

Shaping digital deconstruction: teaching and learning of Mathematics during the lockdown

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Abstract

In this paper we address the issue of how the Covid-19 lockdown experience is impacting on Mathematics teaching and learning processes. This unexpected situation forced the deconstruction of teaching practices and our research is an attempt to understand how mathematics practices of Long-Distance Learning during lockdown were being shaped, and what role this period and the related studies could have for future practices. The main aim of the study, framed by Grounded Theory approach, is to shape the dimensions of the deconstruction process caused by the use of digital technologies in order to both understand the Long Distance Learning emergency period and to encounter the post Covid-19 needs related to mathematics education in a more structured way.

Key words: Mathematics Education, Technology education, Classification

¹ For instance, if a person is using a software like Google Meet on a PC, that person is using a specific example of digital technology which is different of the one used by another person who is

Modelando la deconstrucción digital: enseñanza y aprendizaje de las matemáticas durante el encierro

Resumen

Esta investigación tiene como objetivo estudiar el papel que la experiencia del confinamiento, debido a la Covid-19, ha tenido en los procesos de enseñanza y aprendizaje de las Matemáticas. Esta situación impredecible ha forzado la deconstrucción de las prácticas de enseñanza comunes y esta investigación es un intento para comprender cómo se han ido estructurando las prácticas de aprendizaje a distancia de Matemática durante el encierro y, también, entender qué rol podrían tener en este período y otros estudios relacionados para las prácticas futuras. El objetivo principal del estudio, enmarcado en el método de la Grounded Theory, es dar forma a las dimensiones del proceso de deconstrucción causado por el uso de las tecnologías digitales, con el fin de comprender mejor la enseñanza a distancia durante el período de emergencia y hacer frente a las necesidades posteriores a la Covid-19 relacionadas con la enseñanza de las matemáticas de manera más estructurada.

Palabras clave: Educación matemática, Educación tecnológica, Clasificación

Introduction

The Covid-19 pandemic crisis has forced schools to undergo a major reorganization of the teaching and learning (T/L) practices which did not stop, despite the lockdown and the closure of the school buildings. The institutional systemic response in our country (Italy) was long-distance learning (LDL), made possible thanks to the use of digital technologies. According to Del Zozzo & Santi (2020), with the expression “digital technologies” we mean every feasible combination of hardware and software¹.

Borba, Askar, Engelbrecht, Gadanidis, Llinares and Aguilar (2016) highlight how digital technology has completely deconstructed the image of the mathematics

working on the Google Meet app in his smartphone. Indeed, the same software on different hardware could lead different functionalities.

classroom, enabling new types of classes and working methods that trigger different socio-cultural dynamics:

Currently it seems clear that digital technology is “deconstructing” the notion of the classroom. [...] Mobile technology, PLNs², digital learning objects and other artifacts are “stretching” the classroom, transforming the classroom to the extent that it can hardly be recognized as such. [...] In this scenario, the regular classroom no longer serves as locus for education. Couches, chairs, tables at students’ house, café and Lan Houses are the new classrooms. Flipped classrooms change the notion of what is in and outside of the classroom and also change the roles of students and teachers.

(Borba et al., 2016, pp. 605-606).

Carefully framing and describing what and how this impact acts acquires importance and many researchers in mathematics education all over the world are conducting studies in this direction. In fact:

In a T/L context, digital technologies act similarly to a prism that refracts light: they break down subjects, objects and teaching processes, unpacking and making their various subcomponents visible (and, thus, possible to analyse).

(Del Zozzo & Santi, 2020, p. 25)

Furthermore, during the sanitary emergency, LDL forced the deconstruction of the entire T/L mathematics process revealing all its different aspects. This unexpected situation brought students and teachers to rebuild their T/L practices in a different context with different media. Thus, within this framework, the pandemic crisis has created the conditions to explore this phenomenon of deconstruction profoundly and to identify the different elements in which T/L practices are stratified.

What occurred during the transition and how LDL was shaped by students, teachers and other school members during the lockdown deserves to be carefully analysed in order to develop tools and resources for future school.

In this article, we present an ongoing study about the deconstruction processes related to mathematics T/L practices during LDL in the Italian context. We aim to describe how these processes arose and were inter-related during lockdown and how they can be a resource for the analysis of future practices both for teachers and for researchers in mathematics education.

