ORCHESTRATING WHOLE-CLASS DISCUSSIONS IN MATHEMATICS USING CONNECTED CLASSROOM TECHNOLOGY

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Content

• Background (to our research)
• Connected Classroom Technology
• Pilot study
• Theoretical frames
  – Guiding the Design
  – Analytical tool
• Some preliminary findings
• Further research
Background

• **Context:** Upper secondary school (grade 10 to 12)
  – School development projects
  – Research projects (design research)

• **Task design with the overall aim to foster student’s**
  – instrumental genesis
  – Reasoning and communication abilities (pair work, written responses)

Let us illustrate with an example…
QUADRATIC FUNCTIONS

Quadratic functions can always be written in the form \( f(x) = ax^2 + bx + c \) where \( a, b \) and \( c \) are real numbers and \( a \neq 0 \). In this activity, we shall study quadratic functions written in this form using GeoGebra.

1. Right-click in the Graphics View and mark Grid.
2. Move the entire coordinate system so that the origin is located in the center of the screen.
   
   You do this using the tool:

3. Start by creating the sliders \( a, b \) and \( c \) using the tool: \( \square \) and click somewhere in the Graphics View.

4. Choose the "Increment" 0.5 for all sliders.

Tip: Point at the slider and at the same time press down the right mouse-button. By doing so you can move the slider over the screen.

5. Write the function: \( \text{Input: } f(x) = a \cdot x^2 + b \cdot x + c \)

6. Put the formula (the rule) that you find in the algebra window (to the left on the screen). You do this by highlighting the formula and then "drag" it into the Graphic View.

7. Set the slider \( a \) at 1 and the slider \( b \) at 0.
1. a) Investigate, by dragging the slider $c$, in what way the value of $c$ alters the graph. Change the value of the sliders $a$ and $b$ and find out if your result from above still is valid.

Describe in your own words:

b) The value of the constant $c$ can be found in the coordinate system. How?

c) Give a mathematical explanation why the value of the constant $c$ can be found in this way.

Spring 2017.
8 classes (229 students)
• When presenting the analysis for the teachers, it became obvious that there were many interesting responses among the students, not captured by the teacher during the lesson.

• Conclusion: There is a need for follow-up activities!
  BUT
  – What should they look like?
  – How could they be organized to enhance student engagement?
  – And most interesting…

• How could technology support teachers in their planning and implementation of follow-up activities (e.g. in terms of whole-class discussions based on students’ work on computer-based tasks)?

• A literature review provided a useful notion…
Connected Classroom Technology (CCT)

“… a networked system of personal computers or handheld devices specifically designed to be used in a classroom for interactive teaching and learning.” (Irving, 2006, p.16)
Pilot study

• Spring 2019
• 4 teachers and their classes
• Teaching unit
  – Introduction
  – Pair work
  – Whole-class discussion
• CCT: *Desmos Classroom Activity*
Theories Guiding the Design

• Formative assessment – Five key strategies (Black & William, 2009)
  (1) clarifying and sharing learning intentions and criteria for success;
  (2) engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding;
  (3) providing feedback that moves learners forward;
  (4) activating students as instructional resources for one another; and
  (5) activating students as the owners of their own learning (p. 8).
• three technological functionalities (*FaSMEd*):

(a) sending and displaying,
(b) processing and analysing, and
(c) providing an interactive environment
• The Five Practices (Stein et al., 2008)

(a) anticipating likely student responses to cognitively demanding mathematical tasks,
(b) monitoring students’ responses to the tasks during the explore phase,
(c) selecting particular students to present their mathematical responses during the discuss-and-summarize phase,
(d) purposefully sequencing the student responses that will be displayed, and
(e) helping the class make mathematical connections between different students’ responses and between students’ responses and the key ideas. (p. 321)
(a) anticipating likely student responses

- Previous study (229 students, 8 classes)
Task 1

(a) Investigate, by dragging the slider $c$, in what way the value of $c$ alters the graph. Describe in your own words.
(b) The value of the constant $c$ can be found in the coordinate system. How?
(c) Give a mathematical explanation why the value of $c$ can be found in this way.

