

# CASPER: A framework to assess the difficulty of exercises in terms of semiotic registers

Julien Seznec<sup>1</sup>, Ghislaine Gueudet<sup>2</sup>, Marine Moyon<sup>1</sup>, Jeanne Parmentier<sup>1</sup>, Martin Riopel<sup>3</sup>

<sup>1</sup>Institut Villebon – *Georges Charpak*, France ([julien.seznec@gmail.com](mailto:julien.seznec@gmail.com));

<sup>2</sup>Université Paris-Saclay, France; <sup>3</sup>Université du Québec à Montréal, Canada

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## INTRODUCTION

In this poster we present the first step of a design and research project whose aim is to support university mathematics teachers in their task design activity for first-year students. We focused on semiotic representation registers (Duval, 2006) intervening in mathematical tasks. We developed a framework to assess and adapt the difficulty of mathematical exercises, in terms of registers used and conversions of registers needed, implicitly or explicitly. We called this framework CASPER: *Categorize Activities Systematically with imPlicit / Explicit semiotic Registers*.

## THEORETICAL FRAMEWORK

Duval (2006) introduces the notion of semiotic representation registers as semiotic systems allowing transformations of representations. He distinguishes between two activities: treatments (within the same register) and conversions between two different registers. Conversions between registers are both a source of difficulties and an essential lever for conceptualization processes. Indeed, students shall separate objects from their representations, that is, they must acknowledge the existence of “objects” behind semiotic representations. This is only possible when they are facing multiple representations of the same object. Moreover, the conversion process can be more difficult than a simple encoding. It is the case when representations are not *congruent*, that is when the different signs in both registers cannot be mapped (1) bijectively and (2) univocally, or (3) if the mapping changes the reading order between source and target representation.

Even at the university level, confronting students to these issues is needed and requires a careful design of tasks. University students are expected to develop a flexibility in terms of semiotic registers, and this is one of the difficulties at the secondary-tertiary transition (Gueudet & Vandebrouck, 2022). How can we design a framework to situate and adapt the flexibility required by an exercise with respect to semiotic registers?

## THE CASPER FRAMEWORK

### Defining implicitness with respect to semiotic registers in activities

A register is *explicitly displayed* when it appears in the exercise's text. It is *explicitly mentioned* when the register is suggested without being displayed. It is *explicit* if either of these two situations holds. It is *implicit* if it is in the expected answer without being

explicit in the exercise's text. When there are several registers, the procedure(s) for solving the exercise will involve a conversion of registers. This change is *implicit* when no indication is given to the student about when, how and why they perform the conversion. Otherwise, it is *explicit*.

### **CASPER : Categorize Activity Systematically with imPlicit / Explicit semiotic Registers**

Our framework analyses activities according to 4 categories:

1. Explicit single register (a.k.a. treatment).
2. Multiple explicit registers with explicit conversions
3. Multiple explicit registers with implicit conversions.
4. Multiple registers where at least one is implicit.

In our poster, we present examples with the associated CASPER categories. We also provide examples of how it can be used to adapt a given activity. This could be interesting for teacher to address the secondary-tertiary transition issue.

### **Empirical evaluation**

We conducted an experiment with 28 first-year undergraduate students in a science and technology degree. They were randomly assigned into 4 groups (similar in terms mathematical proficiency, according to their semester 1 grades). Starting from 4 mathematical activities on different themes, we created variations of the exercises according to the 4 CASPER categories for a total of 16 exercises. Participants of each group individually performed the same 4 exercises (covering the 4 activities and the 4 CASPER levels), yet overall, the different groups covered the 16 exercises.

The goal of the experiment was to validate the CASPER framework. We expect the categories to be difficulty levels. Thus, we measure the average success ratio for the different categories. Given the small data situation, we did not reach statistically significant results, but these preliminary results are promising.

### **REFERENCES**

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