Hans-Georg Weigand, University of Wuerzburg (Germany)

Five Theses about the Use of Digital Technologies in future Mathematics Classrooms

A few (personal) thoughts about (necessary) future developments

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H.-G. Weigand

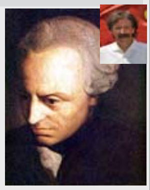
What do we know (today)?

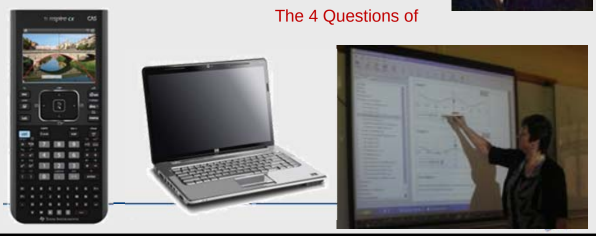
What are our goals?

What shall we do?

Which Math. Education do we want?

The 4 Questions of





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1. What do we know (today concerning the use of ICT in mathematics classrooms)?

The M³-Project in Bavaria …

2005/06 …..

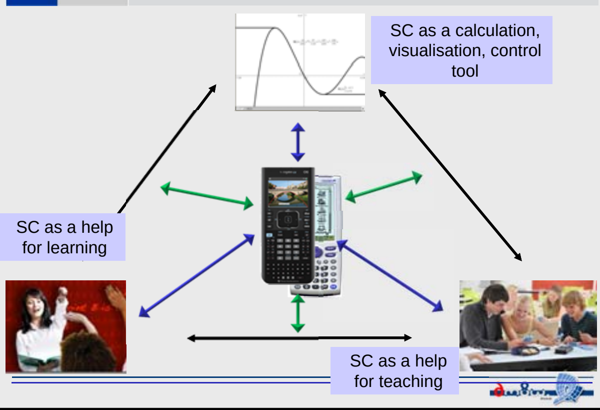
… 2010/11 (20 schools, 60 classes, 2000 SuS)

…. 2011/12 Each school can choose the use of the SC

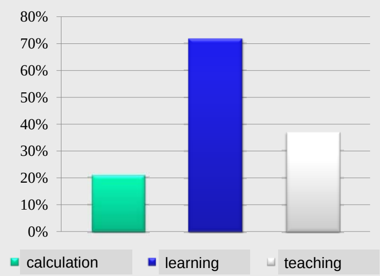
- A greater variety of problem solving strategies
- Students work more individually and with partners
- Little changes of exam-problems
- No difference in paper-and-pencil-competencies
- SC are well-accepted by students and teachers
- Changes in the classroom do not happen only while using a new tool.

M³: Model-Project-Media-in-Mathematics-lessons

Additional values of NT?



Student-interviews: Most important aspect of the SC?



2. What are our goals and expectations?

Expectations

1972 – HP 35

Expectations of many math educators 1972ff

Calculators …

… allow experimental activities in the frame of discovery learning and problem solving

… give a numerical basis for concept formation

… allow the integration of authentic real-life problems into the classroom

… release students from algorithmic calculations

…. will bring far-reaching changes of the goals of mathematics in the classroom.

Expectations 1995 …

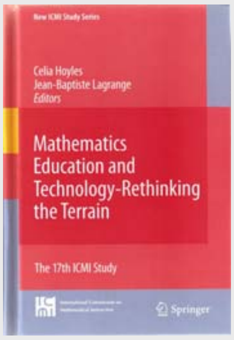
TI-92 (1995)

TI-Nspire

"The power and the flexibility of technology can help **change the focus of school mathematics** completely …. The student no longer will be a calculator … he/she will be an **organizer of strategies** and an **interpreter of results** …"

Many math educators ….. 1995

ICMI Study 17



"Technology still plays a marginal role in mathematics classrooms" (p. 312)

"The impact of this technology (CAS) on most curricula is weak today" (p. 426)

"The situation is not so brilliant and no one would claim that the expectations expressed at the time of the first study (20 years ago) have been fulfilled." (p. 464)

Possible reasons …

We underestimated the difficulties …

… of students and teachers to handle the tools (technical difficulties).

