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Beyond Content & Communication: Scenarios of Mobile Interactive Learning

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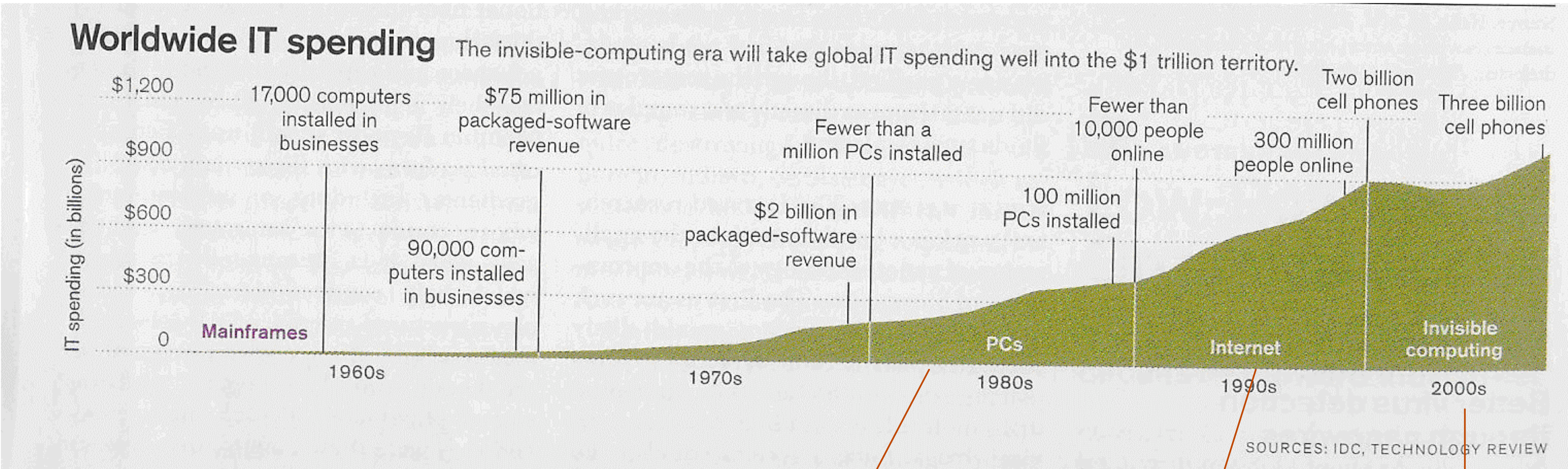
What's the challenge?

- 3 decades of personal technology
  - Essential impact depends (also) on sustained presence of personal technology
  - *Personal computing* at school had never been and still isn't *personal*
- Social / cultural concern
  - Mobile phones are part of the daily personal out-of-school culture
  - mTechnology is cheap and powerful
- Implementation
  - Integration of mLearning requires innovative strategies
  - Models for using and designing are somewhat lacking

Three generations of design



PC
Microworlds

Web
Digital Books

Mobiles
Ubiquitous
Learning

Why Mobile Learning ?

How Do People Learn and How Are They Taught?

- **The philosophy** is that of social constructivism:
  - people learn by constructing knowledge
  - operating cognitive resources (symbols, representations, senses)
  - interacting (with tools, people, and environment)
- **The pedagogy**:
  - teaching is guiding inquiry
  - skills should be mastered with understanding
  - mathematics should be appropriate to all students
  - guidance leads the learners from wherever they are into the culturally-accepted mathematics

How to implement it?

