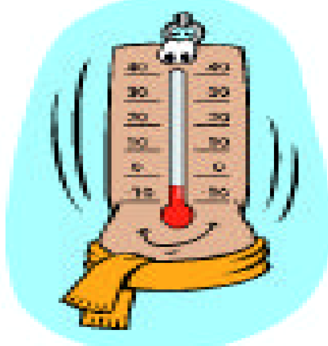
calculate represent

annotate/share

DataGotchi Deep Dive



capture/measure

organize/document

Imagineering a low-cost, handheld mathematical tool for collaborative learning

DataGotchi Deep Dive

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Introduction

We believe there is a huge opportunity for new educational appliances that are low-cost, portable, robust, networkable, and highly tuned to particular curricular needs. We can foresee the potential for the success of these devices in the phenomenal impact of graphing calculators and probeware. However, we are concerned that current graphing calculators and probes are based on their heritages in paper tape adding machines and black-box lab apparatus. The educational community therefore does not see the huge future potential, and is more focussed on hugely expensive desktop computers.

In our view devices would far surpass the ability of conventional classroom tools to engage students in active, constructive, reflective learning. And unlike desktop computers, they would be personalizable by the individual student and usable in the classroom, out in the field, on the school bus, or at home. Because such devices would be communications-savvy, they would enhance classroom workflow, including getting an assignment from the teacher, working collaboratively with fellow students, discussing work with a peer, parent, or tutor, and documenting the completion of successful learning. In addition, because they would connect to measurement and output devices, handheld mathematical appliances would connect math more directly to real world phenomena.

Our group decided that the appropriate next step is not a prototype, but rather a set of concept sketches that would spark dialogue in our community, and draw the interest of potential research and manufacturing partners. IDEO has a brainstorming process called a "deep dive" that results in highly communicative and innovative concept sketches in a very short time. We plan to (a) generate bold, exciting, compact vision pieces with a select group of participants (b) post these to a web server where they could gain additional commentary and (c) utilize the sketches and commentary as discussion starters with selected potential partners for follow-on projects aimed at realizing the vision.

Participants

Leaders

- Jeremy Roschelle, SRI International
- Mike Mills, IDEO
- Peter Stillman, IDEO

Contributors

- Steve Bannasch, Concord Consortium
- Robbie Berg, MIT Media Lab
- Duane Bray, IDEO
- Matt Hand, IDEO
- Nick Jackiw, Key Curriculum Press
- Dave Johnson,
- Yasmin Kafai, UCLA
- Jim Kaput, UMass, Dartmouth
- Dick Lesh, Purdue
- Charlie Patton, MathTech
- Roy Pea, SRI International
- Chunk Seiber, IDEO
- Daniel Kim, IDEO

Student Needs

- personal device
- learn math deeper, quicker, easier
- ability to create, invent, imagine
- useful outside of classroom
- be a tool ~ feel like a toy
- work is private / shared / published
- promote reflection
- multiple representations (graph, table, formula...)
- multiple inputs (voice, cam, sensor...)
- multiple outputs (web page, paper, projection)
- fun, games, paging, sending email

Teacher Needs

- teach meaning of math
- tight coupling to curriculum, standards
- encourage more equal class participation
- record process & end product
- evaluate performance & response
- no down time, easy to fix, robust
- easily explain benefits to critics
- improve relationship to parents

Parent Needs

“What happened at school today?”

- awareness
- confidence in teacher, curriculum, technology
- opportunity to interact
- parent-teacher communication
- my child will be in the hospital all week

Product Identity

- Its the math! (not multimedia)
- Modular/Extensible product family
- Sturdy enough to drop, throw in backpack
- Emphasize communication
- Facilitate control of information flows
- Low cost
- Long battery life

We anticipate a product family of handheld, modular, interactive devices which are tuned to the needs of K-12 math and science education. The centerpiece of the family might be MathPad, a slate & stylus that enables students to jot down numbers, mathematical expressions and functions, and perform operations to manipulate and visualize this information. The MathPad would be able to collect information from Smart Probes which measure motion, light, sound, heat, pH, and other environmental variables. Alternatively, students might point their Datagotchi at an environmental data source at a zoo, nature center, or science museum, to grab relevant data sets. Commercial devices, such as the bicycle-top "Cycleops" computer might also understand the Datagotchi protocols. Back in the classroom, students might beam their work to a Share Board to share it in a classroom discussion, or presentation. In addition, construction kits might allow students to assemble new scientific instruments "Lego-style" or to see mathematical representations as motions and flows via Lines Become Motion (LBM). LBM allows students to draw a graph, which is then translated into physical motion of cars on a track or water flow via stepper motors.

Functionality

specialized ~ powerful ~ optimized ~ robust

- capture/measure
- calculate/represent
- annotate/share
- organize/document

specialized ~ powerful ~ optimized ~ robust

Scenarios

Imagine joining these characters in the second month of the school year at Metric Middle School.

Tamara is 12 years old. She's smart, but not terribly motivated to excel at math. She likes to do her homework together with friends, sometimes around the kitchen table, and sometimes over the phone.

Tamara's mom is a clerk at United Parcel Service. She wants her daughter to succeed in math, and wants to spend more time with Tamara discussing her school, teachers, and friends. But its so hard to get beyond, “What did you do in school today?” “Oh nothing.”

Mr. Keck is Tamara's math teacher. His classroom recently received a set of datagotchis & he attended a 1 week summer workshop on how they can be used. But he is more concerned with implementing the new "connected-contextual" math curriculum his district selected, and particularly concerned about his students performance on the 7th grade statewide tests. There is a small vocal group of parents pushing for "back to basics," and he needs to show that his students performance is improving with the new curriculum.

The Classroom

The **classroom** has 30 students, sitting in groups of 4. The walls are covered with examples of students' projects from previous years. Mr. Keck often uses the overhead projector during discussions, and he likes to walk around and mentor students while they do group work. Mr. Keck believes an orderly classroom flow is a prerequisite to learning, and has spent a good part of September acquainting students with how he likes his classroom to run: things should be tidy, students should move quickly from small group to full discussion tasks, procedural tasks like handing in homework should be done efficiently.

During the course of a school year, Tamara will have to do 6 **projects**, each lasting a week or two. In a project, she will often work with data from measurement sensors (probes), representations like graphs, tables, and algebraic symbols, and concepts like distance-rate-time, linear functions, and simple descriptive statistics. The project will result in presentation to the class, and an collection of pages inserted in Tamara's portfolio.