Theoretical framework

Our methodological approach is based on Grounded theory methodology.

Grounded theory methodology was first defined by Glaser and Strauss in the book *The Discovery of Grounded Theory* (1967) and is shaped within the context of symbolic interactionism and pragmatism (Tarozzi, 2008).

Grounded theory studies are often related to research phenomena which lack theoretical foundation, as, in our case, practices of exclusive long distance learning (LDL) in schools during the pandemic crisis: no specific theory exists for the phenomena under study, and theories used to shape mathematics T/L processes at school are not yet defined specifically for virtual environments.

Grounded theory reverses the hypothesis-testing approach in order to develop a theory deeply connected with data. The researcher conducts simultaneously data collection and analysis, grounding the theoretical assumptions in the data in a process of constant comparison between the different data and aspects of analysis.

Following this process brings to theoretical assumptions profoundly anchored in the data: the categories developed during the research are defined and refined in order to explain what is regarded as significant feature of the data by the researcher in a process of constant comparison between different kinds of data and data analysis.

² Personal Learning Networks

Following Tarozzi (2008) we can describe the research's steps within grounded theory methodology as follows:

- Finding an area that needs to be explored defining a generative research question.
- Define methods and research tools, keeping awareness on the fact that the chosen tools model the data: multiple lenses can be chosen to look at the same phenomenon.
- Data collection and open coding which is made up of:
 - Collection and transcription of the data-interviews, observations, questionnaires.
 - Open coding that consists of a descriptive coding grounded in the data and not in the literature.
- Theoretical sampling that consists of widening the sample until the defined categories can be considered saturated, which means that new sample items do not conduct to new categories.
- Data collection and focused coding: when it starts to emerge principal directions, another data collection is conducted, with a selected sample. The obtained data are analysed using the open coding, that is discussed and integrated during the process. This phase allows to specify interpretative categories and highlight the core themes.
- Writing memos in order to allow “abstraction or ideation” (Glaser, 1978, p.83). Charmaz (2006) distinguish between early memos on critical reflection about data collection and advanced memos that account for the coding and categorizing process.
- Theoretical coding which is related to the definition of the categories and of their respective relationships.

In the next sections we will show how we developed our research following the mentioned points.

We followed the approach of Informed Grounded theory (Thornberg, 2012) in order to enhance the specificity of our research field, which is mathematics education:

the use of external theories and concepts are not determined by their epistemological roots or underlying philosophical assumptions per se, but by their usefulness in the actual study, i.e. by the way they fit and work with the data, codes, concepts and “emerging” theory that the researcher has generated or is going to generate by GT methods.

(Thornberg, 2012, p.251)

Therefore, we referred to the literature and to different theoretical perspectives regarding the emergence of the categories during the research in order to gain insight on the data and to orientate between the different concepts and ideas - e.g. Fandiño Pinilla (2002) to frame evaluation and assessment.

Research Questions

As pointed out in the previous section and by many researchers (Glaser and Strauss, 1967, Strauss & Corbin, 1998, Charmaz, 2006, Thornberg, 2012) the question that allows to begin a study following GT methodology has an explorative aim, and it is related to the question “what’s going on here?”.

In our case, the starting point has been the pandemic crisis and the necessity to understand how T/L practices of LDL in mathematics during lockdown were shaping themselves, and what role this period and the related studies could have for future practices.

The research has led us to a more specific question about LDL in mathematics during the lockdown and our final question is:

- Which sub-components of T/L practices allow to describe and analyse LDL in Mathematics during lockdown and the impact of this phase on future didactical practices?

Methodology

Research tools and data

As a first step in our research we spread an online questionnaire in order to collect information regarding LDL situation among various school contexts. The aim of the questionnaire was to explore the different practices of LDL as perceived by teachers.

The questionnaire has been administered in two versions during the month of April 2020 in order to gain information on a fluid process started a month earlier and that was settling down day by day³. The versions are for the most part stackable, except for the final part of the second version where we added more specific questions focused on the assessment. Globally, we collected the answer of 244 teachers of different grades in different part of Italy.

