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Intervention Tool

Playing with variables and algebraic expressions

1. Introduction

This intervention tool aims to help students with difficulties in the simplification of algebraic expressions as well as those who have trouble with the concept of variable.

2. Theoretical framework of reference

Karagiannakis's and colleagues (2016), propose a model classifying the skills involved in learning mathematics into four domains: core number, memory, reasoning, and visual-spatial. The results of their research support the hypothesis that difficulties in learning mathematics can have multiple origins and they provide a means for sketching students' mathematical learning profiles.

The herein described intervention tool is related to the Memory domain as well as with the mathematical domain Algebra since the students are asked to perform calculations with the numbers and variables they obtain.

1) From another point of view, the **Center for Applied Special Technology** (CAST) has developed a comprehensive framework around the concept of Universal Design for Learning (UDL) - http://www.udlcenter.org - with the aim of focusing research, development, and educational practice on understanding diversity and facilitating learning; UDL includes a set of Principles that focus on individual differences as an important element to understand and design effective instruction for learning. To this aim, UDL advances three foundational principles:

1) Provide multiple means of representation;
2) Provide multiple means of action and expression;
3) Provide multiple means of engagement.

2) Another theoretical reference comes from the **European Project FasMed,** focused on formative assessment in mathematics and science, (https://research.ncl.ac.uk/fasmed/), conceived as a method of teaching where information around the student's accomplishments is interpreted and used by instructors, learners, or their peers, to make choices about the following steps.

3. Design

In the subsections, the activities of the intervention tool are presented in detail**:**

3.1. Difficulties identified through the B2 questionnaire

The difficulties identified in B2 to which this intervention tool is directed are the simplification of algebraic expressions and the role of a variable in such an expression. B2 has several such questions, where the student is asked to simplify an algebraic expression (as is the case of questions 9 and 31) or the variable in an expression is to be replaced by a given number (for example, questions 11, 22 and 23).

Such kind of questions that fall into the domain of Algebra requires that the student identifies terminology (as denominator and numerator), retrieves numerical facts and performs calculations, all skills under the 'Memory' domain.

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3.2. Cognitive area and math domain of interest

Memory/Algebra

3.3. Educational Aims

This intervention tool aims to help students with difficulties in the simplification of algebraic expressions as well as those who have trouble with the concept of variable.

3.4. Addressing to Student /class

This intervention tool may be addressed to the whole class.

3.5. Educational activities: the Intervention Tool

Required material:

- 4 boxes:
- Box 1 with cards with numbers from -10 to -10;
- Box 2 with cards with variables (x, y, z, t) (5 times repeated);
- Box 3 with cards with operations (+ - x :) several times;
- Box 4 with cards with numbers assigned to the variables (x = 1; x = -2; x = 0; x = 1/2; ...).

A team of 1 to 3 students takes 3 numbers from Box 1; next, they take a variable (as many times as they want) from Box 2; after that, they remove operations from Box 3 and create an algebraic expression with the constants and the variables, writing down the expression in a notebook; then, they simplify the expression and write down the simplified version; they take a card with the value of the variable from Box 3 and calculate the value of the two algebraic expressions, the initial one and the simplified version. They verify that the obtained results are equal.

The teams can repeat the exercise increasing the level of difficulty (using fractions, several variables, etc.).

It is expected that this activity provides an opportunity to work the student's self-regulation and persistence (UDL principle *Engagement*) as well as the skill of decoding mathematical language and symbols and activating background knowledge about algebraic expressions and manipulation of variables (UDL principle *Representation*).
The discussion that will arise throughout the experience of playing the game will allow the teacher to informally evaluate the students' comprehension and progress and identify concepts that students are still struggling to understand so that adjustments can be made to future lessons, therefore allowing formative assessment.

4. References

[1] Ernest, P., Psychology of Learning Mathematics, Exeter: University of Exeter, School of Education, (1994).
[2] Karagiannakis, G. N., Baccaglini-Frank, A. E., & Roussos, P. (2016). Detecting strengths and weaknesses in learning mathematics through a model classifying mathematical skills. Australian J. of Learning Difficulties, 21(2), 115–141.
[3] Seng, L. K., An Error Analysis of Form 2 (Grade 7) Students in Simplifying Algebraic Expressions: A Descriptive Study, Electronic Journal of Research in Educational Psychology 8(1):139-162, (2010).

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