Theoretical Frameworks

- Guided inquiry
  - active learner guided by activities and the teacher
- Socio-cultural
  - situated learning paradigm
  - support of social interaction, collaboration
- Communities of learners and teachers
- Learning experiences acquired while immersed in a the real world
- Tools turn out to be instruments (external and psychological)

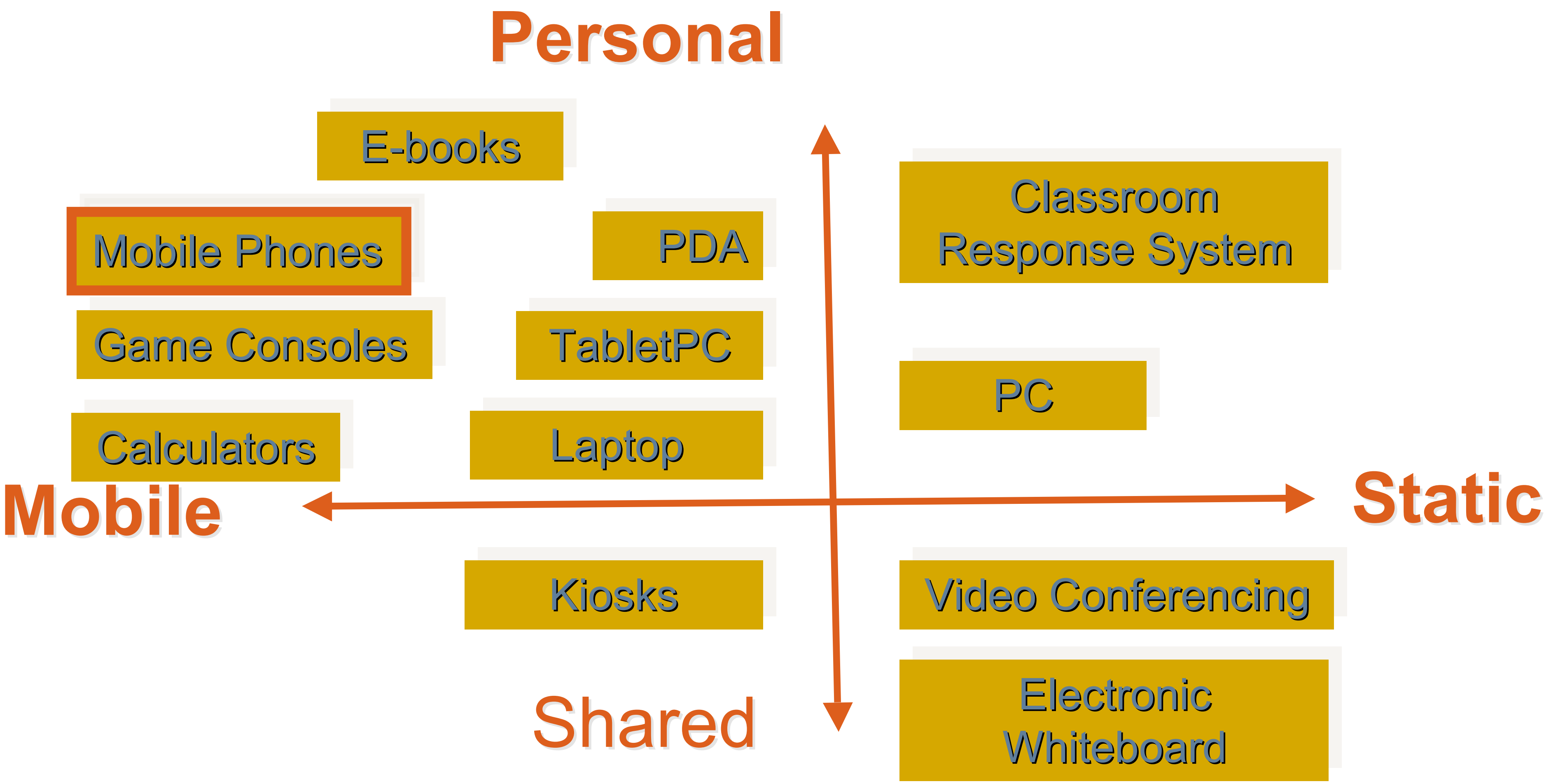
Perspectives of Mobility

Mobile learning refers to:

- technocentric perspective —
  - educational use of portable mobile technology
- learning style —
  - learning differently from formal school
  - learning free of the limitations of space and time
- mobility of the learner (rather than of the technology)

math4mobile approach implements all 3

Learning Technologies

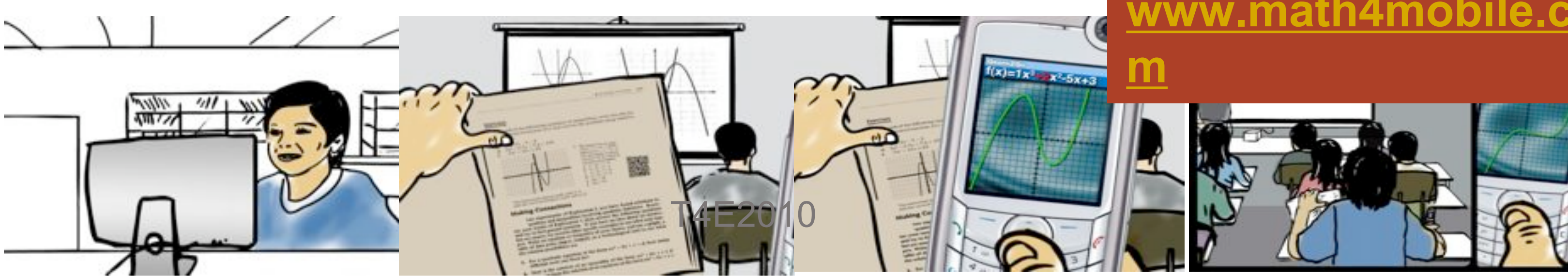


The Goal: Understanding what would make the mobile phone a deserving pedagogical tool

We have taken the following steps:

- Study the designs of inexpensive technology to increase students' commitment and creativity within the framework of the curriculum
- Design the innovations that engage all students with mathematical and scientific ideas
- Define new learning opportunities
- Answer the demands of the real world of schools
- Study the associated socio-cultural aspects

www.math4mobile.com



Design Principles

- **Variety**
  - relatively well-known applications
  - have been successfully tried in various learning settings
  - useful for school and as personal tools
- **Added value**
  - extended communication options
  - personal tools included inside the phone
  - mobility
- **Comply with the hardware limitations**
  - offline use
  - simple graphics
  - small screen
  - phone keyboard
- **Augment with school traditional technology**
  - Classroom Interaction System
  - Augmented Textbooks

Design of Content Applications

- Useful to a wide range of users – **Graph2Go**
- Studied and found to be contributing to learning – **Quad2Go**, **Solve2Go**

- Useful and motivating learning out of the classroom **Fit2Go**, **Sketch2Go**

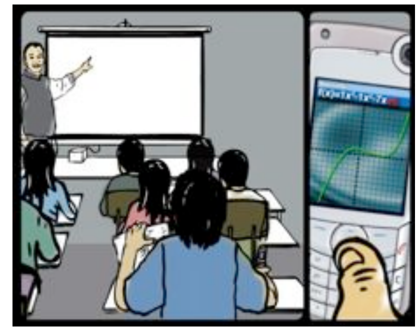
- Take advantage of communication features SMS center

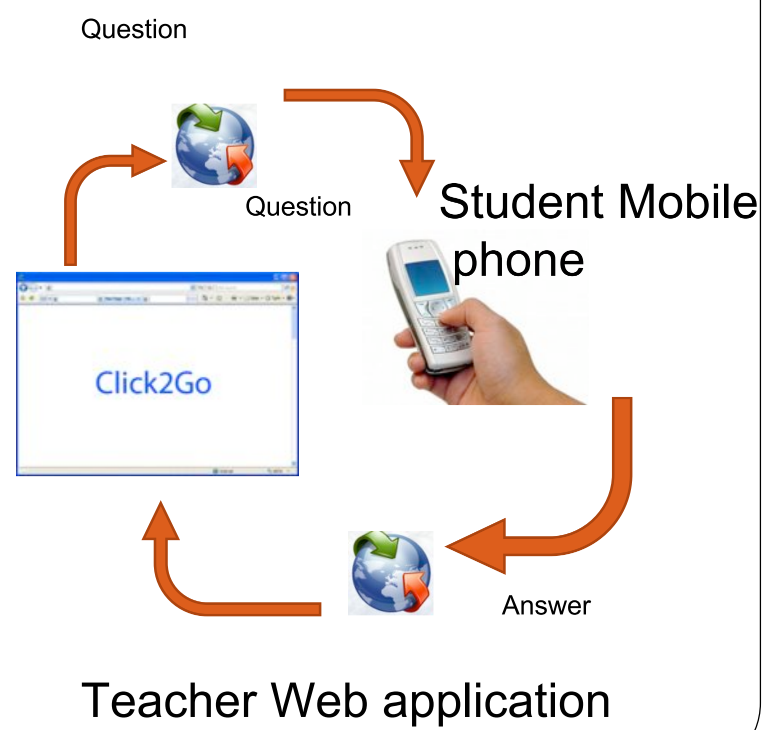
- Fit to limitations and constraints less text typing more control of visuals