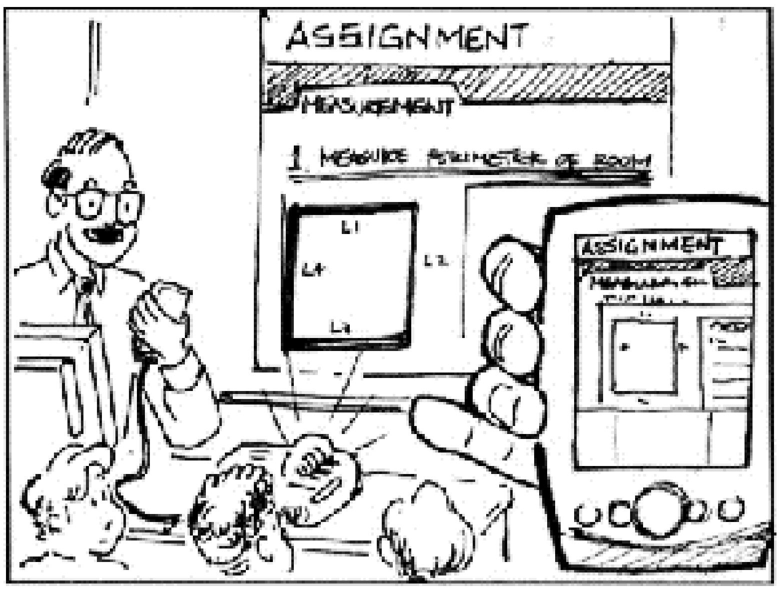
Imagine that it is October and Tamara is doing her first project, which involves coming up with a mathematical way to predict how long it will take different members of the class to get to school, depending on whether they walk, ride a bike, or take the subway. As part of this project, Tamara and her group will need to figure out roughly how fast they walk or bike. And they need to figure out how to estimate the average speed of the subway, despite its stops and starts.

Phases of a math project

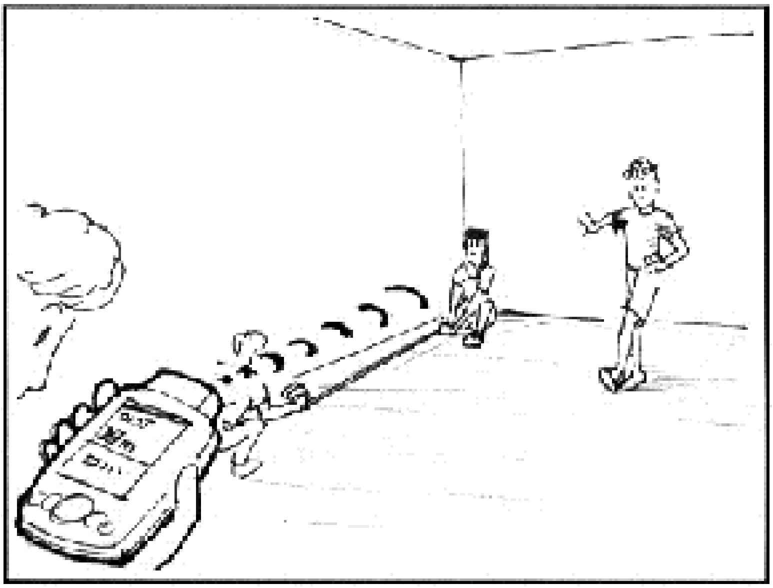
1. Giving the assignment.
2. Making measurements.
3. Sharing in class.
4. Doing homework.
5. Visiting aquarium

Giving the Assignment

Mr. Keck introduces his class to the assignment and the measurement instruments they will use.



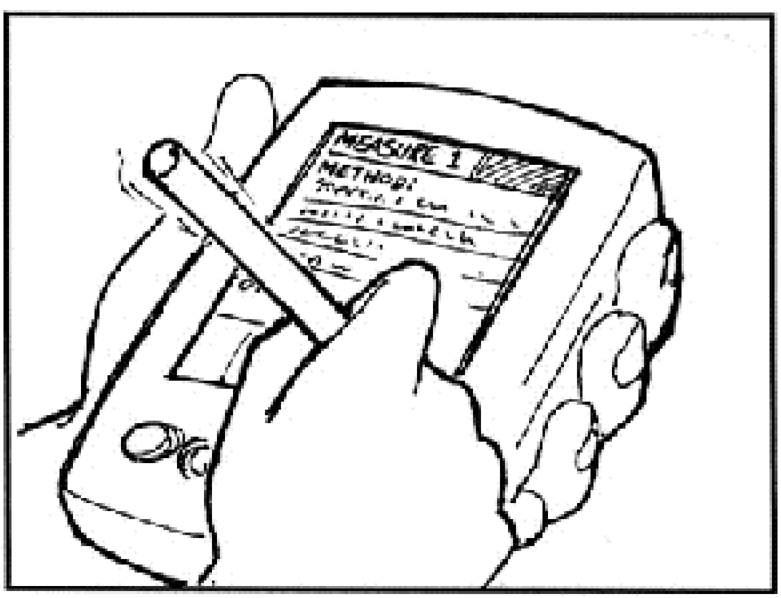
The assignment is to measure the perimeter and circumference of the room in several different ways.



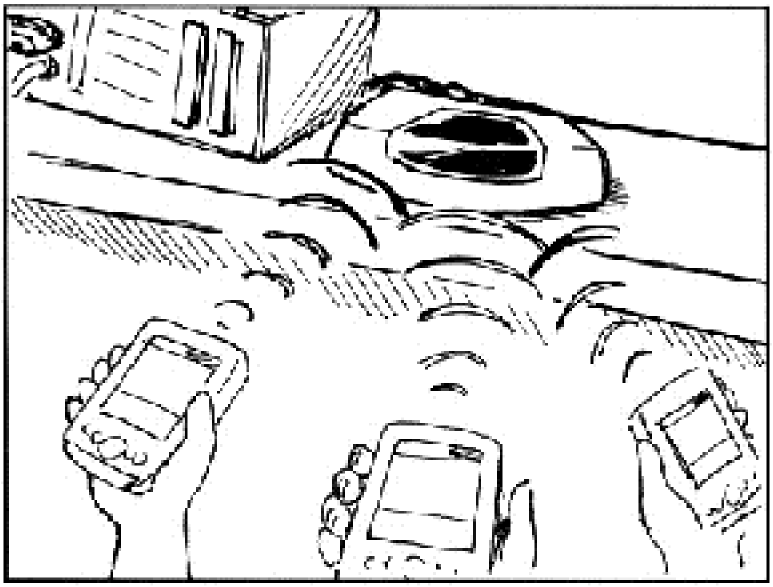
Tamara's team uses a sonar range-finder plug-in to their datagotchi to measure the distances.

Meanwhile...