… of the integration into a – non technology-based developed – curriculum

… to convince – non-technology-experienced –teachers – of the benefit

… to answer the question: Does the use of technology lead to a better understanding?

… to prove the benefits of SC in real classroom situations (long-standing empirical investigations!)

…

3. What shall we do?

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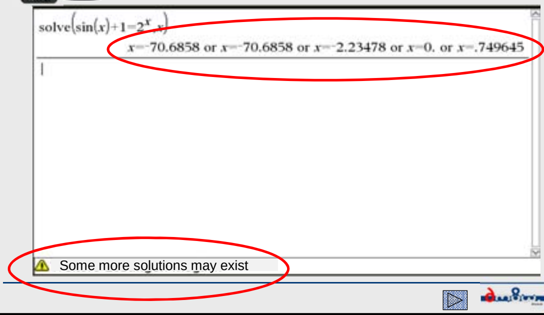
1. Example

Given are f and g with $f(x) = sin(x) + 1$ and $g(x) = 2^x$.

…. c) How many intersection points do the graphs have? Give reasons!



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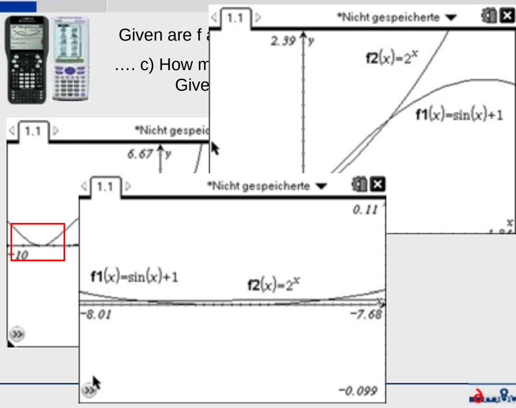
1. Example

Given are f a…

…. c) How m…ve?

Give…



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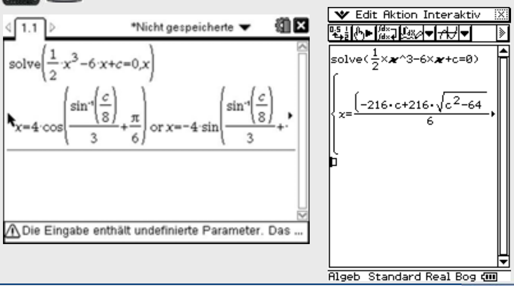
2. Example

Given is the function f_c with $f_c(x) = –$, $c \in$ IR. For which values of c does f_c have exactly one zero? Give reasons!



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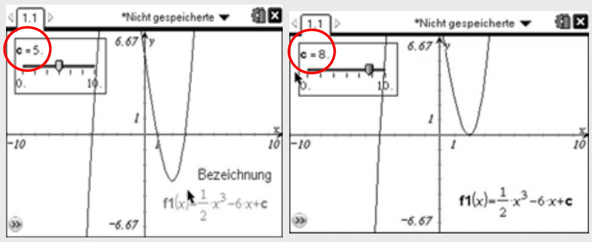

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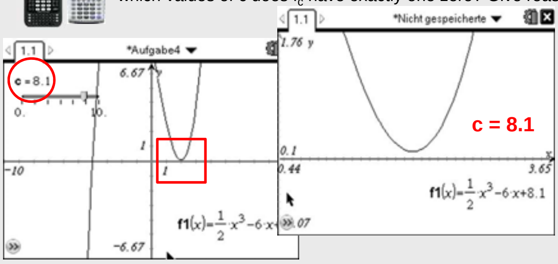

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2. Example

Given is the function f_c with $f_c(x) = –$, $c \in$ IR. For which values of c does f_c have exactly one zero? Give reasons!

