

## **What toolbox is necessary for building exercise environments for algebraic transformations**

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The paper analyses functions that are necessary for building exercise environments for school algebra, and tries to identify which components could be borrowed from universal toolboxes (underlying CAS or libraries of utilities).

Many mistakes of pupils are caused by misunderstanding of operations and the structure of expressions. Therefore, we assume that, in most detailed working modes, the solution step could contain three substeps:

- 1) selection of the operation (conversion rule) from the menu,
- 2) (precise) marking of operand(s) in expression,
- 3) entering the result of operation.

The environment should be able check the input, diagnose errors, give hints, execute steps and create entire solutions automatically. For this, several kernel functionalities are necessary:

1. Sufficient spectrum of syntactical constructions (mixed numbers?).
2. Editor for expressions in planar form.
3. An editing function for marking several separate operands.
4. Verification of syntactical correctness of expressions/marking.
5. Verification of suitability of marked operands for selected operation.
6. Verification of equivalence of expressions/equations/...
7. Execution of all menu operations.
8. Verification of consistency of the entered result with the operation and operands.
9. Execution of 'textbook algorithms' for all task types.
10. Verification of the final form for all task types.

The items 1-4 and 6 could be included in education-oriented CAS-s together with items 7 and 9 for frequently used operations/task types. Verification of 5, 8 and 10 is more sensitive to particular demands/traditions. However, an appropriate library of syntactical utilities could be useful for programmers.

The paper also discusses some general questions (number domain, conversion of expressions to internal form, recording of assumptions of simplification operations, possible universal transformation/checking engines).

Our analysis relies on experiences with the school algebra project T-algebra.