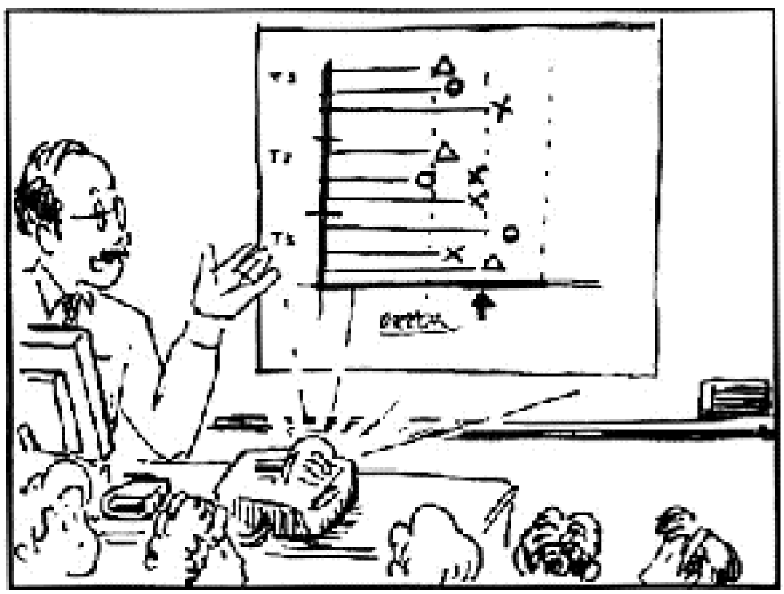
Other students are measuring the room in several different ways: by pacing off steps, by cutting a string to the right length and then measuring the string, etc.



Tamara records the information on their datagotchi and provides voice annotation.

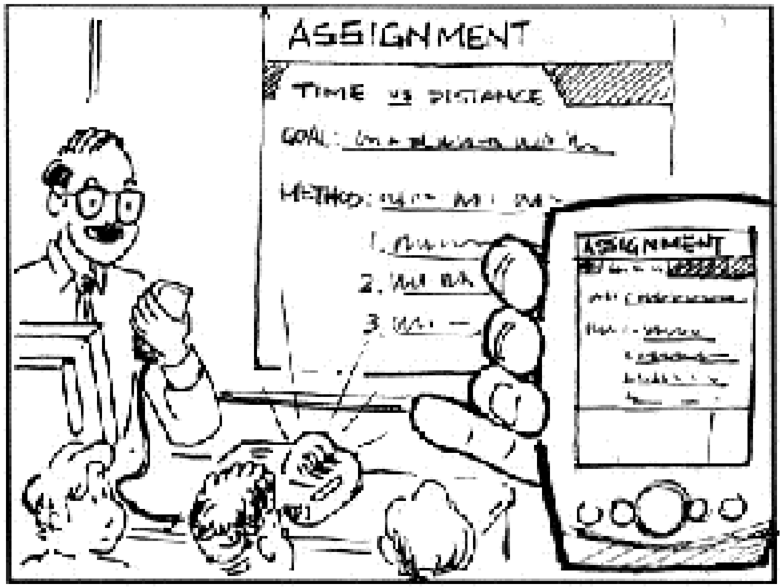


The different teams beam their results into the teacher's portal.



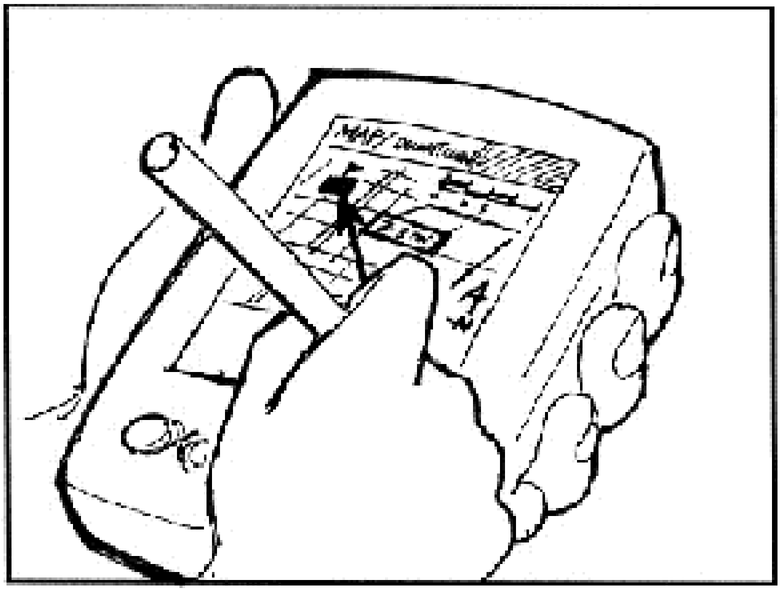
Mr. Keck leads a discussion of the results of the measurements, and asks the students to consider how they might improve the accuracy of their results.

Designing measurement tools

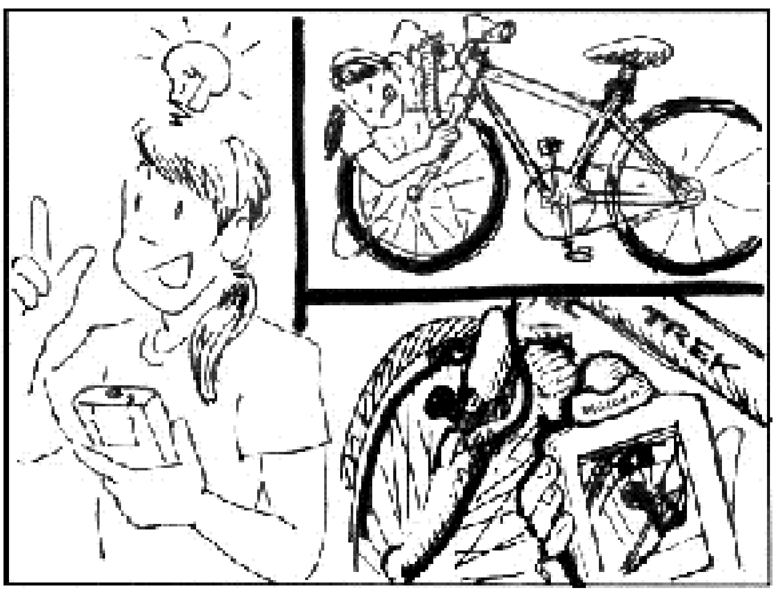


Mr. Keck beams a template to the students for their next assignment.

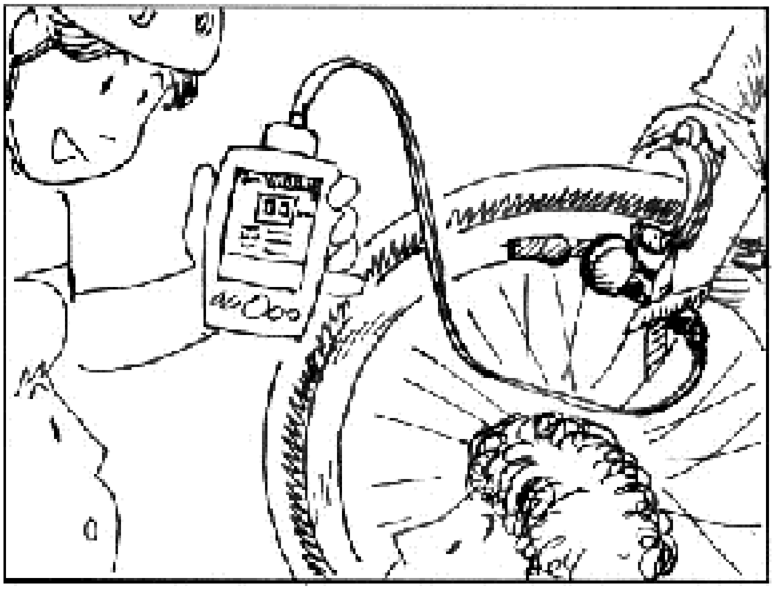
The students review the assignment — which is to measure the distance, rate and time of their trip from home to school — and brainstorm ideas.



