Overview of plenaries and working sessions of the Symposium: Theory of Commognition and the use of technology in teaching and learning processes

August 29 - September 4, 2024
Department of Mathematics, University of Pisa

Opening of the Symposium
time: August 29th 2024, 14:00
place: Aula Magna, Department of Mathematics

Plenary session 1: The DynaMat Research Project: introduction, goals, and design of the interviews and activities
time: August 29th 2024, 14:30-16:00
place: Aula Magna, Department of Mathematics
Speakers: Samuele Antonini, Anna Baccaglini-Frank, and other members of the DynaMat Team
Abstract
The DynaMat Project was funded in 2022 by the Italian Ministry of Universities and Research with the goals of (1) designing and experimenting digital-technology-enhanced activities to foster (remedial) mathematics learning around the concepts of equation and function (grade 10); and of (2) defining and identifying *mathematics discourse participation profiles* of struggling students (grade 10) in algebra, in order to gain insight into how to personalize remedial interventions. The research project takes a commognitive perspective and explores how such a perspective can help reach a more holistic view on learning difficulties and failure in mathematics, bridging cognitive and affective and social approaches, and allowing the study in fine-grained detail of students' participation also in our digital environments. Another research hypothesis is that through careful design of the digital artifacts, environments and tasks it will be possible to initiate processes of "re-alignment" of students' discourse with canonical (or experts') discourse.
The talk will introduce the project, its goals and specific research questions, as well as the design of the students' interviews and activities with digital artifacts. Moreover, we will present some considerations emerging after the first experimental cycle that led to design changes in the interviews and activities with digital artifacts.

Working session 1: Design of DEOs in a discursive framework

time: August 29th 2024, 16:30-18:30

place: Aula Magna, Department of Mathematics

Speakers: Chiara Bonadiman and Samuele Antonini

Abstract

The student-task-digital tool relationship has been widely investigated in mathematics education through different theoretical perspectives, and it is a key component of the DynaMat project. In this workshop we will focus on task design, delving into the relationship between tasks with digital tools, students, and mathematics from a commognitive perspective. In particular, we will introduce some of the tools that we have developed (these and some other ones are visible here: https://www.carme.center/risorse-dynamat/) to describe and discuss the project's design of dynamic explorative objects (DEOs) and related task situation. We will explore how these digital tools have been designed to elicit DEO-specific discourses that a (mathematics) expert can relate to particular mathematical objects, and how our sequences of task situations are designed to promote transitions to and relationships with canonical mathematical discourse, specifically in the domain of algebra. During the workshop we will experience interacting with some analytic tools for a priori analysis developed within the commognitive framework.

Plenary session 2: The invisible pitfalls of routines: Learning and teaching mathematics as managing communication gaps

time: August 30th 2024, 9:00-10:30

place: Aula Magna, Department of Mathematics

Speakers: Anna Sfard

Abstract

Communication in mathematics classrooms is challenged by numerous discursive gaps, most of them invisible, some of them necessary, and some potentially harmful. The talk will open with the introduction of the notion of routine and with the claim that learning at large, and learning mathematics in particular, may be seen as the process of routinization. A number of empirical examples and theoretical arguments will then be brought to show that in many cases, students' "incorrect" mathematical performances, rather than being due to insufficient technical proficiency or the lack of mastery in matching procedures to situations, may result from the learners' idiosyncratic interpretations of those situations. If so, learning may be seen as the process of overcoming discursive gaps between the student and the teacher. This claim, if taken seriously, must change the way in which we think about teaching mathematics and studying the development of mathematical thinking. The talk will conclude with a reflection on how to sensitize ourselves, as mathematics teachers and researchers, to discursive gaps, how to benefit from those that are an inevitable part of learning, and how to cope with those that may hinder the process.

Working session 2: Regulations as Intermediate Routines Between Subjectifying and Mathematizing

time: August 30th 2024, 11:00-13:00

place: Aula Magna, Department of Mathematics

Speakers: Einat Heyd-Metzuyanim

Abstract

The term *Self-Regulated Learning* (SRL) has gained increasing attention over the past two decades in educational research at large, some of which has also entered mathematics education. The term captures important meta-mathematical actions that have not yet been the focus of much commognitive study, despite their potential to provide missing links between mathematizing (communicating about mathematical objects) and identifying (authoring identity stories about the participants in the discourse).

In this workshop, I will share my group's recent attempts to develop commognitive tools that micro-analytically capture some of the actions discussed in the SRL literature, focusing on the planning, monitoring, and evaluating actions involved in the execution of mathematical routines.

The workshop will begin with a brief introduction to the main tool we have developed for capturing regulative routines: the Discourse Mapping Diagram (DMD). This tree-like diagram maps the mathematical routines enacted by students and, on top of this mathematical skeleton, overlays the meta-mathematical regulative actions.

After this introduction, I will share excerpts of 7th-grade students solving problems in early algebra, and we will practice coding the regulatory actions using the DMD

Plenary session 3: **The DynaMat Research Project: cycles of data analysis**

time: August 30th 2024, 14:00-15:30

place: Aula Magna, Department of Mathematics

Speakers: Anna Baccaglini-Frank, Samuele Antonini and other members of the DynaMat Team

Abstract

In this talk we will present preliminary results of the data analyses conducted after the first and second experimental cycles, dividing the presentation into three parts. In the first part we will describe the process of reaching an analytic scheme and template for students' *mathematics discourse participation profiles* (MDPPs), highlighting the cyclic efforts and some difficulties in designing and trialing such an analytic scheme and descriptive template. We will also give a preliminary example of how our ongoing research is attempting to study the effect of our activities with digital artifacts on students' MDPPs. In the second part we will introduce some results from the analyses of data collected during the first experimental cycle, focusing in particular on aspects of students' discourse and how they shift (in expected and unexpected ways) during the tutoring sessions with the activities we designed. In the third part we will present emerging themes from the ongoing analyses of the data from the second experimental cycle, with particular attention to phenomena and constructs that will be explored and discussed in further depth during working sessions 3 and 5.