All the versions of the questionnaire contain open-ended and multiple-choice questions. We can summarize the sections of the questionnaire according to the investigated topic:

- *Technological background.* This section contains mostly closed question designed in order to gain information about the effective teaching practices during LDL. The only exception is the last open-ended question, which has been added to collect the future intentions of teachers about the using of digital technologies.
- *Perspective on LDL.* This section contains mostly closed question as well. It presents some statement regarding virtual classrooms and the use of digital technologies where teachers are asked to express their agreement/disagreement.
- *Mathematics.* Here teachers are asked to give information on their current topic of the mathematics lesson.
- *Assessment:* this last section presents both open-ended and closed question. The open-ended have been designed to gain information on teacher's perspective on student performance, assessment in general. The closed question enabled us to collect information about a comparison between the effective assessment practices before the LDL and during it.

³ The switching to LDL has been the only possible way for continuing activities, due to the complete lockdown for all persons all over Italy that was decided on 8 March and extended every two weeks until May. Schools did not open until the end of the school year in June.

The first two sections have been designed referring to a previous study on virtual classrooms (Del Zozzo, 2019) that enabled us to specify the different possible scenarios and actions occurring during LDL.

The choice of leaving several open-ended questions has been made to allow teacher to express the perceived changes, and their ascribed meanings regarding all the different aspects involved by the questionnaire.

In this article we focus on the qualitative analysis of open-ended questions.

As a second step of our research, we planned a period of observation of LDL in six Italian classes of different grades in two different cities during mathematics lessons and we conducted some interviews with the involved teachers.

The observation lasted one month and ended the 10th of June, last day of the school year in Italy: all lessons were recorded and some of them were transcribed. Four teachers were interviewed, and their interviews were transcribed.

This second data collection was made in order to better understand the T\L processes during LDL and to have a first feedback regarding the coding system emerged by the questionnaire. In order to saturate the coding system and better understand the relationships between categories we conducted the observations in the classes and the focused interviews. The subject of interviews were LDL in general and evaluation in particular, as one of the critical themes emerging during the months of LDL.

Open coding

The analytical process was conducted during the period of data collection and is still ongoing. Memos regarding the coding process and the observations were taken and discussed periodically.

In order to have a general view on how the T\|L process in Mathematics during LDL was shaping itself we chose conveniently the following three open-ended question from the questionnaire:

- Q12: Looking at the practices you are using more frequently (often and/or always), which of them do you think you will continue to use even when you will return to the physical class? Why?
- Q26: Regarding the monitoring process during this period of LDL, please indicate at least one positive and one negative aspect that you have found.
- Q27: Regarding this period of distance learning, did the student's performance improve/upgrade? Why?

The choice was based on the richness of information in the answers.

At the beginning of the coding process, the codes were defined individually by two of the authors of this paper on the same set of 46 answers consistently with the teachers' words written in them. After a comparison of the individual coding, the researchers agreed on a common system that was used to code the rest of the answers. This procedure has been done for each of the three questions. The majority of the codes has been defined from Q12, and the other two set of answers from Q26 and Q27 have been used to refine the coding system.

The Table 1 shows the list of all the labels of the code that emerged from data after an abstraction justified by the informed Grounded theory approach.

The researcher takes the advantage of pre-existing theories and research findings in the substantive field in a sensitive, creative, and flexible way. These are not uncritically adopted in the analysis but are judged in terms of their relevance, fit, and utility. The informed Grounded theorists do not use the literature as forcing applications or deductions but are guided by a set of data sensitizing principles.

(Thornberg, 2012, p. 256)

For instance, to label the categories that regard evaluation and assessment we were inspired by Fandiño Pinilla (2002).

The list has been ordered by occurrence considering a total of 732 answers given by the 244 teachers to the questions Q12, Q26 and Q27.

Table 1.

Open Coding Table with frequency. The detailed label description can be found at the following

link:
https://docs.google.com/document/d/1MYkIBfoyi_FeoidaY8fqs6RWEWSqFQCIJy9h0HFswzw/edit?usp=sharing

	Code label	Tot. Occurrences
1	Didactical practices	281
2	Interactions teacher → student	211
3	Affect system	205
4	Interactions student → teacher	195
5	Evaluation and assessment	135
6	Didactical transposition	127
7	The missing of the physical classroom	107
8	Resources	95
9	Parents' interventions	94
10	Video	92
11	Individualization	91
12	Interaction student ↔ student	72
13	LMS ⁴ and PLN ⁵	68
14	Personal environment	68
15	Scattering	63
16	Teacher's technological competence	55
17	Student's technological competence	45
18	Forms	25
19	Teacher's metacognition	23
20	Curriculum evaluation	22

⁴ Learning Management System

⁵ Personal Learning Networks

21	Interaction teacher ↔ teacher	20
22	Politics	15

Second data collection and focused coding

After the definition of this first coding system we started the second phase of data collection which involved the classrooms in LDL observation and the teachers' interviews.