Tamara downloads a map from the internet, and makes a rough measurement on her Datagotchi.



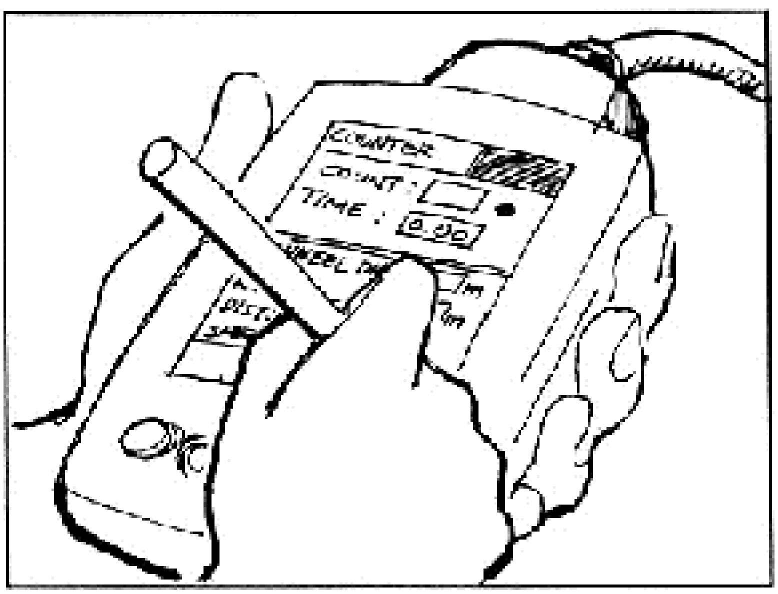
Then inspiration strikes; she could rig a magnet to her bike's wheel and use the Datagotchi to count pulses.



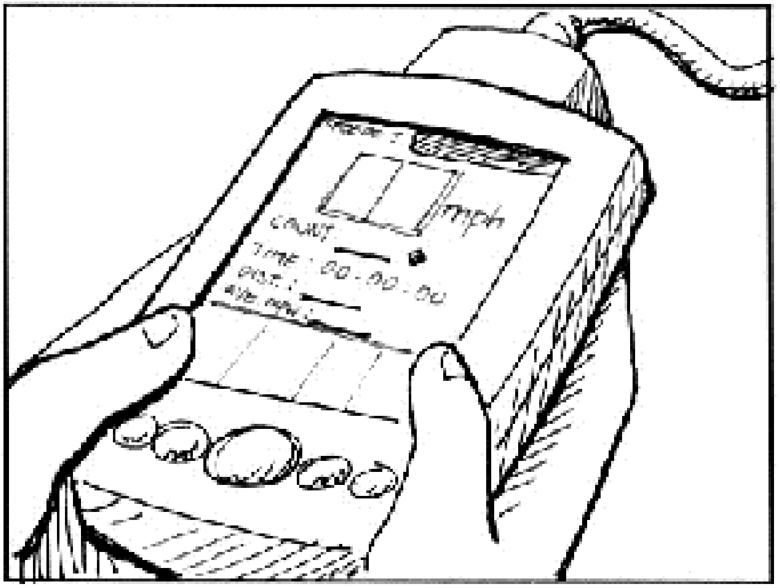
Tamara wires up her gear, and verifiesthat her Datagotchi is counting pulses.

But there's a problem...

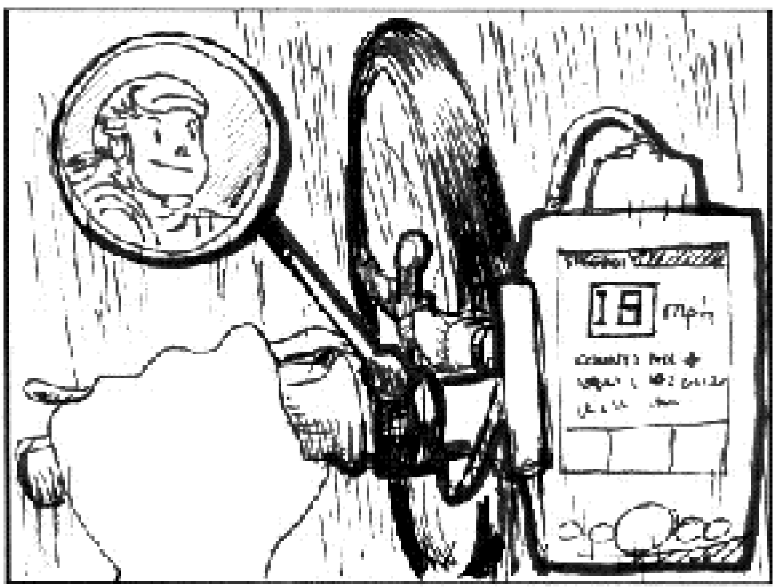
How to convert pulses to distance and speed?



Tamara sets up some calculation on her datagotchi to do the conversions



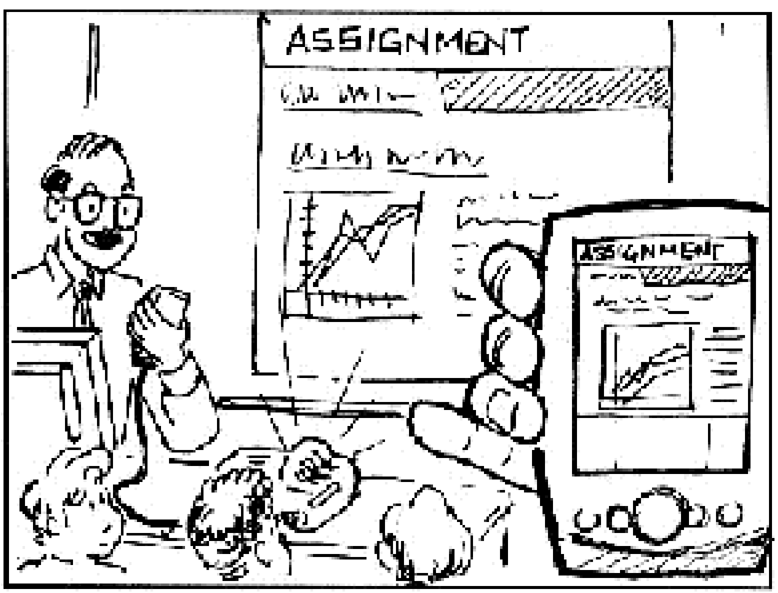
Then she makes a custom form that presents her calculations in a convenient display...