Working session 3: **A subsuming discourse**
time: August 30th 2024, 16:00-18:00
place: Aula Magna, Department of Mathematics
Speakers: Giulia Lisarelli & Bernardo Nannini
Abstract
In the commognitive perspective, processes of *subsuming* have high potential with respect to the development of new discourses. Indeed, historically, critical transitions in mathematics discourses have been characterized by processes in which existing discourses were incorporated into and subsumed by newly developed discourses.
In this workshop we will share excerpts of 10th-grade students interacting with multiple dynamic explorative objects (DEOs), designed to be realizations of the same algebraic signifier. More specifically, they embed an interactive balancing mobile and two moving arrows as realizations of the relationships between two algebraic expressions depending on the same variable. Activities within these DEOs create the need for a common discourse for addressing the behavior of the mobile and of the arrows.
We will then analyze the characteristics of students' discourse to investigate to what extent they develop an algebraic discourse as a form of subsuming discourse.

Plenary session 4: Mathematical learning, identity and discourse: how do commognitive tools tie these together, and what does complexity have to do with it?
time: August 31st 2024, 9:00-10:30
place: Aula Magna, Department of Mathematics
Speakers: Einat Heyd-Metzuyanim
Abstract
Students' and teachers' identities have long been linked to mathematical learning and teaching, yet the mechanisms by which this happens in actual teaching-learning interactions are far from understood. Commognition offers a unique toolset for advancing our understanding of these mechanisms by focusing on the communicational actions—both explicit and implicit—that occur between students and teachers, while addressing the mathematical (cognitive), affective, and social aspects of communication. However, these tools have been constrained by the commognitive micro-analytical lens, which, while providing a key strength of the framework, also limits its applicability to longer-term processes.
In this talk, I will provide an overview of some commognitive works on identity, while introducing complexity theory as a potential solution to the limitations of past research. I will argue that commognition can be considered a sub-type of complexity theories and highlight possible extensions that the "umbrella" of complexity theories can offer. These include: (1) suggesting long-term mechanisms that may be at play in processes of success or failure in learning mathematics, and (2) linking to theories of affect and motivation that have

so far been considered incommensurable with commognition. I will exemplify my theoretical claims with cases from previous and ongoing studies involving middle-school students at different stages of what I term "a ritual cycle of failure"—a particular complexity mechanism where learning-teaching interactions lead to ritualization, characterized by a lack of agency on the part of the student and a focus on procedures rather than the agentive production of narratives about mathematical objects. Such ritualization processes ultimately lead to identities of failure in mathematics.

Working session 4: Routines and discursive gaps
time: August 31st 2024, 11:00-13:00
place: Aula Magna, Department of Mathematics
Speakers: Anna Sfard
Abstract
In the workshop, the participants will analyze episodes of learning-teaching conversations, trying to identify the routines of the interlocutors. They will then have to decide whether there was a discursive gap between the participants due to the difference in those participants' interpretations of the task situation. The purpose of the workshop is to get to understand better the concepts of routine and discursive gaps and to develop an initial ability to identify them in conversations.

Working session 5: Discursive Tuning
time: August 31st 2024, 14:00-16:00
place: Aula Magna, Department of Mathematics
Speakers: Bernardo Nannini, Anna Baccaglini-Frank and Giulia Lisarelli
Abstract
Numerous studies within the commognitive perspective highlight the potential for mathematical learning of situations in which students are faced with the presence of commognitive conflicts: encounters between discourses that are incommensurable with each other. These situations, which can potentially undermine the effectiveness of communication, on the other hand can also foster crucial changes in participants' discourse from the perspective of mathematical learning.
In this workshop we will present and discuss the notion of *Discursive Tuning*, a construct that within the DynaMat project we are developing to analyze situations of commognitive conflicts arising when students participate in a discourse with a digital environment.
After a brief introduction, we will share excerpts of 10th-grade students interacting with dynagraphs, dynamic explorative objects (DEOs) designed to be realizations of mathematical functions. During the workshop, we will attempt to put into practice the notion of Discursive Tuning to capture the possible presence of commognitive conflicts and to analyze possible changes in students' discourse in response to these conflicting situations.

Working session 6: Mathematics Discourse Participation Profile

time: September 2nd 2024, 9:00-11:00

place: Sala Riunioni (first floor), Department of Mathematics

Speakers: Elena Macchioni, Elisa Miragliotta and Federica Poli

Abstract

Starting from the assumption that inclusive education should be based on a careful examination of students' actual educational needs on both the cognitive and noncognitive sides, we synergistically use theoretical constructs of the theory of commognition to develop an analytical and visual tool for identifying students' *Mathematics Discourse Participation Profile* (MDPP). The MDPP is a multidimensional construct designed to capture the characteristics of students' participation in mathematics at a given point in time. The profiles are critical for designing materials and activities that meet the needs of each student.

In this workshop, we will briefly recall the main dimensions of the MDPP, focusing on the crucial role played by the metadiscursive rules as a bridging component between identifying and mathematizing.

In order to show in more detail how the data can be analyzed and to demonstrate how a student's profile can be sketched out, we will share and comment on excerpts with data from 10th grade students.

Participants will then be engaged in the activity of capturing specific aspects of a student's MDPP on the basis of selected excerpts, to start sketching out a MDPP.

The remaining sessions on September 2nd, 3rd and 4th will be held in Sala Riunioni (first floor) of the Department of Mathematics, according to the schedule online.