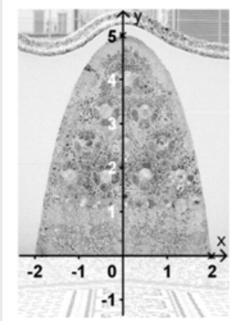
Correct answer: For $c < –8$ or $c > 8$ ….

Student answers:

- "Slider c = 8.1. For c = 8.1 (and more) the function $f_c(x)$ has only one zero."
- "c > 8.1 the function has one zero"
- "c ≥ 8.1"

1. **Thesis**: The relationship between ***real*** and ***mental representations*** is the crucial point for the evaluation of DT (CAS) ("semiotic mediation")!

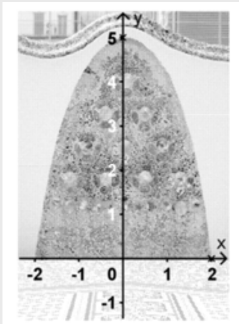
State-wide FINAL EXAM in Bavaria - May 2012



A ceramic art in the Casa Batlló has a shape like a parabola.

Casa Batlló in Barcelona

State-wide FINAL EXAM in Bavaria - May 2012



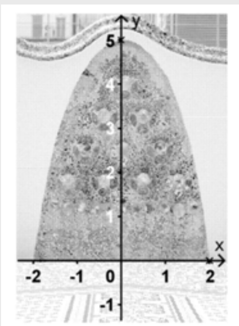
A ceramic art in the Casa Batlló has a shape like a parabola.

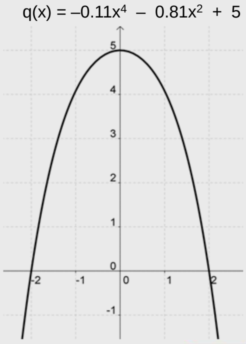
Give a model of the shape by using

$q(x) = ax^4 + bx^3 + cx^2 + dx + e$

Bavaria – May 2012

Solution:
$q(x) = -0.11x^4 - 0.81x^2 + 5$





Bavaria – May 2012

Solution:
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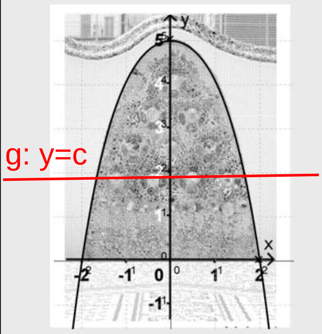
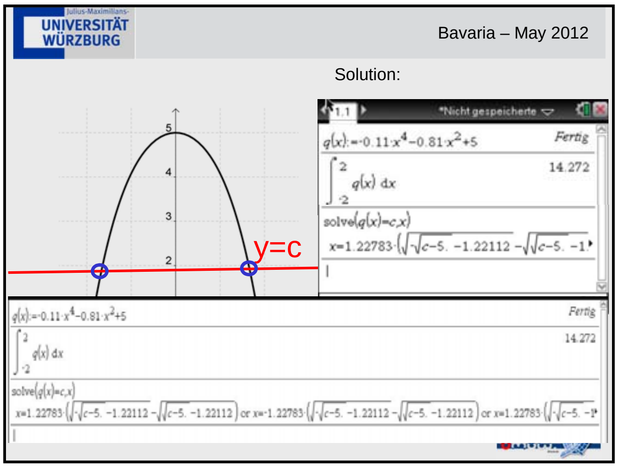


The line g is parallel to the x-axis and divides the work of art into two sections.

