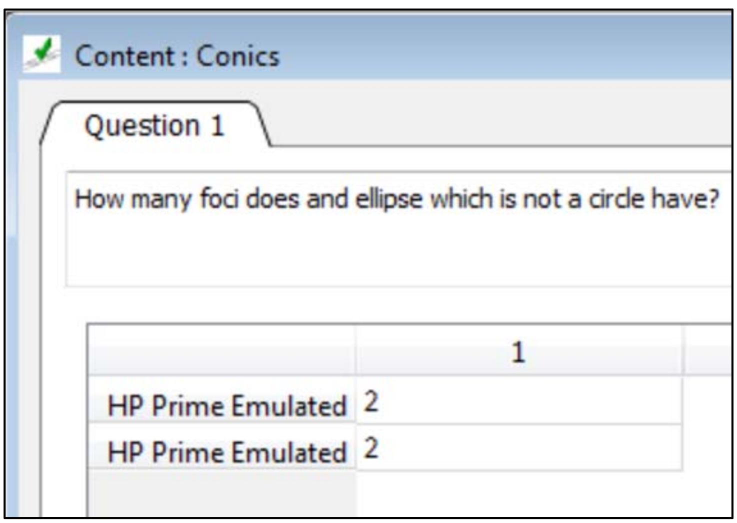

Fig. 4 – All (two) student's responses collected.

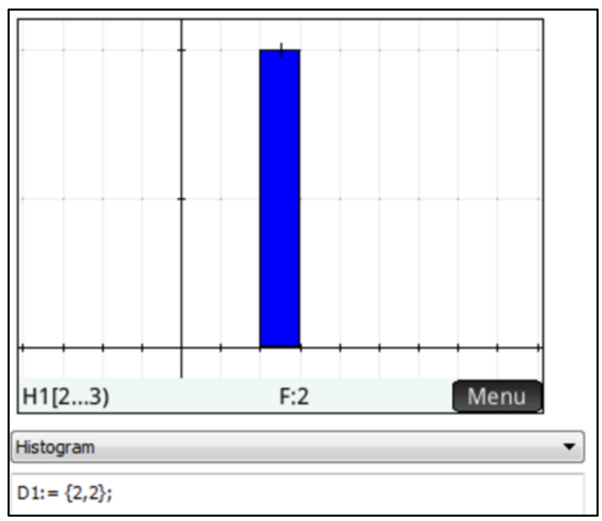

Fig. 5 – The student's data is analyzed.

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The essential feature is *no set up time*, we just get talking mathematically. The HP Connectivity Kit will be available in early February for use in your classroom.

For more information please contact HP's Calculator Business Development Manager, Enrique.Ortiz@hp.com.

The Art of Science Learning

The Art of Science Learning, Incubators for Innovation

The S.T.E.M. Project to Watch in 2014!

Laura Berlin

What happens when you put 100 people from diverse backgrounds and different age groups together on Saturdays to work on solving S.T.E.M. (Science, Technology, Engineering and Math) related civic challenges? If you teach them arts-based learning strategies and allow them to find and follow their enthusiasm, you get amazing innovation!

This is exactly what is happening within the "Art of Science Learning" project developed by musician and scientist Harvey Seifter. This is a multi-million dollar project funded by the National Science Foundation. It involves three major U.S. cities, San Diego, Chicago, and Worchester, Massachusetts to test the theory that the Arts; music, theatre, dance, and visual arts, foster innovation, collaboration, communication and better understanding of complex math and science concepts.

Fig. 1 - Harvey Seifter listens to John Szakcas explain metaphorming.

Phase 1 of the project was carried out in the spring of 2012. "Building Communities of Practice" convened more than 400 scientists, artists, educators, researchers, business leaders and policy makers at the Smithsonian Institute, Illinois Institute of Technology, and Calit2 at UCSD in San Diego. These groups collaborated to explore connections among arts-based learning and scientific innovation. Their findings were applied to the development and organization of Phase 2 of the project, "Incubators for Innovation". This phase began in the fall of 2012 by building public awareness of the project, then soliciting public input and selecting participants.

Now selected, Incubator participants in all three cities will carry out a yearlong collaborative endeavor. Important outcomes will be a national arts-based curriculum for science and math, documented research on how integrating the arts into S.T.E.M. education and practices influences innovation, and the development of new products, services and educational programs. The project will study, specifically, the effect of integrating arts-based learning strategies such as ideation, improvisation and ensemble thinking with science, to create solutions to difficult civic challenges. The three collaborating cities have set up operation centers or "Incubators for Innovation" in major cultural institutions and have selected challenges that were actually voted on by the citizens of each city. The San Diego center is the Balboa Park Cultural Partnership and its challenge is "Water, the mismatch between supply and demand". San Diego was the first to launch its Innovation Incubator this past October 12th. Chicago was next and launched on January 11th. The Chicago Museum of Science and Industry is Chicago's host and its challenge is "Urban Nutrition". Worchester will begin its program in April using the "EcoTarium", the city's Science and Nature Center, as its base. Its challenge is "Alternative Transportation".

San Diego's 100 participants submitted applications last June, 2013, and were chosen by the end of the summer, becoming "Incubator for Innovation" Fellows. Gathered from people currently living and working in the San Diego and Tijuana regions, The San Diego Incubator is composed of people with a wide variety of interests, backgrounds, ethnicities and expertise. There are scientists, engineers, artists, teachers, computer programmers, mathematicians, administrators, business people, community activists, authors and outdoor enthusiasts. There are high school students, college students, working and retired professionals. There are people from all over the world and, also, San Diego natives. There is one thing, however, that each of the Innovation Fellows has in common. That thing is Passion! They all have great passion and commitment for what they do and for making San Diego and our world a better place. The Innovation Fellows do not get paid. They are volunteering their efforts and time in the interest of science, art, learning and our futures in this changing world!