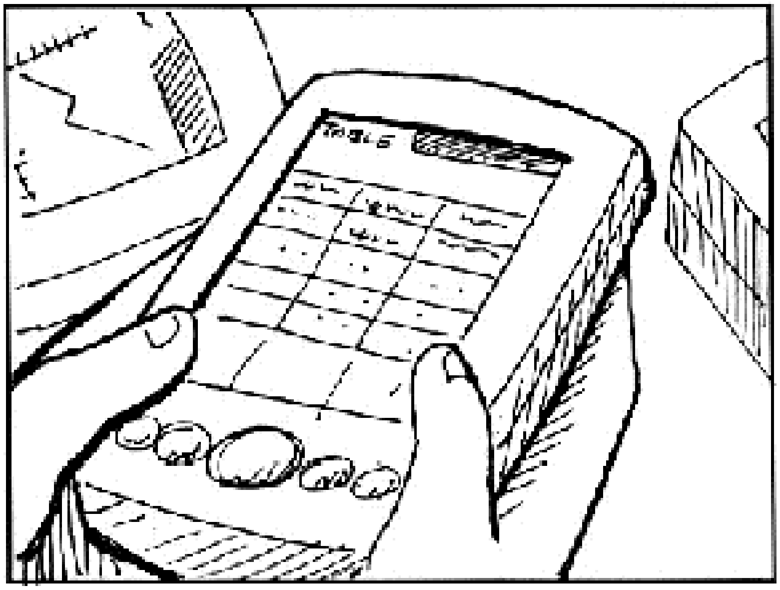
...just perfect to attach to the top of her bike for a live read-out!

Sharing in class

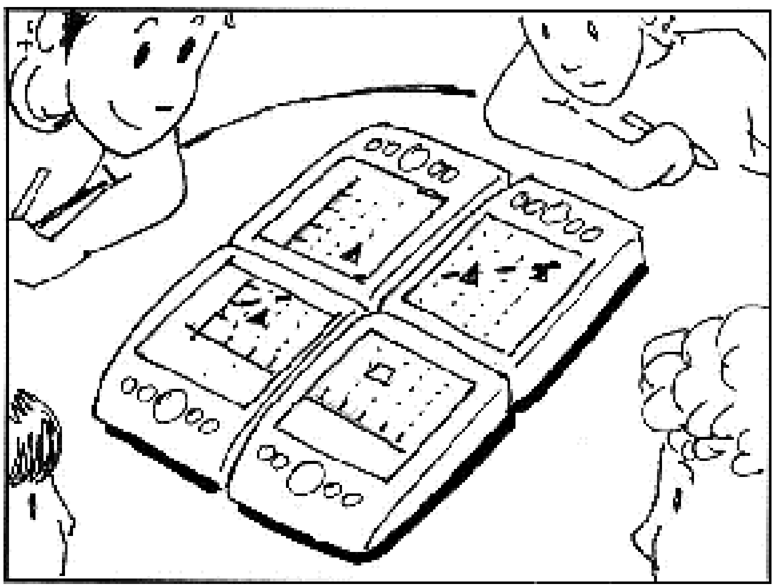
When Kirk arrives in the room, his Datagotchi automatically configures itself for this class.



The assignment involves exploring multiple representations of a motion: using a table, graph, and narrative.

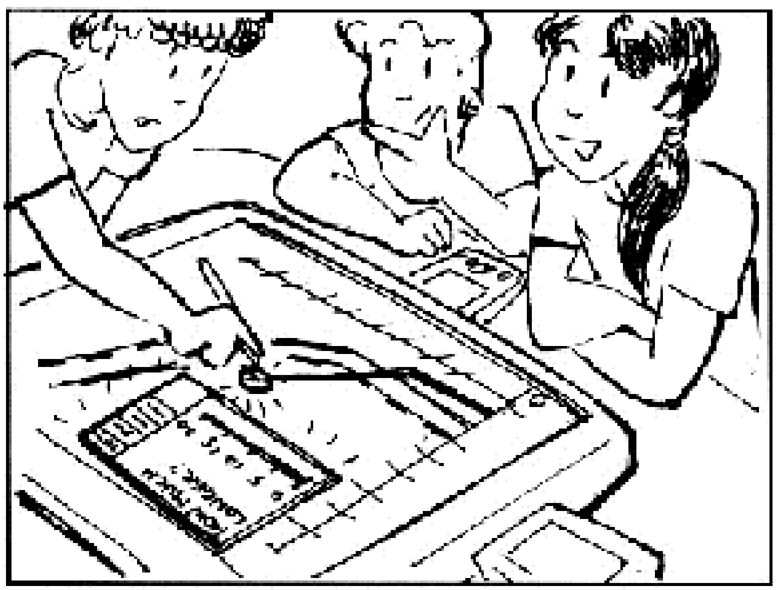


Kirk's datagotchi has a table, but the other students in his group have different representations. They can beam data to each other or...

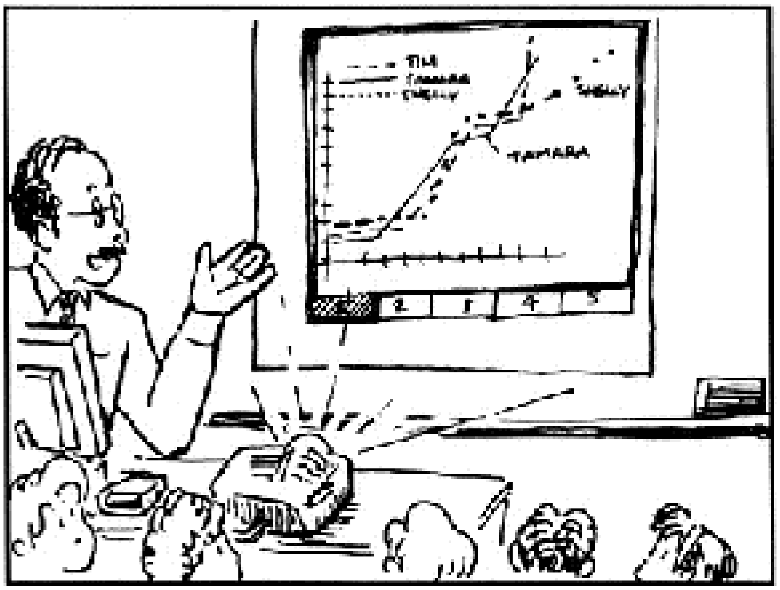


...place their datagotchis in a tiled pattern to form a larger virtual screen or...