The area of the above segment should be 71.5 % of the whole area.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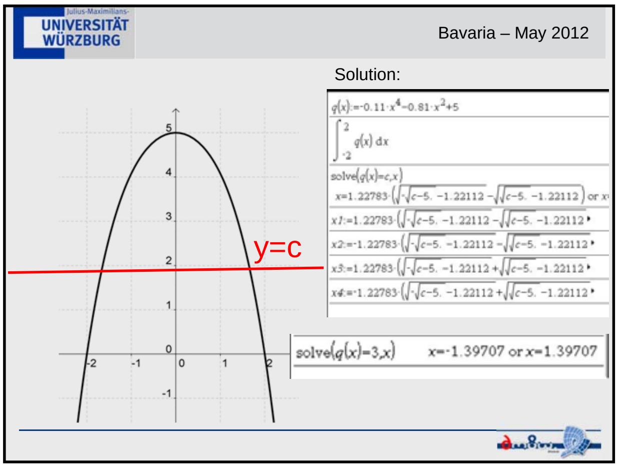
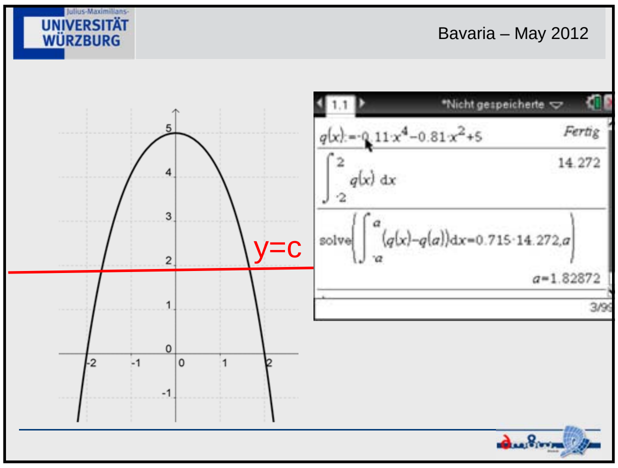
Bavaria – May 2012
Solution:
y=c
solve(g(x)=c,x)
Fertig
14.272


UNIVERSITÄT WÜRZBURG
Bavaria – May 2012
Solution:
y=c
solve(g(x)=3,x) x=-1.39707 or x=1.39707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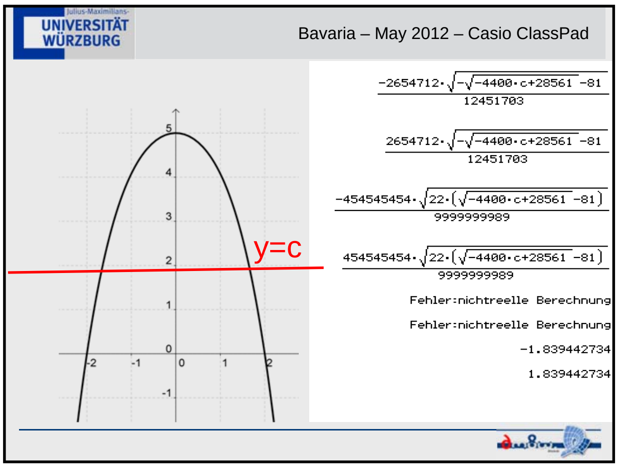
Bavaria – May 2012
y=c
Fertig
14.272
a=1.82872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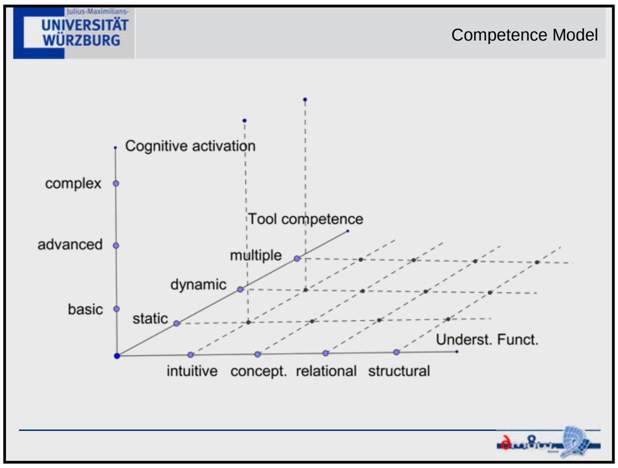
Bavaria – May 2012 – Casio ClassPad
y=c
Fehler:nichtreelle Berechnung
Fehler:nichtreelle Berechnung
-1.839442734
1.839442734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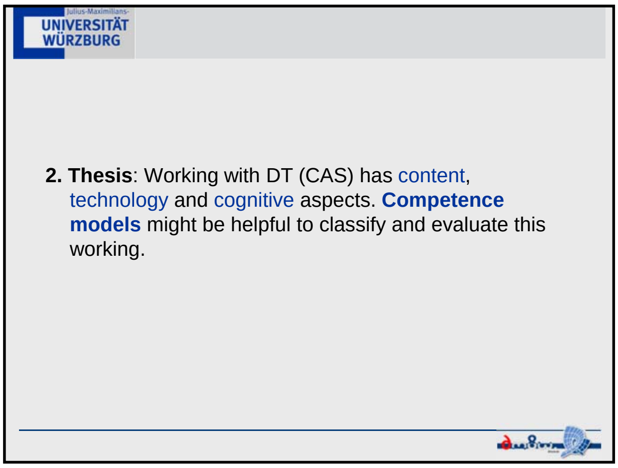
Competence Model
Cognitive activation
complex
advanced
basic
Tool competence
multiple
dynamic
static
Underst. Funct.
intuitive
concept.
relational
structural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2. Thesis: Working with DT (CAS) has content, technology and cognitive aspects. Competence models might be helpful to classify and evaluate this working.