<table>
<thead>
<tr>
<th>Code</th>
<th>Explanation element</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$x = 0$ gives $y = c$</td>
</tr>
<tr>
<td>B</td>
<td>$c$ can be found where the graph intersects the $y$-axis (i.e. repeats the answer to the previous subtask)</td>
</tr>
<tr>
<td>C</td>
<td>Comparing with the standard linear equation, $y = kx + m$</td>
</tr>
<tr>
<td>D</td>
<td>$c$ behaves like/corresponds to $m$</td>
</tr>
<tr>
<td>E</td>
<td>$c$ is the constant term</td>
</tr>
<tr>
<td>F</td>
<td>$c$ is independent of $x$</td>
</tr>
<tr>
<td>G</td>
<td>$c$ is independent of $a$ and/or $b$</td>
</tr>
<tr>
<td>H</td>
<td>solves for $c$</td>
</tr>
<tr>
<td>I</td>
<td>Providing example</td>
</tr>
<tr>
<td>J</td>
<td>Referring to the DMS feedback</td>
</tr>
</tbody>
</table>
(b) monitoring students’ responses to the tasks during the explore phase

*Desmos Classroom Activity* provides two opportunities:
Monitor all students’ progression
• Monitor all student responses to a single item at the same time
(c) selecting particular students to present their mathematical responses during the discuss-and-summarize phase

*Desmos Classroom Activity* provides ‘snapshots’: 
• Chose a selection of student responses by using “snapshot”
The teacher guide included examples of typical students responses to look for:

- ‘c can be found where the graph intersects the y-axis’ (i.e. repeats the answer to the previous subtask)
- Provision of a (numerical) example or referring to the DMS feedback
- Comparison with the standard linear equation, \( y = kx + m \) or ‘c behaves like/corresponds to m’
- ‘c is the constant term’ or ‘c is independent of x’
- ‘x = 0 gives y = c’
(d) purposefully sequencing the student responses that will be displayed
Prepare presentations
Oavsett värdet på a och b så kommer den alltid skära y-axeln på det värde c har.

1. Ask a question (optional)
   Man kan tydligt se vart grafen skar y-axeln och avläsa värdet c.

2. Ask a question (optional)
   För att m-värdet, vilket står för y-axelns skärningpunkt ändras, vilket gör att grafen flyttras upp eller ner.

3. Ask a question (optional)
   c = m-värdet, c är m-värdet i funktionen.
(e) helping the class make mathematical connections between different students’ responses and between students’ responses and the key ideas
The teacher guide included questions to discuss in relation to the typical students

- ‘c can be found where the graph intersects the y-axis’ (i.e. repeats the answer to the previous subtask)

- Provision of an example or referring to the DMS feedback

- Comparison with the standard linear equation, $y = kx + m$ or ‘c behaves like/m corresponds to $m$’

- ‘c is the constant term’ or ‘c is independent of x’

- ‘x = 0 gives $y = c$’

Could the explanation be strengthened? Why does this mean that the graph intersects the y-axis when $y = c$?

What do $m$ in $f(x) = kx + m$ and $c$ in $f(x) = ax^2 + bx + c$ have in common?
Some preliminary findings

*Didactical Variables (DV)* – a tool for design and analysis (Ruthven, Laborde, Leach, & Tiberghien, 2009)

A didactical variable is any aspect of the task/task environment which may influence the unfolding of the expected trajectory of learning.

A principles anaysis of the pros and cons of chosing particular values of didactical variables will be undertaken.
Observation:
The time from that the first pair had performed the task sequence to the beginning of the whole-class discussion was about 25 minutes (in all four classes).

An example of suggested DV:

When should the whole-class discussion start?

When all students have finished all tasks, a specific task, or when expected answer categories are received?
Observation:
The teachers started the selecting process at various times:
8 min, 23 min, 5 min, 16 min

Suggested DV:

When should the selecting process start?

As soon as an appropriate answer has been received, when all students have finished a specific task, or when all expected answer categories are received?
Further research

Develop principles to guide formative teaching activities using CCT through identifying and investigating key didactical variables relating to the following components:

- the **design of task** sequences with good potential to make formative use of CCT facilities
- the **monitoring, selecting and displaying** of student solution(s) as a base for discussion
- the choice of **appropriate interaction types** (e.g. group discussion, student presentation, whole-class discussion) in different situations
- the **orchestration of digital resources** to support effective interaction of these types so that all students are engaged
- the **management of time** and progression in a formative lesson
Many thanks for your attention!