When Routines Strike Back
Developing ICT supported mathematics instructional practices

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Systema Naturae
Some of my notes during these days in Karlstad

When speaking of GeoGebra:

“…students enjoyed it”
“…and they had to guess…”
“…wanted them to compare…”
“…explain the pattern…”
“…wanted to discuss with in groups…”
“… students added the commentary / explanations…”
“…does not need to be fancy…”
“…then you discuss with students why…”
“… the students said “we still need the teacher”…”
Twofold goal of educational design research:

Address real life problems in classrooms and in teachers’ everyday practices but also to contribute to theory and our understanding of the processes involved

"Learning by head, hand and heart"
(Johann Heinrich Pestalozzi)

My research:

Support teachers in the design of effective learning environments supported by ICT

• The notion of High-level evaluation and Low-level evaluation
Three cycles of development

Case 1: "First contact"

Developed to provide feedback to the teachers on their use of GeoGebra to support students conception of the distributive law

Case 2: "A new hope"

Tested with other teachers to guide their use of GeoGebra to engage students in effective “learning modes”

Case 3: "Final cut"

Validating its “usability”
The IRE sequence:
The IRE sequence is a “routine”

Expert teachers develop routines that allow different activities to run fluently

- Socially constructed patterns of behavior
- Facilitators of practice
- Allow teachers to be more opportunistic and flexible in their teaching
- Allow teachers to act unconsciously with speed and accuracy and without effort
An example of IRE

- What time is it, Denise?
- 2:30

- Thank you, Denise
- Very good, Denise

Any differences?

Mehan (1979)
- What time is it, Denise?
- 2:30

- Very good, Denise

or

- Thank you, Denise

Extended IRE sequence

Strategies that teachers may employ:

• Follow-up question
• Pretending not to understand
• Calling on other students
• Repeating the question
• Simplifying elicitations
• Eventually misinterpreting student responses
- What time is it, Denise?
  - 2:30

The IRE sequence

Some evaluations tend to put focus on …

- How to do things and how to get it right

- Why things work as they do and the connection between them

- Very good, Denise

or

- Thank you, Denise
The IRE sequence

How teachers perform the IRE sequence is an indicator for the way teachers use GeoGebra to support students learning in mathematics

(Perez, 2014)
The IRE sequence

Some evaluations (and initiations) are more likely to engage students in more effective modes of learning.

<table>
<thead>
<tr>
<th>Type</th>
<th>Mode</th>
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<tbody>
<tr>
<td>Low-level evaluation:</td>
<td>Passive/Active</td>
</tr>
<tr>
<td>High-level evaluation:</td>
<td>Constructive/Interactive</td>
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Passive (paying attention):

- Listen to a lecture without taking notes
- Watch a video or observe a demonstration
- Study a worked example
- Reading silently

Active (doing something while learning):

- Copy the solution from the board
- Pointing to what one is reading or solving
- Manipulate or measure
- Practicing or rehearsing definitions
Constructive (producing relevant outputs):

- Self-explaining
- Posing problems / asking questions
- Provide justification
- Formulating hypotheses
- Comparing and contrasting
- Reflecting, monitoring and other self-regulation activities

Interactive (being constructive with others):

- Explaining jointly with a peer
- Building on each other’s contributions
- Arguing with a peer (requesting & providing justification)
- Discussing similarities & differences

(Chi, 2009)
High-level evaluation (constructive/Interactive):

Often through "how" and "why" questions in an extended IRE sequence, asking for explanations, making the evaluation (right or wrong) a shared responsibility in the classroom, etc.

- That’s a good idea, why do you think that?
- Do you mean like this ... ?, why not?
- Can you give another explanation?
- Can anyone give an examples of this?
- How could we check if this is correct?
- …
Low-level evaluation (passive/active):

Often when focusing on right or wrong
Simplifying elicitations
Posing knowledge-control questions
Using students reply to continue with the routine.

- Yes that's correct...
- That is almost correct, other suggestions?
- ...