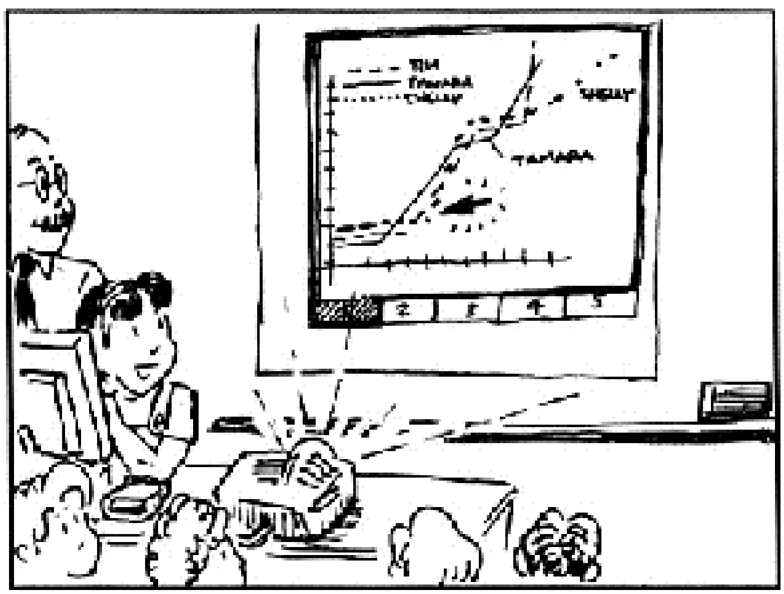
... connect to a larger group display, a shared screen which can be controlled by each datagotchi.



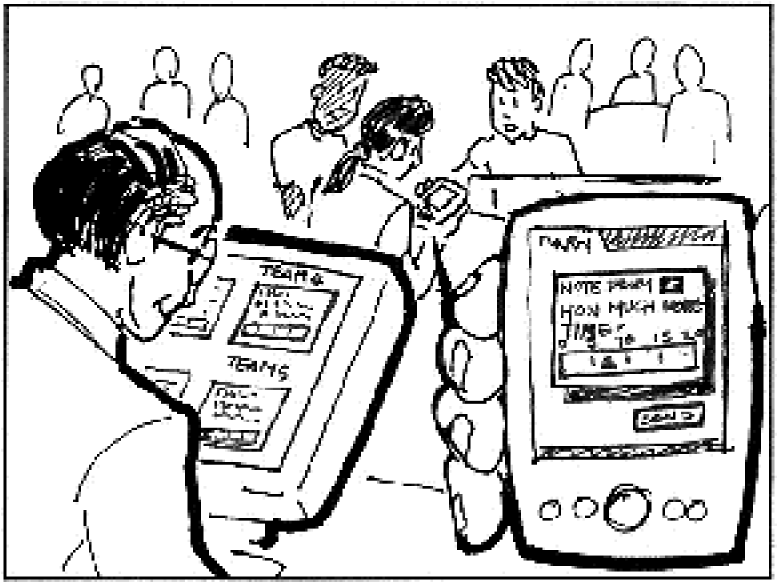
The students discover a problem with their graphs that they don't quite understand.



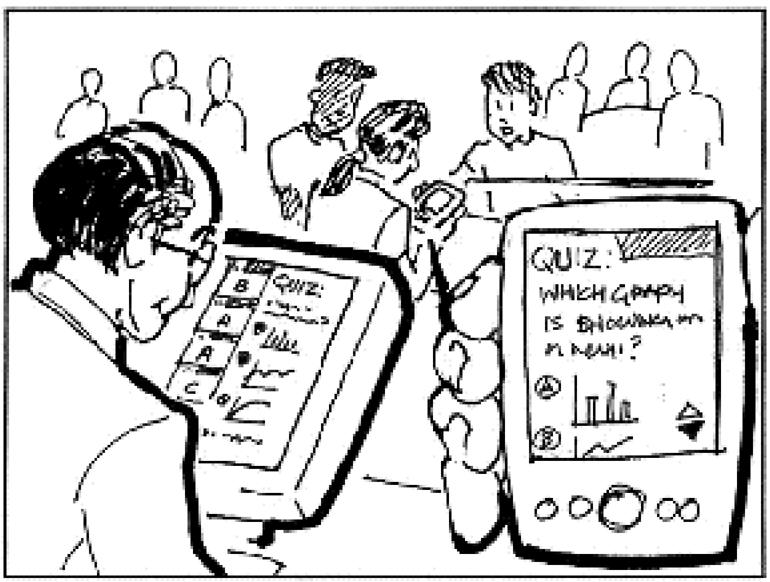
Mr. Keck suggests they share their work with the whole class, because other students are having the same problem.



Tamara controls the full class display from her datagotchi.

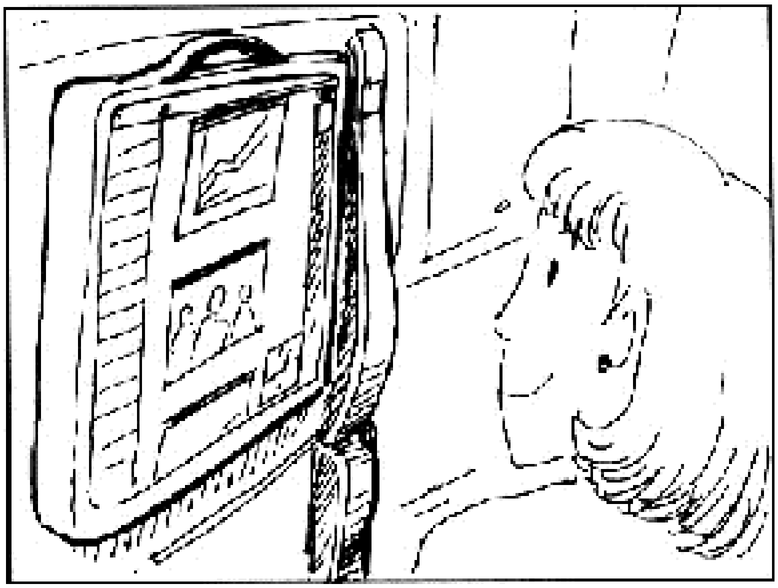


Mr. Keck can send the students an instant message, to find out how much more time they need. Tamara sets a slider to respond.