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A paper-and-pencil solution

Given is the function f with $f(x) = (x – 2)^2 + 3$. Determine the equation of the tangent in the point P(1 / 4).

$f(x) = (x – 2)^2 + 3.$

$f'(x) = 2(x – 2)$

$= 2x – 4$

Slope in P: $f'(1) = – 2$

Tangent: $y = mx + b$ .....

Piece of paper

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Given is the function f with $f(x) = (x – 2)^2 + 3$. Determine the equation of the tangent in the point P(1 / 4).

$y = m \cdot x + t$

$f'(x) = 2x - 4$ $\left(\frac{d}{dx}(x-2)^2+3\right)$

$f'(1) = -2$ → $m = -2$

$y = -2 \cdot x + 6$

$4 = -2 \cdot 1 + t$

→ solve $(4 = -2 \cdot 1 + t, x)$ → $t = 6$

tanLine$((x-2)^2+3, x, 1)$ ⇒ $y = -2x + 6$

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Given is the function f with $f(x) = (x – 2)^2 + 3$. Determine the equation of the tangent in the point P(1 / 4).

Gleichung Tangente = $-2x+6$

Main Menü $f(x) = (x-2)^2 + 3$ ableiten mit diff

Grafik Menü Analyse – Skizze – Tangente

equation tangent = $-2x+6$

main menue $f(x) = (x\text{-}2)^2 + 3$ differentiate with diff

graphic menue analyse – scetch – tangent

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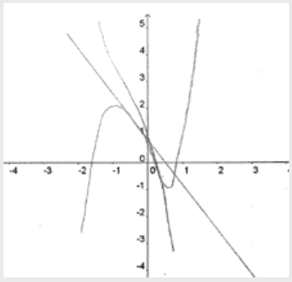
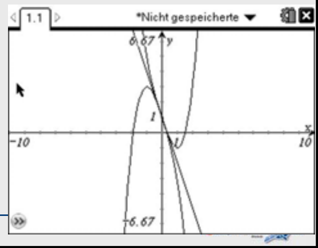
The graphs of f_a with $f_a(x) = a{\cdot}x^3 – 3x + 1$, $a \in$ IR …



Für a = -1, 0, 1



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3. Thesis: We have to develop **criteria** for (non-)correct, (non-)accepted **manual representations** (which may also been on the screen) of solutions!

