



Early Developments for Access to Maths

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Multimodal Interaction with Maths: Some Requirements

design criteria for multimod. i.	common accessible GUI criteria	mathematical interaction
coherence	Gestalt preserves contextual information, WYSIWYG, visualization of focus	output-modality and input modality should match tracked focus; coherence with visual user interface
exploration	spatial or hierarchical navigation,	spatial or hierarchical navigation, for ex. matrices and fractions
support metaphers	write symbols, verbalize names, visualize icons,	verbalize names, Braille symbols& rules, or non-verbal sound
learnability	preserve knowledge gained in textual interaction (cut and paste), paper&pencil techniques	apply existing Braille-notations or synthetic speech
adaptability	support multiple input techniques and multiple output media apply user profile	allow for extension of maths notations



Applying the Criteria

	coherence	exploration	metapher	lernability	adaptability
6-dot	lowest	mechanical problems	Braille codes	low	low
7-dot	low	Low	Braille codes	medium	low
8-dot	medium	Low	Braille codes	medium	lowest
speech	medium	lowest	names, sounds	high	medium
LaTeX, DTD	high but lacks focus	medium	none	lowest	high

HTML and Maths: Incoherent

- DTD for HTML 3.0 was rejected for its maths solution

- Project MEDOC problem: Image Tag

`<P><P>`

- Improvement (see also Open University [Fine, 2008])

`ALT="$a_nx^n+a_{n-1}x^{n-1}+\dots+a_1x+a_0=0, a_i \in \mathbb{R}, a_n \neq 0,$"`

The screenshot shows a Netscape browser window with the title "Netscape - [Algebra (Gleichungen und Ungleichungen)]". The address bar contains the URL "http://medoc.informatik.tu-muenchen.de/Books/stoecker/part-1/node82.htm#SECTION00300". The page content includes the heading "Algebraische Gleichung n-ten Grades (Grundform):" followed by the equation $a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x + a_0 = 0, a_i \in \mathbb{R}, a_n \neq 0,$. Below this, it says "kompakte Summenschreibweise:" and shows the summation $\sum_{i=0}^n a_i x^i = 0.$. A paragraph with a question mark icon states "Die Suche nach Polynom-Nullstellen führt auf algebraische Gleichungen." At the bottom, it defines "Diophantische Gleichung: Algebraische Gleichung mit ganzzahligen Koeffizienten, für die nur".



The MATHS Workstation

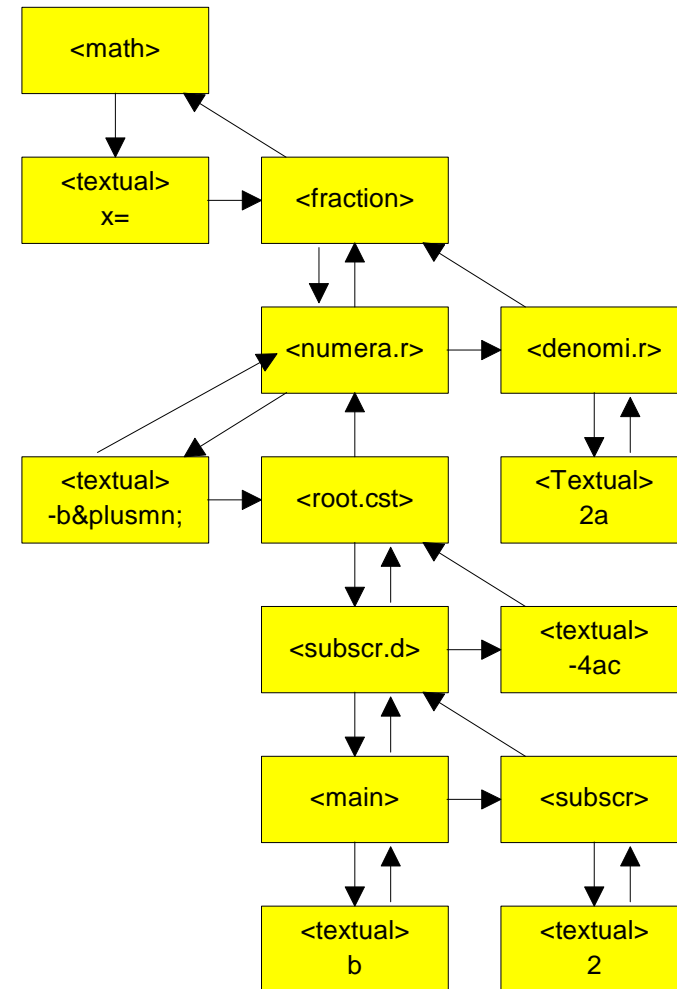
- EU TIDE project 1994-1997
 - Univ. Cork, Ireland
 - Grif S.A., France
 - K.U.Leuven, Belgium
 - F.H.Papenmeier GmbH, Germany
 - Univ. York, UK
- writing and reading maths
- SGML Editor with WYSIWYG (Grif S.A)
- WinDOTS Screenreader (F.H.Papenmeier)
- flemish Woluwe Braillecode, German, Engl. and Dutch Speech, LaTeX export
- School studies in Ireland with low-vision and in Belgium with blind students
- evaluation by blind mathematicians in UK
- integrates
 - GUI
 - magnification
 - Braille output/Braille input
 - Speech output/non-verbal sound/Speech input (pilot study)
- extends the screenreader
 - cut&paste
 - printing on paper through Browser with LaTeX plugin
 - printing Braille

Sample Representation

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

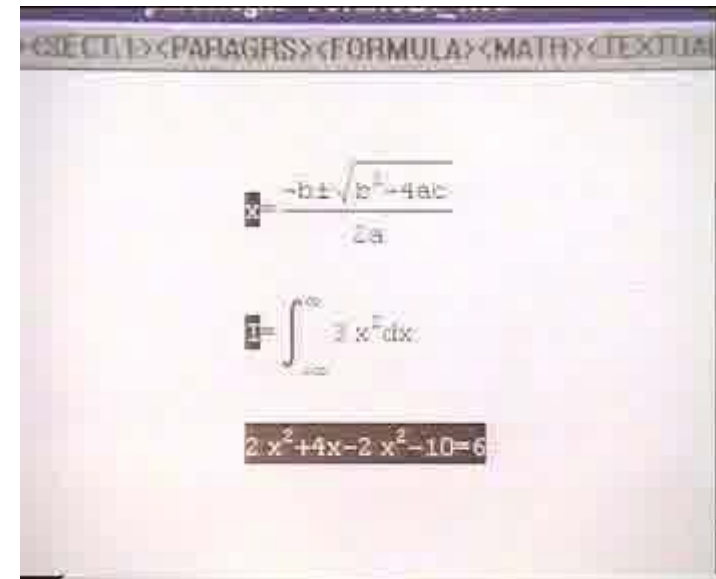
x equals minus b
plus or minus
square root ...

x=-b ...



Speech and Sound

- Speech output
 - applies prosody for German/English
 - 16 pitch levels
 - different pauses
- non-verbal sound
 - provides overview
 - feedback for keyboard input
- approx. 150 mnemonic commands:
 - type
 - show, current, **N**ext, Previous, begin, end
 - start, finish, overview
 - mathematical terms
 - equation, **E**xpression, paren, fraction, nominator, denominator, exponent, index, limit, big operand, root, vector, matrix
 - input for example Control **N E**
 - evaluation confirmed learnability



Braille

- Braille input on A standard keyboard
- support routing keys and buttons on Braille display
- dynamic Braille
 - collapse terms and
 - expand terms