Since October, led by founder Harvey Seifter and San Diego director, Nan Renner, San Diego "Fellows" have been meeting on Saturdays, learning together and working together. They have gone through training by national and local expert faculty in visual and performing arts-based strategies. They have been practicing the application of these strategies to S.T.E.M. related learning and "practice" civic challenges. Some Incubator members, doubtful, at first, of the value of this process, were told to "suspend their judgment", be open-minded and give this arts-based process a chance. And so they have. In doing so, they have learned to use sculpture and "metaphorming", jazz music, chamber music and ensembles, movement, dance and choreography, improvisational and experimental theater, narration, storytelling and poetry, surrealism, observational drawing, illustration, collage, muraling and photography………all to better understand complex concepts, processes and express and communicate ideas!

Fig. 2 – Sculpture making to express concepts and processes.

Now, three months later, almost all skeptics have been quieted. There is incredible collaboration and innovation happening! Now, Innovation Incubator Fellows are ready to apply what they have learned to San Diego's Civic Challenge, "The mismatch of our water supply and demand". The group has already identified many opportunities for innovative products, services, and educational programs to address this dilemma. They will narrow these down to the 10 ideas that have the greatest potential for success and impact on the problem. The ideas developed must involve S.T.E.M. disciplines and be truly new and innovative. The fellows will divide themselves into 10 groups to work on these solutions, based on their own interests. Each group will be given mentors and experts that will, in the coming months, support them in the design, development, and marketing, business planning and testing of their ideas. By October, 2014, many of these innovations will be launched to market!

This National "Incubators for Innovation" project will attempt to document what a growing number of people already suspect; that the Arts are accelerators of learning and innovation. This notion is starting to be taken seriously. The January 5th, 2014, *San Diego Union-Tribune* newspaper named Nan Renner, San

Diego's Innovation Incubator Director, as one of San Diego's ***"People to Watch" in 2014***!

In the article, Renner who is an artist and scientist with a "cognitive science" doctorate from UCSD, explains, "*when you get people engaged in doing and making and interacting with each other and the world, that opens up a wider range of possibilities in terms of creativity and learning.*" She continues, "*It's going to take more than one 'Art of Science Learning' project, but this project, in building the evidence base that the arts make a difference, could have a big impact in education and where we choose to invest our money in education, and what we think about creative collaboration.*"

Fig. 3 - Field measurements along Pueblo watershed.

The project directors have incorporated public events in to the meeting schedules of the Incubators for Innovation. On December 14, interested San Diegans joined San Diego Incubator Fellows in a field study, mapping and measuring at a variety of locations along the San Diego Pueblo Watershed.

On January 25, the public is also invited to join the San Diego Incubator in learning about "The World of Water – Ecosystem, Infrastructure, and Innovations" from experts in the field. This will take place at The San Diego Natural History Museum from 10 :00 am – 2:00 pm. For free admission to this event:

Register to WATER: In Search of Solutions.

https://docs.google.com/a/bpcp.org/forms/d/13LmrP-pHLz-hkIDYHRZExsOdVHeBEEXxCj9Sq-MgyfE/viewform

During March through September there will be multiple public prototype galleries and showcases. Finally, on October 20, 2014 there will be a "Water Innovation Demo" open to the public to introduce and display "Incubator" developed innovations that have made it to "market launch". More specific information about dates, locations, times and content of these public events can be gained by contacting The Art of Science Learning project at www.info@artofsciencelearning.org or The Balboa Park Cultural Partnership at www.bpcp.org , (619) 232-7502 ext. 1210.

Nan Renner is the Director of San Diego Incubator for Innovation.

Amanda Sincavage is the San Diego Incubator Administrator.

Aly Evans is the National Project Manager.

Harvey Seifter is the Founder, Principal Investigator and National Project Director

Do the Arts really have the power to foster greater understanding, collaboration, communication and innovation? Do music, theatre, dance, and visual art really have value in science, technology, engineering and math learning?

Continue to follow and watch, the "Art of Science Learning" Incubators for Innovation project and you are sure to find out!

Personal Note:

I became interested in the "Art of Science Learning" project in the Spring of 2012 when I learned about it at a "STEM Education Economics and Equity" seminar in San Diego. I became personally involved after I became a fellow this October. So far it has been an amazing experience - if not life changing, certainly life enriching.

About the Author

Laura. Berlin is a visual arts teacher and department head at Clairemont High School in San Diego. She holds Single Subject Teaching Credentials in Visual Art and English and a Master's Degree in Technology and Learning. Her current interest in in the "Art of Science Learning" project.

“Learning about Apps” to “Learning with Apps"

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Transitioning from "Learning about Apps" to "Learning with Apps"

Jim Vanides

It's an exciting time for technology using educators, with an abundance of choices and apps. But before we get app-a-plexic (or app-athetic), let's take a deep breath and remember that it all starts with "learning".

While the technologies continue to change, my general framework for thinking strategically about teaching, learning, and technology still applies.