![Diagram of the evaluation process with labels: Initiate, Evaluate, and Reply.]

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Pedagogical tool:

Low-Level Evaluation (LLE)

Teacher actions that stimulate students being

- Passive  "Minimal or shallow understanding"
- Active  "Shallow understanding"

High-Level Evaluation (HLE)

Teacher actions that stimulate students being

- Constructive  "Deeper understanding that might transfer"
- Interactive  "Understanding that might innovate novel ideas"
One way to think about how to use GeoGebra

Create opportunities for students being

- Constructive
- Interactive

By using the affordances provided by GeoGebra

- Computations
- Representations (multiple and dynamic)
- Communication
Case 2: "A new hope"

Diagram:
- Demonstration of the lesson
- Lesson conducted within the teacher group
- Lesson conducted with students
- Workshop 1: Problem solving
- Workshop 2: GeoGebra
- Teacher learning community

Feedback loops:
- Demonstration of the lesson to the teacher group
- Lesson conducted within the teacher group to students
- Lesson conducted with students to teacher group

Research driven intervention:
- Workshop 1: Problem solving
- Workshop 2: GeoGebra
The dominating mode of student engagement expected throughout the lesson

<table>
<thead>
<tr>
<th>Introduction</th>
<th>Geometrical problem</th>
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</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7</td>
<td>8 9 10 11 12 13 14 15 16 17 18 19</td>
</tr>
</tbody>
</table>

- Passive/Active
- Constructive/Interactive
The question is where to position the point M so that the size of the two areas (blue and red) coincides.

The dynamical affordances were used to support students initial “guesses”.
A built-in grid in GeoGebra provided affordances for comparing areas by counting the number of squares within each rectangle.
Once a pattern was discovered and a hypothesis was formulated the computational affordances were used to control the hypothesis.

The hypothesis was proven by geometrical/algebraic reasoning.
Evaluating students’ guesses by right or wrong

Simplifying the task
The teachers’ progress (3 teachers)

• Awareness of their own daily use of HLE and LLE
• Started to use HLE more frequently
• Overusing HLE
• Using the computational affordances to provide LLE and producing serious shortcomings in how the lesson was enacted.

Involving students in mathematical thinking (problem solving)  
Low level evaluation

Finding solutions and “getting it right”

• More importantly, the teachers were able to use the tool to analyze their actions and recognize this situation
Case 3: ”final cut” (preliminary)

8 teachers from different schools

Three stages:

• Create opportunities for challenging routinized instructional behavior: Introduction of GeoGebra and the “tool”
• Plan and implement a learning activity (in GeoGebra)
• Reflect on and share the experience
Case 3: "final cut" (some evidence of usability)

... I have had the same lesson several times before, but much more close-ended. In the sense that I control and draw the figures and then I formulate the relationship between x and y straight away.

But now I started instead with "how could the farmer do if he had 600 m" or whatever.

I made the students approach the whiteboard to draw different alternatives. Then we talked about how he [the farmer] could reason when choosing one of these [the different possibilities].

Then I thought of this [] ... now I am just going to try to... and then several different properties of the areas came up that they saw in a completely different way compared to how I have done previously when I have had the same lesson.

When the class was over, we had even talked about second-degree equations having none, one or two solutions. It was great!
Constructive/Interactive

Stimulates

High-level evaluation

Often with focus on

Logos
(knowing about praxis, how and why)

Passive/Active

Stimulates

Low-level evaluation

Praxis
(”doing”)
The challenge:

- Willingness to use GeoGebra does not guarantee that it is used **effectively**

- Teaching routines (teaching techniques) can inhibit the full potential of GeoGebra to support learning
What we learned about Low-level evaluation/High-level evaluation:

• Don't over-use HLE
• It's not about bad and good evaluation
• Teachers were at the beginning confusing being motivated with being Interactive
• The computational affordances of GeoGebra supports LLE
• Helping teachers to reflect on their own practices and their use of GeoGebra
Thank you for listening!

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