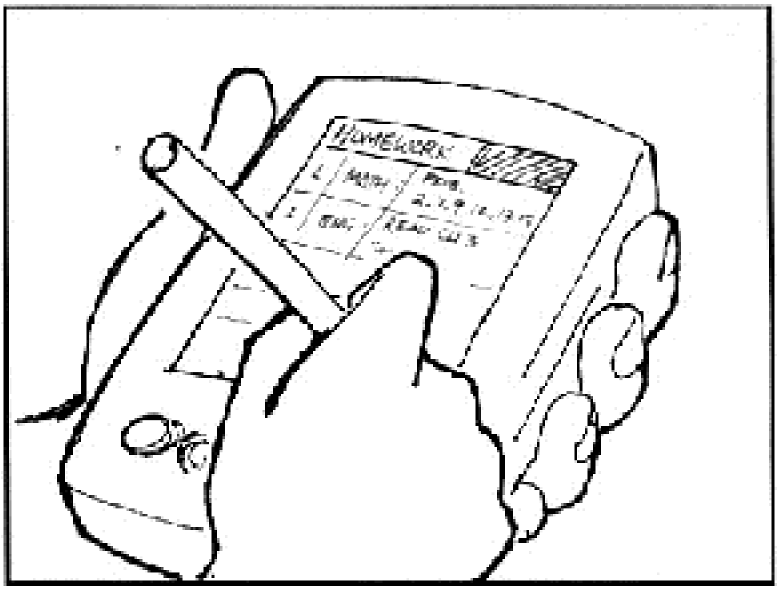
Mr. Keck can also send the students a pop quiz. The results are automatically tabulated on his workstation, allowing him to get a sense of how the class is doing.

Doing homework

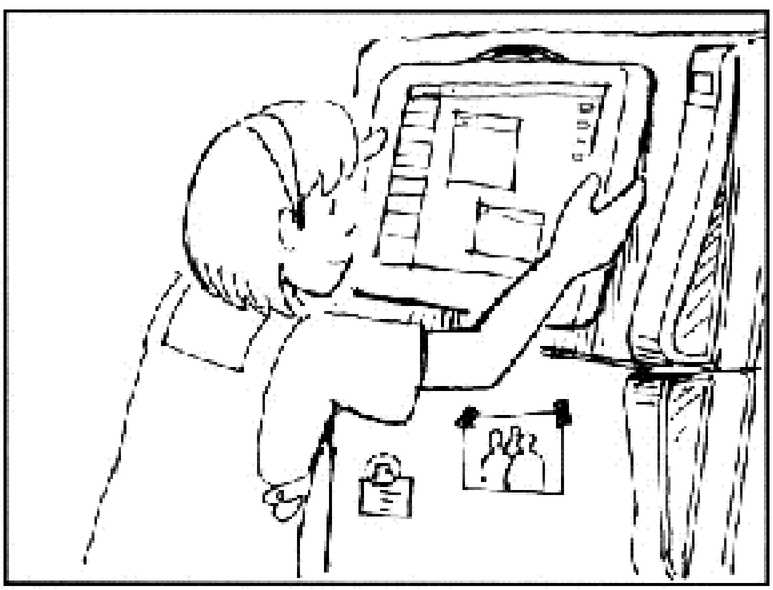


Tamara's mom can check in on today's math class from the fridge top display.

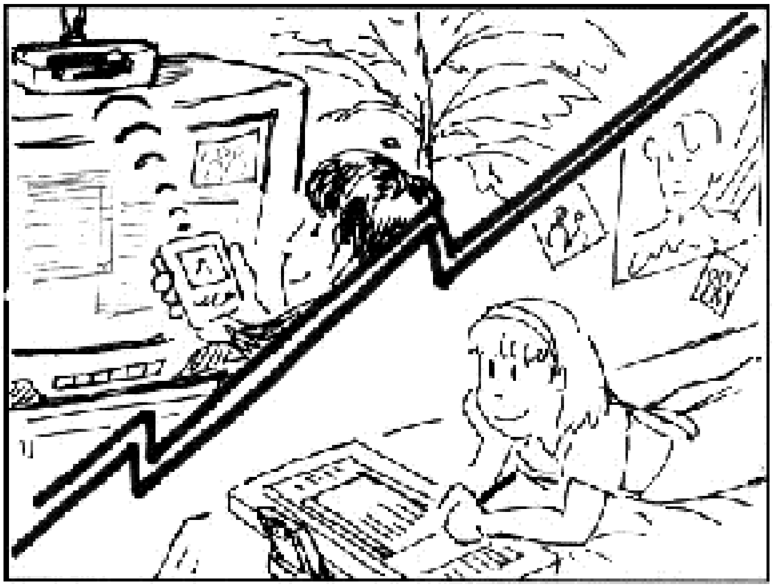
On the subway ride home, the Tamara compares to do lists with her friend.



They decide what each will do for tonight's homework.

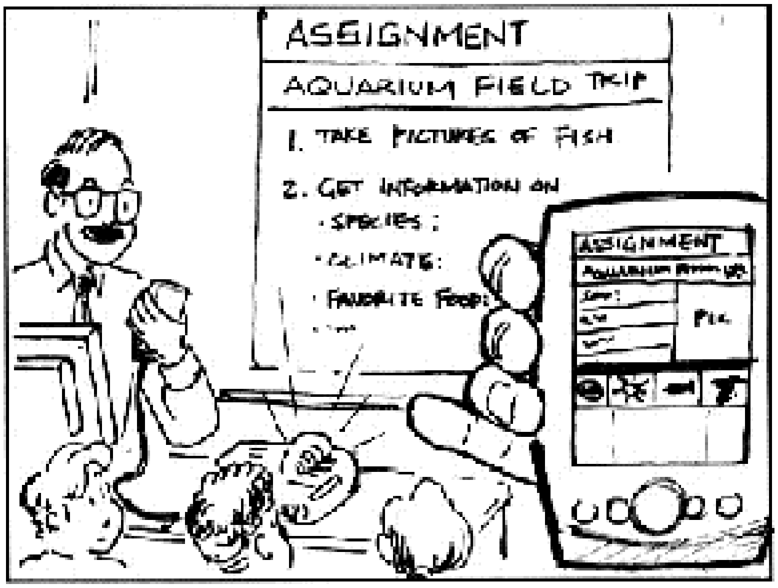


At home, Tamara takes down the fridge-top display and connects it to her datagotchi, so she can use it as a bigger screen.

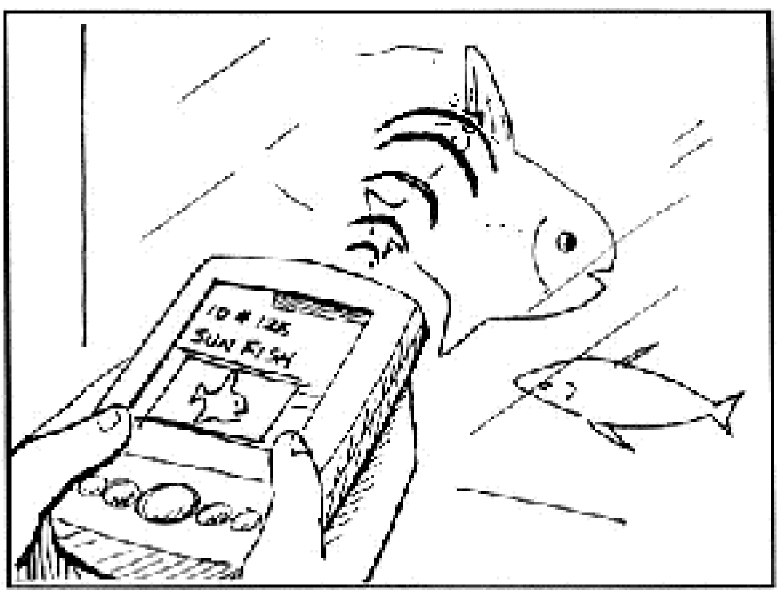


Kirk uses his TV set as a bigger screen, and collaborates with Tamara over the internet.