Step 1) start with what's not working

We're surrounded by "education standards" and learning objectives; we're also surrounded by data – albeit sometimes not in the right form or at the right time to be entirely useful. What is sometimes missed is the students. We don't have to wait for standardized tests in the spring to know that for some students, "schooling" as they're currently experiencing it doesn't work for them.

The first question is not, "What apps are good for 5th grade?" Rather, the first question should be, "Are all my 5th graders ap-t (sic) to succeed?" Using all the data at our disposal, from formal assessments, to student-produced work that demonstrates mastery, to attendance rates, discipline rates, and simple qualitative indicators, we can and must articulate what's not working and for whom. These are the challenges worthy of our laser-focused efforts.

Step 2) verbs before nouns

I first blogged about this back in 2005, then repeated in 2009 with "Successful EdTEch: First the Verbs, then the Nouns". This framework is based on a memorable conversation with my friend and education colleague Dan Gilbert, who worked with Stanford faculty who were attempting to use the Stanford Wallenberg Hall high tech experimental classrooms. The most common first reaction was something akin to "deer in the headlights" – frozen when confronted by a vast array of technology.

Dan began to explain, "Think about the VERBS first" – the actions and activities of students and teacher/facilitators. Once they articulated what the desired experience would be, then he could set about helping to identify what the NOUNS (technology) needed to be to create and support these experiences.

Great teaching has always been about "powerful experiences" best described by verbs, so it's no wonder that Common Core and the Next Generation Science Standards are emphasizing "higher order thinking" and other active learning verbs.

A few of my favorite verbs

Whenever I get asked, "What are some of your favorite technologies for learning?" I find myself talking about experiences. Core to these experience of some of my favorite verbs:

***Accessing* Caring People –** Sure, access to information is good, but access to great people is even better. Students, especially those who are struggling, benefit tremendously from caring mentors, tutors, coaches, experts, and peers – from all around the world. For students with a personal learning network like this, there is no stopping them from exploring their interests and catapulting their careers in exciting and meaningful directions.

***Collaborating* in (international) Teams –** Most, if not all, of the great challenges facing society will require collaboration to solve. We also know that the most memorable, high-impact learning experiences are challenge-based, problem-based activities that involve students in addressing real issues in their community and around the world – and in this flat, global economy, problem-based-learning in a context that requires international collaboration is even more rewarding (see "4 Reasons Why Global Fluency Matters – an open letter to 6th graders everywhere"). Let's prepare our students for the REAL 21st century where global fluency is the next resume differentiator.

***Creating* (not consuming)** – I first heard this mantra from Larry Rosenstock, founder of High Tech High in San Diego, California. When I asked, "What role does technology play at your schools?", he replied, "Students should be creators, not consumers…" It's not sufficient to memorize answers to questions in the back of the chapter. The world (and the world of work) needs graduates who can think and can create solutions to real challenges; who can not only write to pass the test, but can publish to change minds and shape society; who can not only recognize works of art, but can exercise extraordinary creativity to create art that helps us remember our humanity.

Inquiring* and *Investigating – Science is greatly misunderstood. Let's let our students in on a little secret: Doing science is not about following a recipe that gets us to "the right answer" before the bell rings. Real science starts with wondering – and in many ways, begins with NOT knowing. Allowing our students to explore and wonder unlocks their curiosity; technology allows them to more deeply inquire and investigate, unlocking real scientific experiences.

STEP 3) IDENTIFY THE NOUNS (technologies)

The goal in the end is to create powerful learning experiences that solve the challenges described in STEP 1. More often than not, these experiences are ones that would not have been possible without the combination of great teaching (verbs) and the right technology (nouns).

As an advocate for the transformation of STEM(+) learning and teaching, I've been a big supporter of pen-based computing. It started with grants to educators a decade ago when when "tablet pcs" were convertible laptops with high-resolution digitizing pens and screens. For STEM(+) subjects, drawing diagrams and graphs is a natural – and sometimes the only way to have a meaningful math/science/engineering design discussion. When it comes to STEM(+) learning and teaching, even simple software becomes immensely important (see "5 Easy Tablet PC Tips" circa 2007-2009).

But the nouns have continued to evolve – so I will follow up this article with **Part 2: My Favorite EdTech Nouns (and why).** If you'd like me to include some of YOUR favorite EdTech nouns, tweet me @jgvanides and tell me what and WHY...

About the Author

Jim Vanides is a member of the HP Office of Global Social Innovation, responsible for worldwide education philanthropy strategy and programs. This includes the 2010 HP Catalyst Initiative (www.hp.com/go/hpcatalyst) and the 2009 HP Innovations in Education initiative, a $20M investment reaching schools, colleges, and universities in 26 countries. In addition to authoring the blog, "Teaching, Learning, and Technology in Higher Education" (www.hp.com/go/hied-blog) he is a contributing author on the K12 education blog, Guide to Digital Learning Environments (www.guide2digitallearning.com/blog). Jim's past work at HP has included engineering design, engineering management, and program management in R&D, Manufacturing, and Business Development. He holds a BS in Engineering and a MA in Education, both from Stanford University.

Meet Namir Shammas

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Customer Corner

Meet Namir Shammas

Editor's note. Customer Corner has appeared in past issues of ***HP Solve*** where we interviewed the worldwide users of HP's calculators. Past interviews have been of users who live and work in the US, UK, Canada and Germany. We now go to Richmond Virginia for our next interview.

***HP Solve*: What is your background?**

Namir: I am a native of Baghdad, Iraq. I attended an elementary school run by *the British and a high school that was run by American Jesuits from Boston College. I came to the US in late 1978. I speak Arabic, French, and English.*

***HP Solve*: What did you study at school?**

Namir: I studied chemical engineering at the University of Baghdad and at the University of Michigan.