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Criteria for written solutions

- There are no general rules!
- It is not enough to only write down, what‘s on the screen!
- Be aware of keywords, like „show …. “, „explain … “, „prove …“, …
- The solution has to be understandable „for others“, and it has to be seen when and where the SC was used.
- The solution describes the mathematical activities, it is not only a description in a special „calculator language“.

4. Thesis: The *acceptance* of new technologies requires a global concept of teaching and learning. **Connectivity** will be the key word in the future.

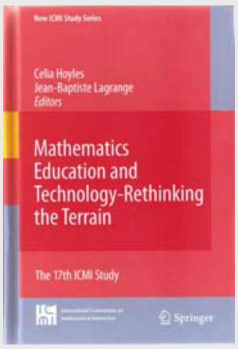
4. Thesis: Connectivity

4. Thesis: Connectivity

But : Connectivity does not necessarily imply better learning. Connectivity is the basis for better teaching and learning.

5. Thesis: We need ***visions*** which are based on empirical results and theoretical considerations, but we also need visions which are based “only” on new and creative ideas, and we have to have the courage to discuss also visions which look - nowadays – like illusions.

ICMI Study 17, 2010



Opening address of Seymour Papert at the Study Conference Dec. 2006 in Hanoi:
30 years of digital Technologies in Mathematics Education *and the Future*.

“We need a vision!”

Visions

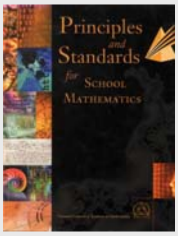
Arthur Brehmer (Ed.), The World in 100 Years, Berlin **1910**,

The wireless century (Robert Sloss): …
The telephone in the vest pocket (p. 35ff)

The wireless century (Robert Sloss): … The telephone in the vest pocket (p. 35ff)

„The citizen of the wireless century will walk everywhere with his „receiver“ … On his way to work, in the underground, everywhere, he will listen to the „spoken newspaper“ and he will get all the news he wants … And if he wants, he will be able to connect with every theater, every church, every concert hall and he can take part on the lecture, the sermon, the music session. …. The events of the whole world will be open to him …"

NCTM Standards 1989 & 2000"

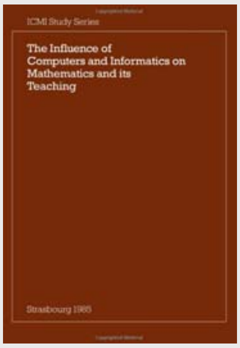


The Technology Principle

The Technology Principle: Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning.

… Calculators and computers are reshaping the mathematical landscape … Students can learn more mathematics more deeply with the appropriate and responsible use of technology. ….

First ICMI Study 1986



R. F. Churchhouse (Ed.)

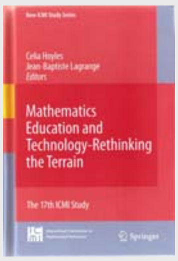
"Technology in mathematics education might work as a newly active volcano – the mathematical mountain is changing before our eyes" (J. Kaput 1992, p. 515).

A paradox

We need a vision …

… and visions are based on big questions!

A paradox



Big questions:

"How can technology-integrated environments be designed so as to foster significant mathematical thinking and learning opportunities for students?" (p. 16)

"How does the use of different digital technologies influence the learning of different mathematical concepts?" (p. 82)

5. Thesis: Visions

We need a vision …

… and visions are based on big questions!

… But (empirical) answers are mostly small!

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Xavi: Pep[1)] explains us *why* we play the way we play!
SZ: *Why*?

Xavi: Yes, there are many good teams, but they don't know *why* they play the way they play. Many things happen by heart. We know *why* we do the defense, *why* we play corners short not long, *why* we move right and not left, *why* we put pressure, …

[1)] *Josep Guardiola*

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Th@nk you!

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