

## Use of ICT in formative scenarios for algebraic skills

### Paper for ISDDE conference

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### Introduction

In this informal paper I will first give a general outline of the research questions to be answered in my study on the “Use of ICT for acquiring, practicing and assessing relevant mathematical skills”. Then I will focus on two specific issues that arise during the course of it. Firstly what ICT tool to use. Secondly how an ICT tool could be used in a didactic scenario. Two directions that address these issues are:

- criteria for ICT tools for assessing algebraic skills
- and a scenario I call *formative scenario's* with varying feedback.

Finally this will lead to several points for discussion in the ISDDE topic group on (computer) assessment.

### General outline of research

In the Netherlands – as in many other EU-countries- universities complain about the algebraic skill level of students coming from secondary school. It is unclear whether these complaints have to do with basic skills or “actual conceptual understanding”, which we refer to as symbol sense (Arcavi, 1994).

Three key topics come together in my paper, providing the foundation of our conceptual framework: tool use, assessment and algebraic skills.

The first topic concerns acquiring algebraic skills. Here we discern basic skills, for example solving an equation, but in particular conceptual understanding. Arcavi (1994) calls this “symbol sense”.

In this case, formative assessment would be appropriate; aimed at assessment *for* learning. Assessment contributes to learning and understanding of concepts (Black & Wiliam, 1998). Feedback plays an important in formative assessment. On the other hand, recording scores and results of students remains important: summative assessment, assessment *of* learning. Combining both summative and formative assessment in one scenario seems to make sense.

In assessment for learning using ICT tools can be beneficial. ICT tools can help with giving users feedback, may focus on process rather than result, track results or scores and provide several ‘modes’, ranging from practice to exam. Thus, assessment is *for* learning.

This research focuses on the following central research question:

*In what way can the use of ICT support acquiring, practicing and assessing relevant mathematical skills?*

The hypothesis is that the use of ICT tools, if carefully integrated, can increase algebraic skill performance in general and symbol sense in particular.

The main research question is elaborated into the following sub-questions:

- a) What are characteristics and criteria for an appropriate tool for assessment of algebraic skills?
- b) What role can feedback play when using an ICT tool for acquiring algebraic skills?
- c) How does instrumental genesis take place when learning algebraic skills, both basic skills and symbol sense?
- d) How can transfer of algebraic skills take place from the tool towards pen-and-paper?
- e) How can formative and summative assessment be successfully combined in one didactical scenario for an ICT tool for acquiring, practicing and assessing algebraic skills?

My input for the ISDDE conference will focus on sub questions a, b and e:

- A) Preliminary results of preparatory research on tool choice
- B) Thoughts on a *formative scenario*, involving varying feedback

### A) ICT Tools for assessment of algebraic skills

The first step in choosing an appropriate tool for assessing algebraic skills is to compile a list of criteria for determining strengths and weaknesses. The prototype list of criteria is based on our theoretical framework and own experiences. The categories are based on the three key concepts that underpin this research: algebraic skills, tool use and assessment. We distilled several criteria from every key concept. For example, the theoretical background on

assessment yielded criteria for the *use of feedback*. In a first round the list of criteria was distributed to several international experts to increase the validity through intersubjectivity. It will yield an enhanced version of the list. In a second round we aim to investigate the importance of every individual item.

As research sources we used, amongst others:

- The assessment criteria are from the seven principles of good feedback practice (Nicol & MacFarlane-Dick, 2006) and eleven “conditions under which assessment supports students’ learning” (Gibbs & Simpson, 2004).
- Types of feedback (University of Waterloo, 2000)
- Authoring facilities for teachers, addressing the needs of the “neglected learners” (Sangwin & Grove, 2006).
- Many of the more general criteria found in the IDEA: Identifying Design Principles in Educational Applets (Underwood et al., 2005).
- Three characteristics, two from microworld being *advanced editing* to let the student develop his or her *own reasoning steps*, and *epistemic feedback*, one from the CAS paradigm *availability of commands* (Nicaud, Bouhineau, & Chaachoua, 2004).
- Articles on cognitive fidelity, mathematical fidelity and expressive/exploratory environments. (Beeson, 1989; Bliss & Ogborn, 1989; Dick, 2007).