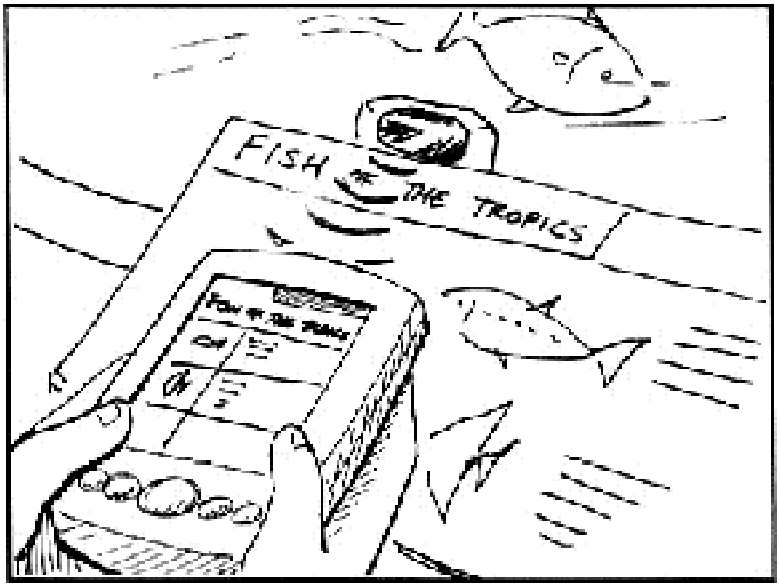
A field trip



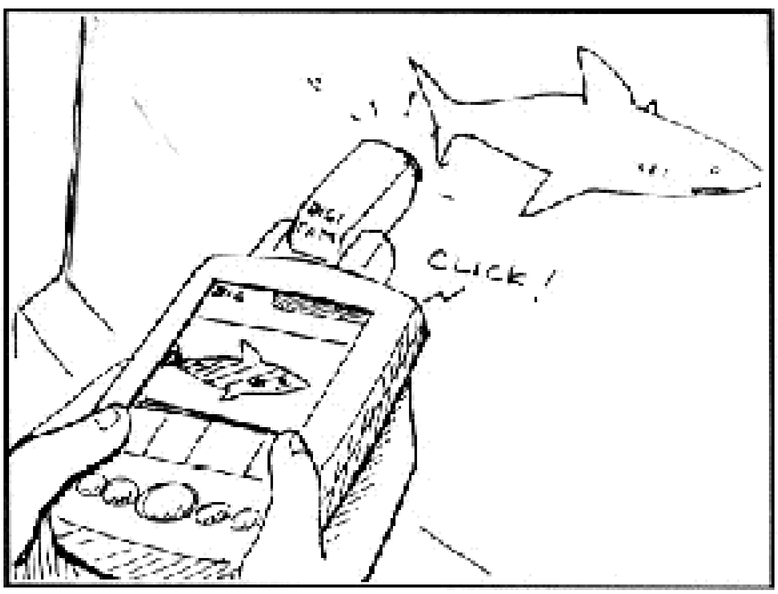
Before leaving for the bus, Mr. Keck beams the assignment to each of his students. They are to measure the speed of various fish at the acquarium.



The fish are tagged in a special way (like bar codes) so that when Tamara beams her datagotchi at the fish she gets information about it.



The students can measure the fish's speed by triangulation of distance and...



... by using the build-in stopwatch in their datagotchi.

Key Insights

- Follow the success of graphing calculators

  Graphing calculators are simple, powerful, robust, low power devices. They are tightly coupled to the math curriculum, and have a clear identity as math-science tools. Don't design a general purpose handheld computer or try to meet all needs in one device. The Datagotchi opportunity is to go beyond graphing calculators in collaboration support, interaction design, extensibility and programmability, and integration with networks.

- Voice annotation / recognition would be powerful

  In many scenarios, it would be useful to students to quickly annotate their work with voice. They could annotate measurements with information about units or the conditions under which the measurement was taken. Working at home, they could annotate and highlight difficulties in an assignment. Voice could enable students to better document their learning in assessments. Voice recognition might be a network service, available when the student is connected.

- Large set of measurement types & inputs

  Such as flow rate, weight, dilution, density, body measures, heart rate, count tapping, maps, bikes, pets, still or video cameras, GPS, stop watch, magnetic sensors, sketching. These imply an array of external devices that can easily and quickly be coupled to the DataGotchi.

- **Many scenarios call for modular larger screen**
  Small screens, such as on PalmPilots can be effective in very focussed tasks. But they are too restrictive in many scenarios: a group of students working around a table, a class discussion, sharing work with a teacher or parent. Moreover, it is difficult to visualize 3D representations, or to see multiple representations in a limited pixel space. Thus the primary "add-on" devices beyond sensors are likely to be modular screens to which a single unit or set of DataGotchis can dock.

- **Templates to organize work flow**
  A major hassle for teachers and students alike in using technology is facilitating the flow of work products as they move through a complex activity structure, with many phases. Our four brainstorming groups each settled on the idea of a template as a structure that spans many tasks and representations, and allows them to be viewed as an organized whole. Teachers could get activity templates that match specific projects or lessons in their curriculum. Students could "fill in" areas of the template as they progress. The template is like the conventional mimeographed worksheet, but with more advanced interactional and representational capabilities in each slot.

- Collaboration policies / spaces

  Likewise learning needs to smoothly flow between individual, group, and full-class discussion modes of work. Many activities will require enforceable collaboration policies that establish who can share what information with whom, and when. It must be easy to move private work into a "BuddyMode" conference, and to use a "DataLasso" to grab a private copy of work in a shared space. A spatial/containment metaphor might help users easily navigate various collaboration places and capabilities.

- Programmability / scriptability

  The DataGotchi should have programming and/or scripting capabilities to (a) allow third party developers to add new forms of representation and interaction (b) allow teachers to customize templates and (c) allow students to invent their own means of solving problems.

- Backend architecture

  The DataGotchi should be designed with a network in mind. The network might provide facilities for accessing templates, exchanging work between the teacher and students, enabling wide-area network conferencing, storing work products and portfolios, linking to the internet, etc.

Existing Products

- PalmPilot
- Apple e-mate
- Texas Instruments graphing calculators
- Royal DaVinci handhelds
- GameBoy

Future Directions

- Use scenarios to drive market research
- R&D on collaboration spaces, policies, workflow
- Partner with manufacturer to build prototype