***HP Solve*: What is your occupation?**

Namir: I am retired now. I have worked in the water treatment business, writing programming language books, and writing technical documentation for corporations.

***HP Solve*: Do you do much traveling?**

Namir: I have traveled a lot since childhood. My parents felt that traveling was a form of education one cannot get in school. I still travel a lot now with my wife and visit various countries and continents. We visit places I never thought I would ever see. I used to travel for a water treatment company and take my HP-41C and its accessories with me.

***HP Solve*: Have you noticed anything interesting about calculator usage during your travels?**

Namir: While living in Paris in 1978 I did see HP promoting the HP-34C (and other HP models) in some local electronics shows. Once the PCs became more popular, I saw less of calculators while traveling.

***HP Solve*: When were you first exposed to HP calculators?**

Namir: I learned about the HP-65 in 1974, while still in Iraq, when my brother showed me a two-page advertisement for that machine in a French business publication. I had never heard of HP before that. The notion of a personal programmable machine captured my fascination. I was determined to buy one from Europe by 1975.

***HP Solve*: When did you first see or use an HP calculator?**

Namir: Since HP calculators were not sold in Iraq, I actually never saw an HP calculator until I bought one from Switzerland in 1975. In 1974 I did borrow the manual of the HP-35 from a local friend to learn about that machine, learn about working with the stack, and understand RPN (Reverse Polish Notation).

In mid-August 1975, I arrived in Switzerland for vacation. My family (who was already there) handed me fliers for the HP-65, HP-45, HP-21, HP-25C, and the HP-55, right out of the airport! I carefully studied the features of each machine to decide which one to buy. On August 22, 1975, I bought an HP-55 from the Geneva airport. I learned to master the HP-55 and use it well in my chemical engineering studies.

***HP Solve*: What machine did you buy after your first?**

Namir: I was able to buy an HP-67 while still in Iraq. HP had an office there to sell minicomputers to the government. I ran into an HP calculator salesman (who was an Iraqi working out of Athens, Greece, then HP's center for Middle East sales). The salesman, who was impressed of my use of the HP-55, agreed to sell me an HP-67 calculator.

***HP Solve*: What HP calculators have you used since?**
Namir: I have used many HP calculators since. The long list includes the HP-41C, HP-41CV, HP-41CX, HP-29C, HP-33C, HP-34C, HP-42S, HP-71B, HP-75C, HP-48SX, HP-48GX, HP-49G, HP-50G, HP-32SII, HP-33s, HP-35s, HP 39gII, and the HP Prime. Recently, I have collected the emulators for many of these machines running on the Apple iPad and the Android tablets.

***HP Solve*: What have you used your calculators for?**
Namir: I used HP calculators for college, work in water treatment, and in exploring statistical and numerical algorithms.

***HP Solve*: Does your calculator usage involve more than your profession?**
Namir: Yes, I program calculators to implement legacy numerical analysis algorithms as well as try new methods that I develop. Since vintage calculators are slower than PCs, the speed of these algorithms becomes very tangible. Thus calculators are excellent computing devises that give you a very good feel for the speed and efficiency of numerical/statistical calculations.

***HP Solve*: What was the largest problem you have solved with an HP calculator?**
Namir: A few years ago, I developed a 400-page statistical pac for the HP-35s. The programs in this pac were a complete rewrite of a comprehensive set of statistical pacs and user library solutions for HP-65, HP-67, and HP-41C. I also added a few new statistical programs to take advantage of the HP-35s' large memory and ability to pack multiple numbers in each stack/memory register.

***HP Solve*: What are you currently using HP calculators for?**
Namir: I use HP calculators to test legacy numerical methods, regression analysis calculations, and testing new numerical methods.

***HP Solve*: What appeals to you about HP calculators?**
Namir: I enjoyed the quality of HP calculators, the support for RPN, expandability of certain HP calculator models, and the availability of rich sets of functions - HP typically stays ahead of the pack.

***HP Solve*: Do you have a website?**
Namir: Yes at www.namirshammas.com. My web site has a lot of postings for HP calculators.

***HP Solve*: What are the important aspects of your website?**
Namir: New algorithms that I develop and also material for HHC presentations that I make.

***HP Solve*: Do you write or post calculator articles on your website?**
Namir: Yes I do.

***HP Solve*: Can you explain in more detail?**
Namir: I post programs for HP calculators, present programs for vintage pocket computers that work with BASIC, list new algorithms that I design, and offer free tutorials for the open-source R statistical language.

***HP Solve*: Have you had contact with HHC?**
Namir: Yes of course. I have been a member of PPC, CHHU, and now HHC.

***HP Solve*: How many HHCs have you attended?**
Namir: About nine conferences in the last ten years.

***HP Solve*: What have you gained from the HHCs?**
Namir: HHC conferences are wonderful for fellowship with like-minded calculator enthusiasts. I often present new numerical and statistical algorithms to HHC attendees - an ideal audience for me. In addition, HHC is a wonderful place to learn about new HP calculators.

***HP Solve*: Do you have a calculator collection? How extensive is your collection?**
Namir: I have a little museum of vintage calculators at home. My collection includes all scientific and programmable HP calculators.