Augment With Traditional School Setting
Design of Learner Response System

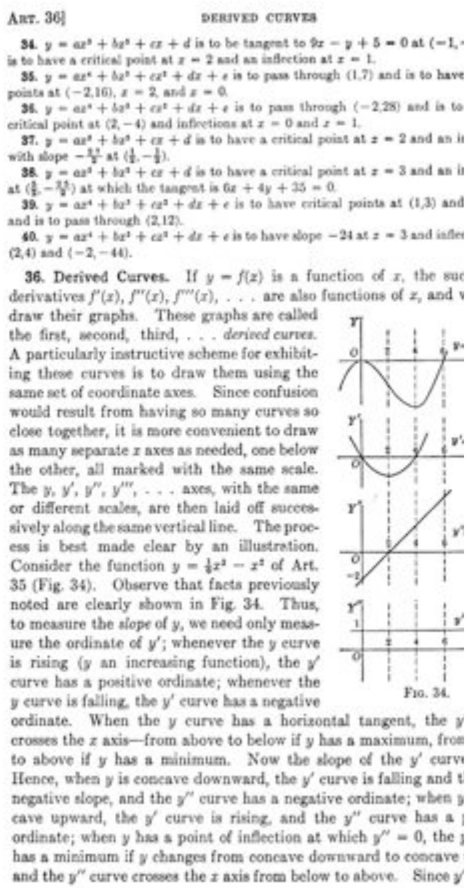
Click2Go facilitates:

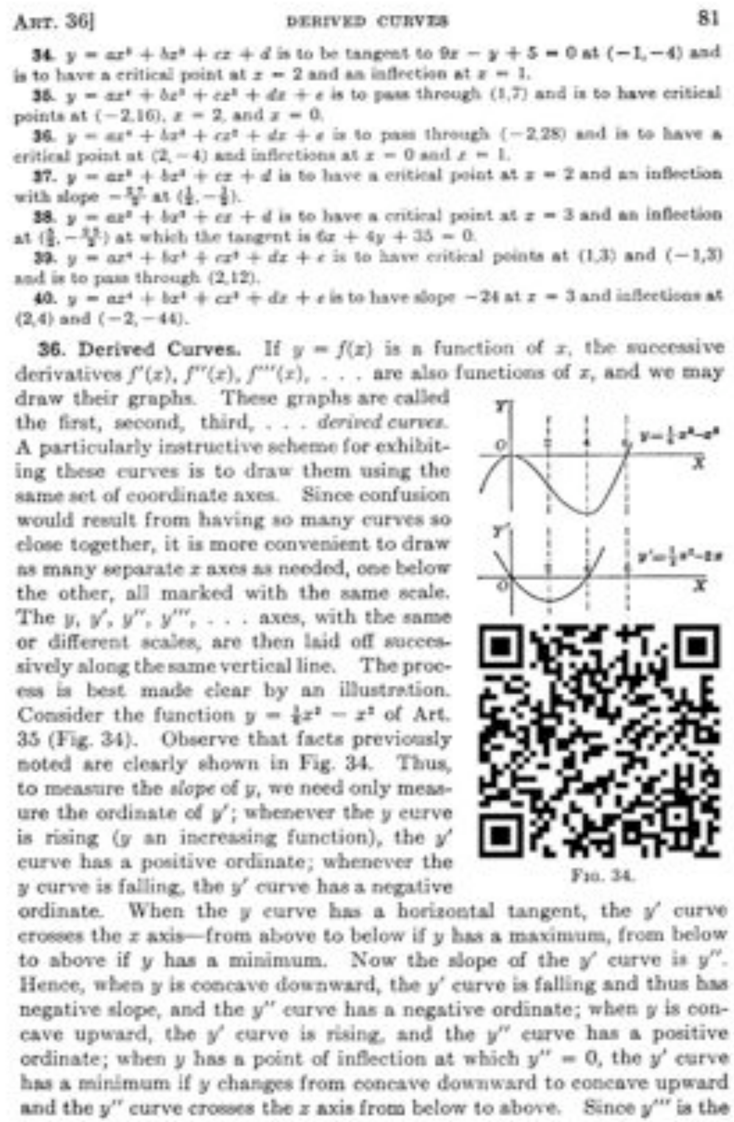
- Teaching large groups
- Online interaction and feedback on discussed problems in large groups
- Close and open questions
- Simultaneous presentation on a smart-board and mobile phones
- Using WiFi communication





