Using interactive items in arithmetic problems to help Grade 3 students shift from intuitive to arithmetic-based strategies and create mental representation.

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Abstract

In 2014, 32% of Grade 3 students in fundamental schools in Luxembourg failed to attain the minimum required skill level in mathematics; rising from 30% of students in 2015, as measured by the Ep.Stan examination, a standardized assessment of students at national level. These results have been rather stable since 2011, suggesting that almost 1 in 3 students in grade 3 do not possess the mathematical skills they would need to successfully progress in school. Most students in this bottom tier of performance in mathematics are also found to have low scores in reading skills in the German language (these students also tend to be recent arrivals with a low socio-economic profile) (Martin et al 2014), which as we will see has a compounding effect on their mathematics performance.

At the beginning of grade 3 in the fundamental schools in Luxembourg, students begin to delve into the skills needed to solve arithmetic wording problems. That students encounter more barriers to perform highly in the resolution of arithmetic wording problems than in those problems presented in a numeric form is however a well-known fact (Reusser 1990). The needed skills are not only mathematical, but well-developed skills in reading the language are needed, to solve an arithmetic wording problem (LeBlanc & Weber-Russel 1996). Both conditions do not allow the low performing students, who also perform less well in Ep.Stan, to succeed.
The purpose of this PhD study will be to measure the impact on the test results from Ep. Stan of the grade 3 students by letting students learn on wording problems that require intuitive strategies at first, up to those needing a more arithmetic strategy through interactive animated items in the digital learning environment MathemaTIC.

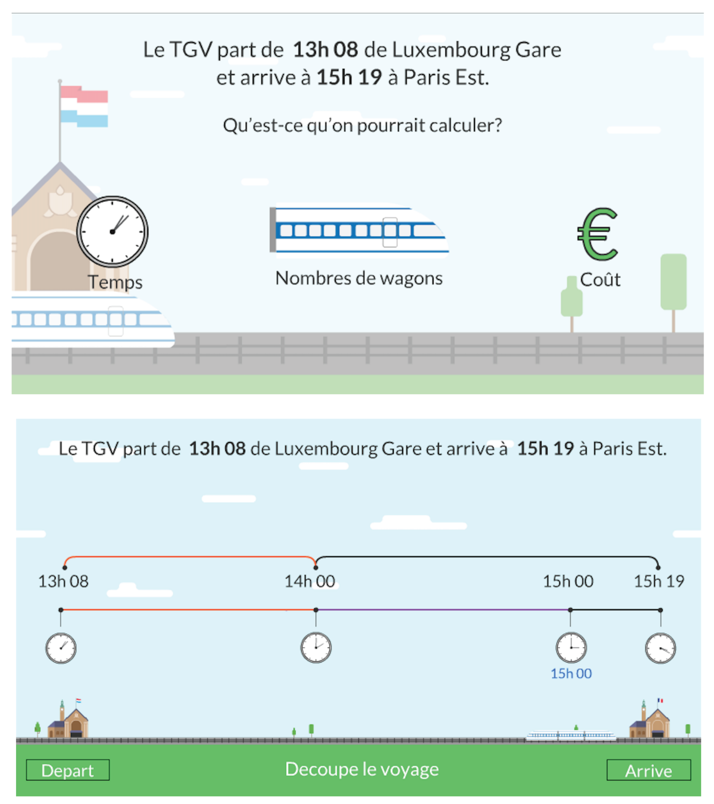
Research Questions

The following research questions were advanced to guide this study:

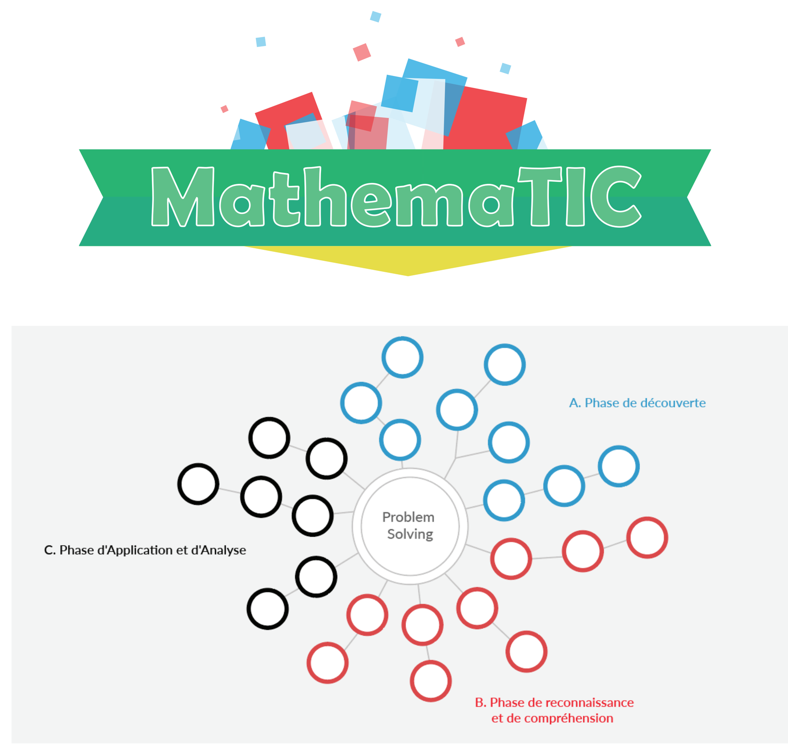
- Do grade 3 students' skills in resolution of arithmetic wording problems improve in the national testing Ep.Stan after the use of the designed learning environment?