***HP Solve*: Do you have any "special" HP calculators?**
Namir: I have the HP-41CL that contains a special board created by Systemyde. The HP-41CL contains just about all of the pre-programmed ROMs that HP made. Another special calculator is the WP34S which is a repurposed HP-30b (or HP-20b) calculator that implements a superset version of the HP-42S. The WP34s was created by Walter and Pauli.

***HP Solve*: What does your family think of your interest in calculators?**
Namir: They think that I am an eccentric "genius". I am just a dedicated low-level math/stat hobbyist. You can think of me as a hobbyist astronomer competing with professional astronomers. Even hobbyist astronomers sometimes discover heavenly bodies in our wide cosmos!

***HP Solve*: What kind of HP calculator would you like in the future?**
Namir: The HP Prime is a step in the right direction since it brings with it an amazingly rich set of functionality. I would like to see Wi-Fi-enabled HP calculators that run Matlab-like software or R-like statistical software.

***HP Solve*: What other HP calculator related projects have you worked on?**
Namir: Last year I published four HP 39gII programs in ***HP Solve***. These programs demonstrated the power of the HP-39gII in performing amazing sets of regression modeling. The good news is that these HP 39gII programs are completely compatible with the HP Prime.

***HP Solve*: Do you have any additional comments that may be of interest to *HP Solve* readers?**
Namir: Students and professionals who are interested in using programmable calculators can perhaps best benefit from a Wiki site where they can locate material they need. While ***HP Solve*** keeps its readers updated with news about HP calculators and their applications, a Wiki site would serve as a wonderful repertoire of applications and techniques that can serve the readers for a long period.

30. ***HP Solve*: Thank you for spending your time with us**.

The Birth of an Algorithm

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The Birth of an Algorithm

Namir Shammas

Introduction

Solving for the roots of nonlinear functions and polynomials is one of the cornerstones of numerical analysis. Over the centuries, mathematicians have developed new root-seeking algorithms and refined existing ones. The Bisection method remains one of the simplest and slowest root-seeking methods. Numerical Analysis books still discuss the Bisection method mainly for historical reasons. The method's main virtue is that is it guaranteed to obtain the root in proper ranges of values that contain a root.

This article shows you how to start with the Bisection method and create a new version that significantly accelerates the rate of convergence to a root value. The process is iterative. You will see a few design choices—ones that work and one that does not. I will present implementations for the HP Prime graphing calculator.

The Bisection Method

The Bisection method implements a simple idea. Given a root-bracketing range [A, B] and a function f(x) = 0 that is continuous in that range, the method iteratively shrinks that root-bracketing range. The basic idea as follows:

- Pick a point m inside the range [A, B]. The best choice for m is the median of that range.
- Calculate the value of f(m).
- Compare the signs of f(m) and f(A). If the two functions have the same sign, then replace A with m. Otherwise replace B with m. This step reduces the size of the root-bracketing interval by half.
- Repeat the above steps until the absolute difference between the updated values of A and B is equal and/or below a small tolerance value. This tolerance value reflects the accuracy of the calculated root.

We can calculate the number of iterations required to reduce the initial root-bracketing interval into one equal or less than the tolerance value. The estimated number of iterations is approximately log(|B-A|/tolerance)/log(2). This is a unique feature of the Bisection method. The implementations of the Bisection method usually store the values of f(A) and f(B) to avoid recalculating them in subsequent iterations. In the range-reducing step, the stored value of f(A) or f(B) is replaced by the value of f(m). Figure 1 shows a general plot for a Bisection method iteration.

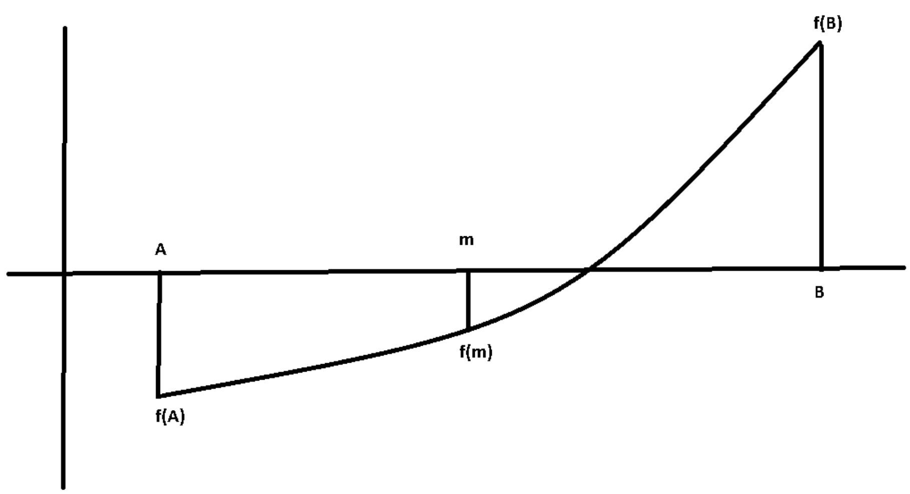

Figure 2 – The Bisection method.