Design of Augmented Textbook





ART. 36] DERIVED CURVES 81

34. $y = ax^3 + bx^2 + cx + d$ is to be tangent to $9x - y + 5 = 0$ at $(-1, -4)$ and is to have a critical point at $x = 2$ and an inflection at $x = 1$.

35. $y = ax^4 + bx^3 + cx^2 + dx + e$ is to pass through $(1,7)$ and is to have critical points at $(-2,16)$, $x = 2$, and $x = 0$.

36. $y = ax^4 + bx^3 + cx^2 + dx + e$ is to pass through $(-2,28)$ and is to have a critical point at $(2,-4)$ and inflections at $x = 0$ and $x = 1$.

37. $y = ax^3 + bx^2 + cx + d$ is to have a critical point at $x = 2$ and an inflection with slope $-\frac{27}{2}$ at $(\frac{1}{2}, -\frac{1}{2})$.

38. $y = ax^3 + bx^2 + cx + d$ is to have a critical point at $x = 3$ and an inflection at $(\frac{5}{2}, -\frac{25}{2})$ at which the tangent is $6x + 4y + 35 = 0$.

39. $y = ax^4 + bx^3 + cx^2 + dx + e$ is to have critical points at $(1,3)$ and $(-1,3)$ and is to pass through $(2,12)$.

40. $y = ax^4 + bx^3 + cx^2 + dx + e$ is to have slope -24 at $x = 3$ and inflections at $(2,4)$ and $(-2,-44)$.

36. Derived Curves. If $y = f(x)$ is a function of x, the successive derivatives $f'(x)$, $f''(x)$, $f'''(x)$, . . . are also functions of x, and we may draw their graphs. These graphs are called the first, second, third, . . . *derived curves*. A particularly instructive scheme for exhibiting these curves is to draw them using the same set of coordinate axes. Since confusion would result from having so many curves so close together, it is more convenient to draw as many separate x axes as needed, one below the other, all marked with the same scale. The y, y', y'', y''', . . . axes, with the same or different scales, are then laid off successively along the same vertical line. The process is best made clear by an illustration. Consider the function $y = \frac{1}{3}x^3 - x^2$ of Art. 35 (Fig. 34). Observe that facts previously noted are clearly shown in Fig. 34. Thus, to measure the *slope* of y, we need only measure the ordinate of y'; whenever the y curve is rising (y an increasing function), the y' curve has a positive ordinate; whenever the y curve is falling, the y' curve has a negative ordinate. When the y curve has a horizontal tangent, the y' curve crosses the x axis—from above to below if y has a maximum, from below to above if y has a minimum. Now the slope of the y' curve is y''. Hence, when y is concave downward, the y' curve is falling and thus has negative slope, and the y'' curve has a negative ordinate; when y is concave upward, the y' curve is rising, and the y'' curve has a positive ordinate; when y has a point of inflection at which $y'' = 0$, the y' curve has a minimum if y changes from concave downward to concave upward and the y'' curve crosses the x axis from below to above. Since y''' is the

Fig. 34.