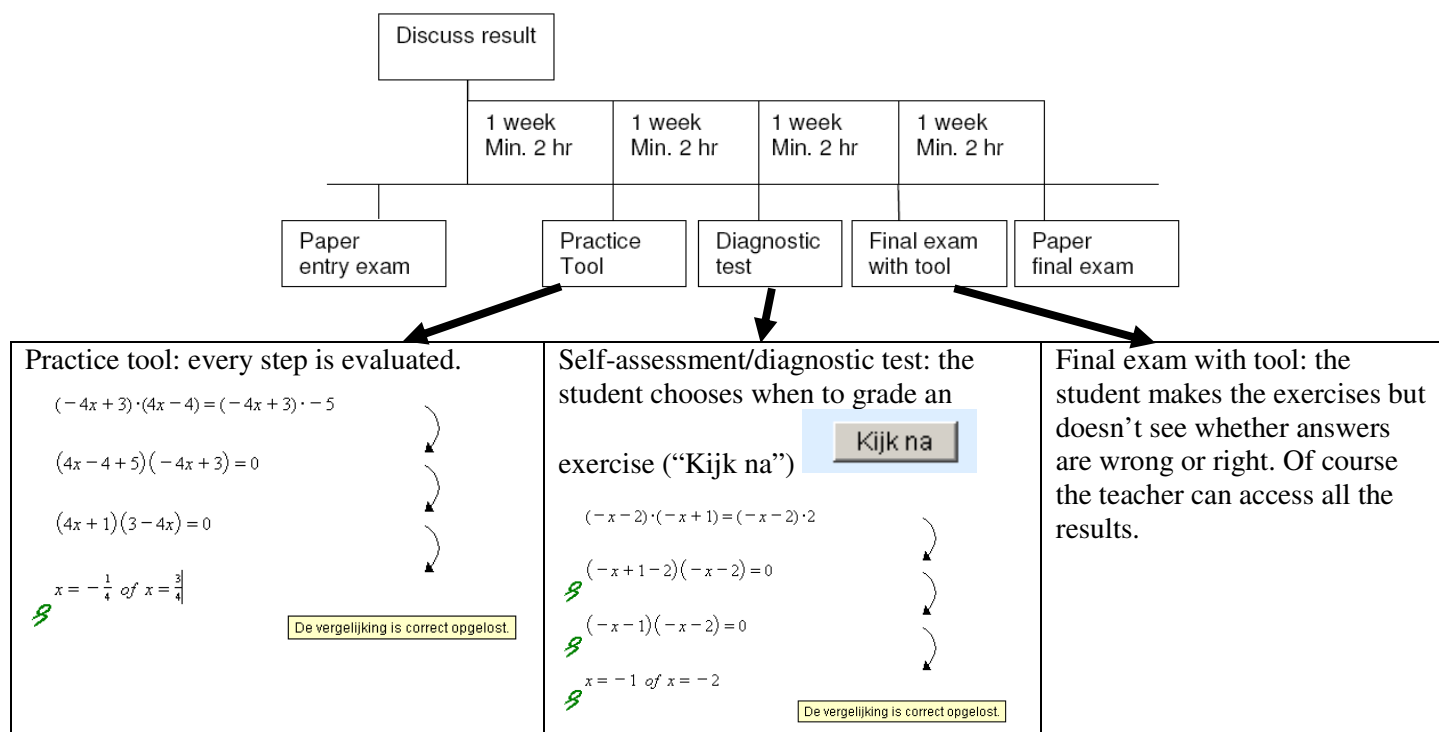
Preliminary results of the first round should be available around the time of the conference. The list will be used for evaluating and choosing an appropriate tool. Together with analysis of content involving *symbol sense* –not touched upon in this paper- it will form the basis of our first prototype.

## B) Formative scenario's

I am implementing a formative scenario that combines both elements from summative and formative assessment. Here, a tool is used in different ‘modes’. One of the criteria mentioned in the preceding paragraph is that a tool is able to be used in several ‘modes’. This is the case for several tools, for example Maple TA, the Digital Mathematical Environment and WIMS. Using these ‘modes’ it is possible to make a balanced *formative scenario*. In our research we will use three cycles of design research. In the first cycle we fine-tune the design of the prototype and feedback to be used. In the second cycle the prototype is used in a formative scenario:

- starting with a paper-and-pencil pretest;
- using a tool in subsequent ‘modes’, at school and at home;
- using the tool for an exam, a high-scale test;
- ending with a paper-and pencil posttest;

In a third cycle the scale of the experiment is increased. The target population involves the last years of secondary education and first years of higher education. Focus is on algebraic skills.



## Discussion

Central in our research is the combination of formative and summative assessment of algebraic skills in one scenario involving an ICT tool. What variables regarding feedback play a role in such a scenario?

Thoughts are:

- varying the amount of feedback (first more, then less?)
- varying the type of feedback (e.g. conceptual, procedural, representations)
- varying the timing of the feedback (first direct, later delayed?)

In the end this scenario should (partially) solve the problem of transfer of algebraic skills with an ICT tool and algebraic skills with paper-and-pencil. To fully benefit from a tool it should record both answers and reasoning steps.

One of the biggest challenges lies in the types of feedback a tool provides. This is why the first cycle of my design experiment focuses on this aspect.

How can a tool anticipate what answers will be given?

Does one need domain reasoning? Or “just” a feedback tree?

## Demo session

Assessment of algebraic skills in several ‘modes’: practicing, self-assessment and exam. Varying feedback, for example through representations. Thoughts on further requirements for tools.

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