Listing 1 shows the HP Prime source code for functions **MYFX** and **Bisection**. The first Prime function implements the mathematical function f(x) = 0. The second Prime function implements the Bisection method. This function has three argument, namely, a, b, and toler (the tolerance value). The function returns a list containing the root value and the number of iterations. Listing 1 has the target function coded as $e^x – 3x^2$. Throughout this article we will find the roots of this function. If you want to locate the roots of another function, you need to edit the statements inside **MYFX**.

```
EXPORT MYFX(x)
BEGIN
  RETURN e^(x)-3*x²;
END;

EXPORT Bisection(a,b,toler)
BEGIN
  LOCAL Fa, Fb, m, Fm, iter;

  Fa:=MYFX(a);
  Fb:=MYFX(b);
  IF Fa*Fb>0 THEN
    RETURN "A and B have same sign functions";
  END;

  iter:=0;
  REPEAT
    iter:=iter+1;
    m:=(a+b)/2;
    Fm:=MYFX(m);
    IF Fa*Fm>0 THEN
      a:=m;
      Fa:=Fm;
    ELSE
      b:=m;
      Fb:=Fm;
    END;
  UNTIL (ABS(a-b)<toler OR Fm==0);
  RETURN {(a+b)/2,iter};
END;
```

Listing1 – The Bisection function.

Notice that function **Bisection** checks the signs of the initial values of f(A) and f(B). If they are the same, the function returns an error message. Figure 2 show sample use of the **Bisection** function. The

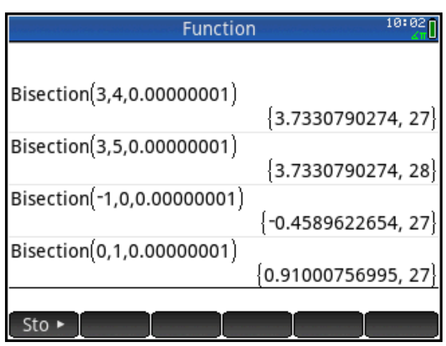

Figure 2 – Sample use of the Bisection Function.

calculations show how to obtain roots in the intervals [3, 4], [3, 5], [–1, 0], and [0, 1]. The first two intervals lead to the same root. The number of iterations is rather high due to the slow convergence.

The Bisection Plus Algorithm Take 1

Now that you have seen and worked with the Bisection method, let's look into improving it. While selecting the median of the root-bracketing interval is optimum in certain ways, let's see if we can do better. The first approach is to calculate a random value *around* the median. This approach requires defining a range around the median from which we get a random value. If use a broad range around the median we may drift close towards the end of the interval [A, B]. Statistically, this wide range will give us poorer performance on the average. By contrast, a rather narrow interval around the median might help us tweak the midpoint selection. I choose to make that interval as |(B–A)|/4. This means that the interval will range from |(B–A)|/8 below the median to |(B–A)|/8 above it. Mathematically this translates into:

m = (A+B)/2 + |(B–A)|/4 * (Random number between –0.5 and 0.5)

Figure 3 shows a general plot for the Bisection Plus (take 1) method. The red region depicts the range used to calculate the random value of m. The figure also marks the midpoint of the range [A, B].

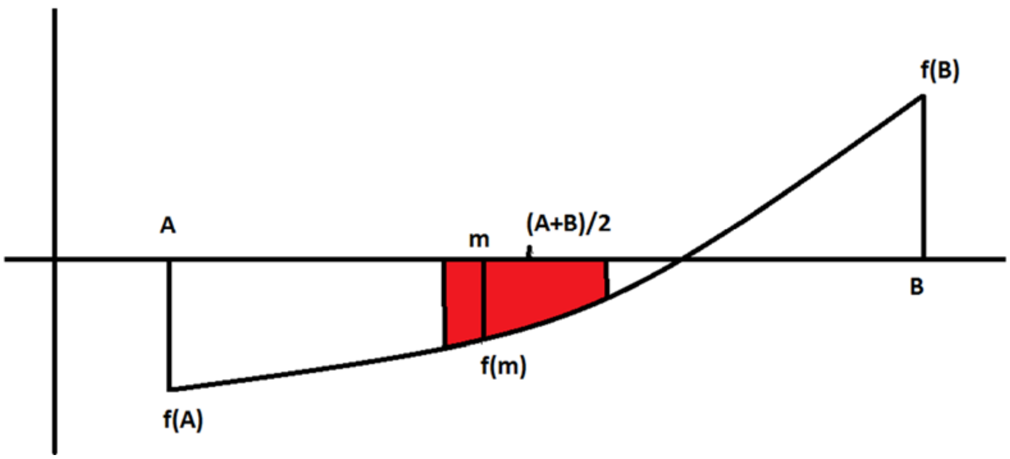

Figure 3 – The Bisection Plus (take 1) method.

Listing 2 shows the HP Prime implementation of the above method as function **BisecPlus1**.

```
EXPORT BisecPlus1(a,b,toler)
BEGIN
  LOCAL Fa, Fb, m, Fm, iter, r;

  Fa:=MYFX(a);
  Fb:=MYFX(b);
  IF Fa*Fb>0 THEN
    RETURN "A and B have same sign functions";
  END;

  iter:=0;
  REPEAT
    iter:=iter+1;
    m:=(a+b)/2;
    r:=ABS(b-a)/4;
```

```
    m:=m+r*(RANDOM()-0.5);
    Fm:=MYFX(m);
    IF Fa*Fm>0 THEN
      a:=m;
      Fa:=Fm;
    ELSE
      b:=m;
      Fb:=Fm;
    END;
  UNTIL (ABS(a-b)<toler OR Fm==0);
  RETURN {(a+b)/2,iter};
END;
```

Listing2 – The BisecPlus1 function.

Listing 2 shows the code for function **BisecPlus1**. This function has the same parameters and returns the same type of values as function **Bisection**. Keep in mind that the number of iterations will vary when you run the function several times, since the code uses random numbers. Figure 4 shows sample runs for the function **BisecPlus1**. The figure shows several runs for the root in the interval [3, 4]. Notice that the number of iterations ranges from 27 to 29. Nevertheless the results are disappointing since the change in the algorithm did not significantly reduce the number of iterations.