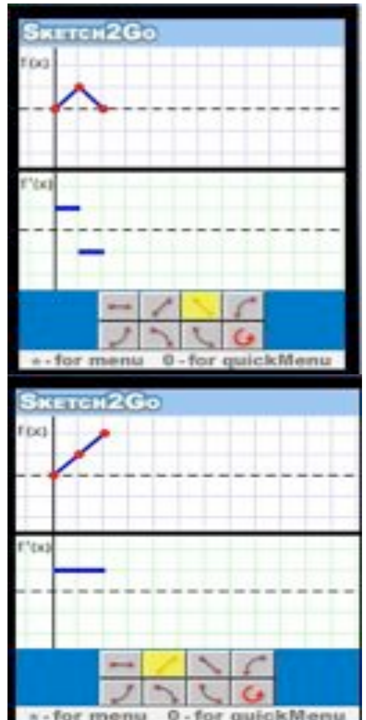
Making It Work:
Identifying Variables

- **Space:** in class, in and around school, anywhere
- **Size:** individual, group, whole class
- **Learning mode:** modeling, practicing, exploring, solving
- **Teacher's role:** instructor, moderator, assessor, observer
- **Means of use:** online, offline, asynchronous, synchronous
- **Media components (ubiquity) :** eBoard, website, PC, textbook, calculator

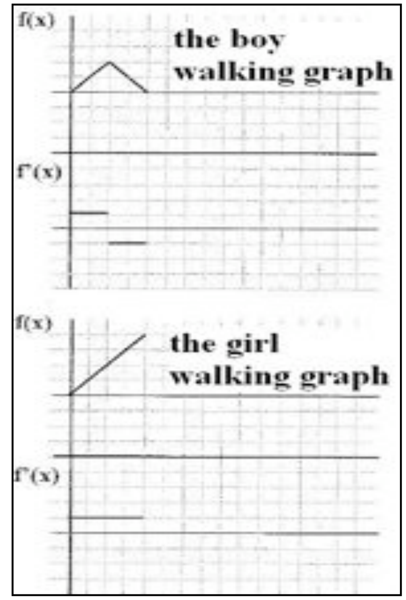
Scenario 1:
Mathematical Modeling Inquiry

Botzer and Yerushalmy, 2007

Amman videotaped two kids walking and sent the video to her friend by MMS



Dana used the *sketch2go* to construct graphs showing the boy and the girl walking and sent it to Amman by SMS



Amman confirmed that the graphs were correct and sketched the graphs in her diary

Scenario 2:
Online Inquiry Moderation

Botzer and Yerushalmy, 2010

Participants of the mathematical asynchronous **M-discussion**:

One activity, 4 applications, one student, one moderator (M), a group of students

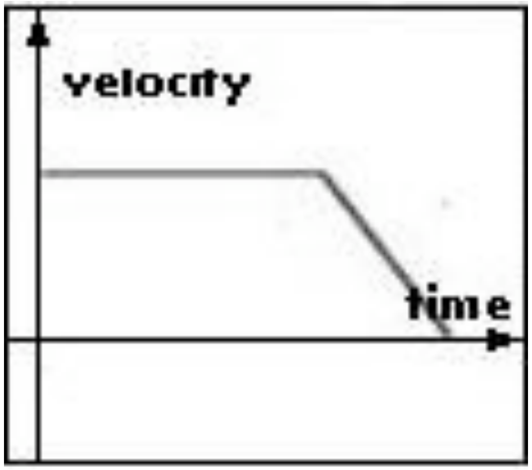
- S: Am I choosing the right application?
- S: Am I choosing the right tool within the application?
- M: Offering or reducing options
- M: Reframing an individual query to serve as a group discussion issue
- **S:** Sending graphic examples
- **S:** Discussing correctness
- **S:** Resolving conflicts
- **S:** Providing explanations

Scenario 3: **Practicing Online**

Botzer and Yerushalmy, 2010

- **SMS sketching - a practice item**

  When you receive this velocity vs. time graph by SMS, use the **Sketch2go** application to sketch a corresponding position vs. time graph. Compare your derivative graph with the given graph to check whether your graph is correct.