- Can the progress of the skill levels of resolution of arithmetic wording problems already been measured during the use of the designed learning environment?

Items



Structure of the designed learning environment



The skill levels to improve

	Base Cycle 2		Base Cycle 3			Base Cycle 4
Competences	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Analysis of the wording of an arithmetic problem, and planning of the steps leading to the solution	The pupil identifies the relevant information in the wording of a very simple arithmetic problem, but a rephrasing might be necessary.	The pupil recognizes relations or similarities between the solving steps of problems dealt with in class.	The pupil identifies and writes down in-formation that seems relevant to solve a simple arithmetic problem, and he rejects the irrelevant details.	The pupil writes down the object of the operation and he outlines the cho-sen way to solve a simple arithmetic problem, thereto he has recourse to methods dealt with in class.	The pupil establishes a plan with the different steps in view of an individual solving of more complex arithmetic problems with at least 3 numerical data.	In the wording of an arithmetic prob-lem dealing with known strategies the pupil identifies relevant information and the steps to make, and he presents them in an appropriate way either in a diagram, a table, a semantic map or an arrow diagram.
Solution of an arithmetic problem	The pupil uses strategies dealt with in class to solve simple addition and subtraction problems with one operation (e.g.: status è transforma-tion è status), and he	The pupil solves more complex addi-tion and subtraction problems with one operation (e.g. starting from the initial or from the final status, he finds the transfor-	The pupil solves in writing a simple arith-metic problem with up to 3 numerical data, if need be even with the teacher's help; he uses known strategies, he	Using the strategies dealt with in class, the pupil solves autonomously simple arithmetic problems with at least 3 numerical data and 2 arithmetic operations (+, -, •, :), he communicates the solution and the steps to solve the problem both orally and in writing, with the help of mathematical language.	To solve more complex arithme-tic problems not previously dealt with in class and comprising at least 3 numerical data, the pupil chooses and develops his approach and indi-vidual strategies.	Resorting to known strategies dealt with in class, the pupil solves autonomous-ly and in writing a problem with up to 2 quantities and 4 numerical data.
Interpretation and assessment of the results	The pupil proves the correctness of the result of a simple problem.	The pupil identifies a simple arithmetic problem, whose question is not linked to the given information ("the captain's age").	Having recourse to estimation and round-ing strategies, the pu-pil checks the results of simple problems.	The pupil checks and explains the result and his own approach in writing; for this purpose he uses the appro-pri-ate mathematical terms.	The pupil compares his own approach to solve a problem to the other pupils' reasoning, and he thinks about the different steps together with his classmates.	The pupil justifies his approach and the reasoning that led him to the solution and he confirms or refutes the explanations of other pupils.

Item Structure

According to Brissiaud and Sander in 2010 on strategies students use to solve the arithmetic wording problems, students rely on the situation described in the wording. There are types of wording problems which could be solved by intuitive strategies (SI problems) and others that would prerequisite more arithmetic knowledge (CC problems). So depending on how the wording problem is presented to the student and the chosen numbers, the strategy and the needed arithmetic knowledge differ (Brissiaud & Sanders 2010).

Beside the arithmetic skills, the language skills, reading and comprehension of the wording problem are necessary to create a mental representation of the described situation, which is vital to find the strategy to solve it (Reusser 1990). In agreement with these researches, ways to improve the skills of solving word problems could be the training of the students on the different types of problems, from SI problems to CC problems, and to support students in creating a mental representation of the described situation.

Study Design

This Phd is a design-based research (Colins et al 2004) and will therefore be divided in different phases of testing, analysing data and remodelling the design during the study according to the results obtained from the data collection. Grade 3 students will take part in the EpStan 3.1 in November 2016. Based on the results of EpStan 3.1, the researcher will choose a representative group of 20 classes of students who will work during on MathemaTIC from January 2017 to July 2018. Between June and November 2017 the researcher will redefine the design taking in consideration the use of students and teachers, based on qualitative data from students and teacher interviews and collected logdatas in MathemaTIC. After the redesign and second period of use in 2018, the same students will take part in the EpStan 4.1 in 2018. A comparison will be carried out between the students who have been using MathemaTIC and those in a control group, to measure a possible increase of the skill levels from the students who used MathemaTIC. Before the first use in class in 2017, during the redesign in 2017 and at the end of use in 2018, usability testing will be carried out in an Human-Computer-Interaction Labatory through the concurrent and retrospective think-aloud-protocol (Kuusela & Paul 2000). This to get data on the first choices students made in the different wording problems and the use of the main interface.

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Poster Design: Sol Chang
Vretta