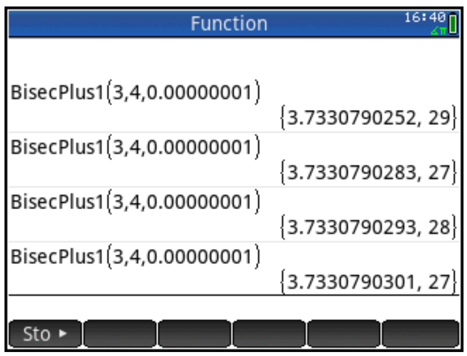

Figure 4 – Sample use of the BisecPlus1 Function.

The Bisection Plus Algorithm Take 2

The first attempt to improve the Bisection method basically fell flat on its face. Back to the proverbial drawing board!

I was inspired for the next approach by Ostrowski's root-seeking method[3]. Unlike typical root-seeking algorithms, Ostrowski designed his algorithm to calculate not one, but two refinements for the root in each iteration! Thus the new approach observes the following tasks:

- Calculate the midpoint m and its function value f(m) just like with the Bisection method.
- Use the point at the median and either range endpoints to calculate a straight line. Find the X intersect of that line, call it m2. An alternative approach is to calculate m2 as the X intersect of the line going through the points at A and B. This alternate approach does well for some cases, but not as good as the approach using the point at (m, f(m)).
- Determine if m and m2 have functions of opposite signs. If this condition is true, then the method replaces the root-bracketing range [A, B] with the narrower range of [m, m2].
- If m and m2 have functions of the same sign, replace A or B with m2, just like in the Bisection method.

- The iterations should also check if the value of m2 is very close to the one in the previous iteration. If this is the case, the method can return a root value.

The design of the step for calculating m2 went through several refinements. The choices available for calculating m2 were:

1. Always calculate m2 using points (A, f(A)) and (m, f(m)).
2. Systematically alternate the calculation of m2 between using points (A, f(A)) and (m, f(m)) and points (B, f(B)) and (m, f(m)).
3. Select A or B, such that the sign of the associated function value is opposite of the sign of f(m). Use that end point and (m, f(m)) to calculate m2.

The third choice proved to be the best, because it made sure that m2 falls in the interval of [A, B]. In addition, the calculated straight line is using the point at m, which is usually closer to the root than the points at A and B. Figure 5 shows a general plot for the new Bisection (take 2) method.

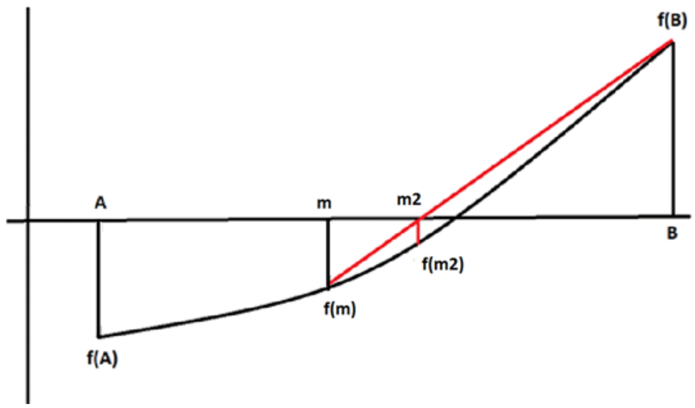

Figure 5 – The Bisection Plus (take 2) method.

Listing 3 shows the HP Prime implementation of the above method as function **BisecPlus2**.

```
EXPORT BisecPlus2(a,b,toler)
BEGIN
  LOCAL Fa, Fb, m, Fm, iter, lastm2;
  LOCAL m2, Fm2, slope, intercept;

  Fa:=MYFX(a);
  Fb:=MYFX(b);
  IF Fa*Fb>0 THEN
    RETURN "A and B have same sign functions";
  END;

  lastm2:=a;
  iter:=0;
  REPEAT
    iter:=iter+1;
    m:=(a+b)/2;
    Fm:=MYFX(m);
    IF Fa*Fm>0 THEN
      slope:=(Fb-Fm)/(b-m);
      intercept:=Fb-slope*b;
```

```
    ELSE
      slope:=(Fa-Fm)/(a-m);
      intercept:=Fa-slope*a;
    End;
    m2:=-intercept/slope;
    Fm2:=MYFX(m2);
    IF Fm*Fm2<0 THEN
      a:=m;
      Fa:=Fm;
      b:=m2;
      Fb:=Fm2;

    ELSE
      IF Fa*Fm2>0 THEN
        a:=m2;
        Fa:=Fm2;
      ELSE
        b:=m2;
        Fb:=Fm2;
      END;
    END;
    IF Fa*Fm>0 THEN
      a:=m;
      Fa:=Fm;
    ELSE
      b:=m;
      Fb:=Fm;
    END;
    IF ABS(lastm2-m2)<toler THEN
      RETURN {(a+b)/2,iter};
    END;
    lastm2:=m2;
  UNTIL (ABS(a-b)<toler OR Fm==0);
  RETURN {(a+b)/2,iter};
END;
```

Listing3 – The BisecPlus3 function.