- **SMS solving - an assessment item**

  The following expressions describe the position vs. time of the two race cars.

  When will car A pass car B?

  A: $x(t)=t^2+3t+1$; B: $x(t)=3t+5$

Scenario 4: Beyond Graphing Calculator

In-class Problem Solving

Pre-service teachers choice of tasks with graphic calculator (Left) and with math4mobile (Right)

$Y = 33x^3 - 100x^2 + 101x + 100$ $Y = 0.25x^4 - 17x^3 - 2x^2 + 200x$ Draw the graphs of the functions and determine where they are increasing or decreasing.	The following expression describes the position vs. time of the motion of a toy car: $X(t)=2t^2+3t+2$ 1. Use *Graph2go* to explore this function and determine the meaning of each of the coefficients for the motion of the car. 2. Add the graph of the derivative. What features of the motion does the graph of the derivative describe? 3. Change each of the coefficients of the x(t) function, and explore the graph of the derivative, and interpret the graph with reference to the motion of the toy car.

Scenario 5: The Phone as a Personal Toolkit

Botzer and Yerushalmy, 2010

In-class measuring task: The motion of a toy car

1. Observe the motion of the toy car in the inclined plan. Predict how the position vs. time graph will look and sketch it.

2. Take several measurements of position and time. Use a ruler to mark the line at equal distances on the inclined plan and the stop-watch in your cell phone to measure time.

3. Use the *Fit2go* application to mark the (x,t) points and find a graph that traverses the points you marked. Compare the resulting graph with the one you predicted.

Scenario 6:
Practicing via the Online Support Site

- The user chooses the practiced level
- The site checks whether the user has the application required for the task (fit2go)
- The site sends a task by SMS:
  "Write an equation for parabola passing through (a,b), (x,y) & (v,w)”
- The user solves the problem:
  * working separately from the application that is used for checking
  * working by trial and error with the application
  * in need of help: the application provides the correct graph and equation
- The user leaves a voice message asking for human help

Scenario 7: **Ubiquitous Inquiry**

A challenging item:

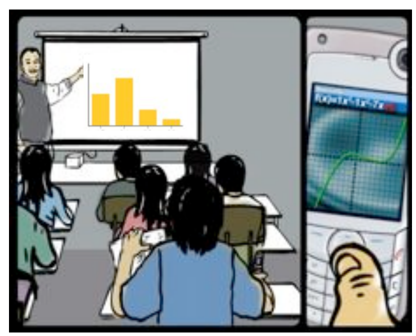
- Majority of answers are incorrect
- Immediate presentation of the diversity promotes discussion

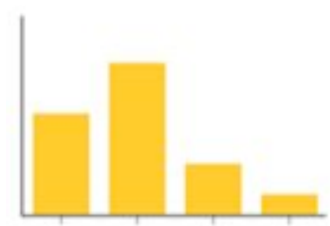
$$\int_1^x f(t)dt = F(?)$$

- $F(x)$
- $F(t)$
- $F + C$
- All the above

Further Pedagogical Challenges

- Design settings for teaching
- Create items database
- Enable visual communication
- Implement analysis of open answers





Beyond "clicking responses"

- Clickers help teachers devote more class time to talks, thinking, and jotting, to help develop student ideas further.
- Support for assessment of students who are not present in class
- Support for problem solving and increase of conceptual understanding through **Peer Instruction** described by Mazur and colleagues (2010)
- Use of simulations and interactive diagrams to support visual discourse
- Most reports refer to elite universities teaching large groups of physics and science students
- **Peer Instruction** increased conceptual learning and traditional problem-solving skills, and reduced the number of students who dropped out of the course
- **Effects of clickers:** high student motivation, honest answers due to anonymity, enjoyment and involvement, and the effectiveness of immediate feedback.
- Mobile phone clickers used as Learners' Question System