Listing 3 shows the code for function **BisecPlus2**. This function has the same parameters and returns the same type of values as function **Bisection**. Figure 6 shows several runs for the root in the intervals [3, 4], [3, 5], [–1, 0] and [0, 1]. The results are very encouraging and show that the additional linear interpolation step contributes significantly to zooming in on the root. The price to pay for this acceleration is having two function calls per iteration, as opposed to a single one in the Bisection method.

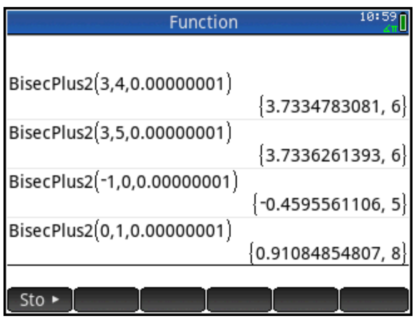

Figure 6 – Sample use of the BisecPlus2 Function.

Nevertheless, the total number of function calls in this version of the Bisection Plus is still less than that of the Bisection method.

How Good is the Bisection Plus Method?

I have compared the results of the Bisection Plus method with Newton's method (the most popular method) and the results are very encouraging. In most cases, the Bisection Plus gives results that are not far behind those of Newton's method. In some cases, the Bisection Plus is able to match or even outdo Newton's method.

Observations and Conclusions

This article showed you the process of crafting a new algorithm from an old one. While the first attempt failed, the second one produced encouraging results. The Bisection Plus method uses midpoint selection followed by a linear interpolation to zoom in on the root. The new method is not susceptible to low tangent values near the root as is the case with Newton's method.

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3. Namir Shammas, *Ostrowski's Method for Finding Roots*, HP Solve, July 2012, issue #28.

About the Author

Namir Shammas is a native of Baghdad, Iraq. He resides in Richmond, Virginia, USA. Namir graduated with a degree in Chemical Engineering from the University of Baghdad. He also received a master degree in Chemical Engineering from the University of Michigan, Ann Arbor. He worked for a few years in the field of water treatment before focusing for 17 years on writing programming books and articles. Later he worked in corporate technical documentation. He is a big fan of HP calculators and collects many vintage models. His hobbies also include traveling, music, movies (especially French movies), chemistry, cosmology, Jungian psychology, mythology, statistics, and math. As a former PPC and CHHU member, Namir enjoys attending the HHC conferences. Email me at: nshammas@aol.com

From The Editor

HP Solve #33 page 33

From The Editor – Issue 33

HP Prime continues to surprise and inspire teachers. The connectivity kit is described in this issue and will be available in February as the article by Chris Olley mentions.

Here is the content of this issue

S01 – A Prime Graphed Rose for You by G.T. Springer provides a primer for making advanced graphs; in this case a rose, stem, and petals.

S02 –Formative Assessment in the Math Classroom by Christi Cole explains how she has applied the process to not only help her students but to improve her teaching approach.

S03 –Dialogic Teaching with the HP Prime Connectivity Kit by Chris Olley provides a few examples and application of the HP Prime connectivity kit.

S04 – The Art of Science Learning, Incubators for Innovation by Laura Berlin explains how she became involved with a learning project called Art of Science Learning. Science (STEM) teaching using the arts greatly inspires student's involvement.

S05 – Transitioning from "Learning about Apps" to "Learning with Apps" by Jim Vanides describes a process of using "verbs before nouns" as a process for discovering and applying educational applications programs.

S06 – Customer Corner is an ***HP Solve*** feature of interviewing long time HP customers to provide an insight as to how and why they have been so active using HP calculators. ***HP Solve*** contributor Namir Shammas started his HP calculator usage in 1974 with the HP-65 in Iraq.

S07 – The Birth of an Algorithm by Namir Shammas is our technical article for this issue. Starting with the classical taught-in-most-math-classes Bisection Method for solving the roots of an equation, Namir uses the HP Prime to develop and test a new and improved Bisection root finding algorithm.

S08 – From the Editor, Regular/assorted Columns

- **From the editor.**
- **HHC 2013 Conference at Ft. Collins - report.**

That is it for this issue. We hope you enjoy it. Write us with your ideas for future topics including being an author yourself at: hpsolve@hp.com or rjnelsoncf@cox.net

Richard J. Nelson – Technical Editor.

HHC 2013 at Ft. Collins

Photo by Joseph K. Horn

The annual HP Handheld Conference, HHC, was held the fourth weekend in September (21st & 22nd) in Ft. Collins Colorado - the "home" of HP's calculators. You may see who registered and what presentations were covered during the two Conference days (18 Hrs.) at: http://hhuc.us/2013/reglist.htm

The basic format of an HHC hasn't changed much since the first conference in 1979 but the methods and technology of documenting the work of the HP User Community has changed as we increase our efficiency by using cloud computing to make the work of the attendees more readily available to everyone. See ftp://hhuc.us/hhuc/2013/files/

We provided each attendee with a thumb drive containing the presentations as well as providing the files at the link given above. The question that the HHC Committee wants to answere: Is the thumb drive necessary? If all files are posted to the cloud before and during the conference is it necessary to buy and distribute a thumb drive? We try to keep the Conference costs as low as possible and this is a cost item.

The HHC website for all HHC websites since 1999 may be found at: http://hhuc.us/ The website for HHC 2013 is at: http://hhuc.us/2013/index.htm

The location for HHC 2014 hasn't been determined yet and interested readers may sign up for the HHC list at http://lists.brouhaha.com/mailman/listinfo/hhc to receive information as it develops. The dates are September 20 and 21, 2014.