Scenario 8:

Making Paper Textbooks Interactive

Libraries of exercises:

Using exercises' generator rather than specific exercises

$x^2 = -4$

$(x-1)(x+3) = 0$

$x^2 + 1 = x^2 + 3$

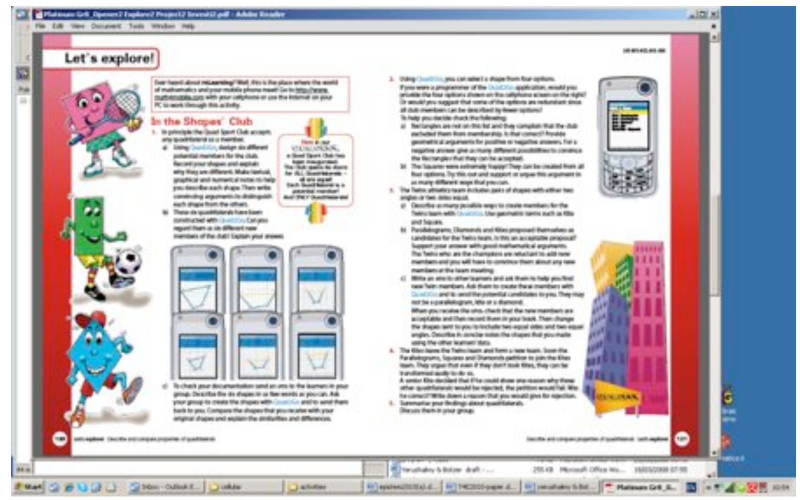
$5(x+2)^2 + 1 = 16$

$(5x-4)(2x-1) = 4x+3$

$2(x-1)^2 = \text{-}(2)(x+1)(x+2)$

Animated exposition:

Replacing variety of pictures with a single Interactive Diagram



Interactive Exercises

Interactive Geometry Environment

What would make the mobile phone a deserving pedagogical tool?

Following the math4mobile R&D we suggest:

- Use the vast accumulated knowledge on T4E
- Develop with the view of what might best fit the new medium
- Invest in educational development and special design – that will help reasonable implementation
- Study what personal technology really means
- Think "ubiquitous"- phone is a part of many school & home technologies
- Study worldwide teachers' needs in realistic settings
- Scalability – adopt and invent new mobile dissemination models
- It offers opportunities to support sustained development!

Related Published Research

- Botzer, G. & Yerushalmy, M. (2007) Mobile Applications for Mobile learning. In the proceedings to the *Cognition and Exploratory Learning in the Digital Age* (CELDA). December. Algarve, Portugal.
- Bayaa, N. & Daher, W. (2009). Learning Mathematics in an Authentic Mobile Environment: the Perceptions of Students. *International Journal of Interactive Mobile Technologies*, 3 (Special Issue, IMCL 2009), 6-14.
- Daher, W. (2009). Students' Perceptions of Learning Mathematics with Cellular Phones and Applets. *iJET* – Volume 4, Issue 1, doi:10.3991/ijet.v4i1.686
- Daher, W. (2010). Building mathematical knowledge in an authentic mobile phone environment. *Australasian Journal of Educational Technology*, 26(1), 85-104. http://www.ascilite.org.au/ajet/ajet26/daher.html
- Baya'a, N. & Daher, W. (2010). Middle School Students' Learning of Mathematics Using Mobile Phones: Conditions and Consequences. *Journal of Interactive Learning Research*, 21(1), 1-25.
- Yerushalmy, M. & Botzer, G. (to appear September 2010) Teaching secondary mathematics in the mobile age. In Zaslavsky, O. and Sullivan, P. (Eds.) *Tasks For Secondary Mathematics Teacher Education.*