A proper theoretical sampling was not possible due to lack of time depending on the emergency and its fast evolution. Nevertheless, after the first coding process, we were able to refine our research question about LDL during the lockdown: we started to notice some levels that were deconstructing the T\L processes due to the virtual environment and, in the meantime, we were recognizing them as independent from the emergency.

Furthermore, to highlight what was still missing to analyse a real observed T\L processes in a virtual environment, we tested the first coding system to shape also the data collected from the observations and the interviews in order to verify its completeness and consistency.

During observation, a big issue emerged, the issue of evaluation on LDL: the approaching of the end of the school led teacher, principals and the minister of education to a heated debate on evaluation that strongly influenced the school life. Thus, we noticed that the data we were collecting required us to expand and better specify our categories related to evaluation.

Table 2 shows the additional code labels that emerged after the analysis of i) the remaining open questions of the questionnaires related to evaluation, ii) the transcriptions of the 4 teacher's interviews and iii) the transcriptions of some of the lessons we observed.

Table 2.

Saturation Coding Table. The detailed label description can be found at the following link: https://docs.google.com/document/d/1MYkIBfoyi_FeoidaY8fqs6RWEWSqFQCIJy9h0HFswzw/edit?usp=sharing

	Code label
23	Authenticity/autonomy
24	Object of the evaluation/assessment
25	Tools and means of evaluation/assessment
26	Type of the assessment (formative/summative)
27	Previous information about the student
28	Trust/control

Results and answer to our research question

Let us recall here the final research question we try to answer in the following:

FRQ: Which sub-components of T/L practices allow to describe and analyse LDL in Mathematics during lockdown and its impact on future practices?

After the saturation of the coding system we came back to the totality of our data. We reflected in many occasions during the entire research period on the existing relations between the codes. In order to finally provide an answer to FRQ, we arrived at a definition of potential macro-categories. Figure 1 shows the diagram that organizes the various categories and macro-categories (the blue ones) in a hierarchical way.

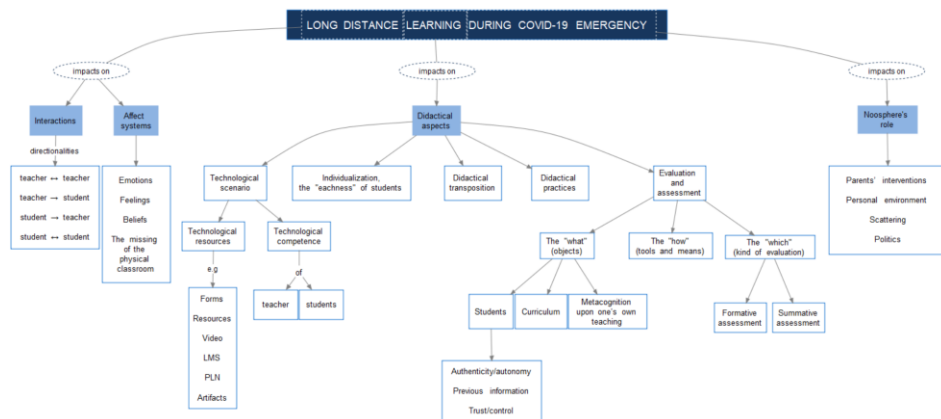


Figure 1. Diagram of theoretical coding.

Discussion

As can be seen in the diagram, we found 4 different macro-categories that organize the multitude of elements involved.

The first category regards the Interactions and their directionalities – e.g. some teachers noted an improvement in the communication from their student to them. This category suggests the future need of a careful planning of the interaction in order to enhance mathematical communication between students, student and teacher and teachers.

The second category regards the Affect systems: Beliefs on mathematics and on digital technologies, feelings and emotions related to LDL during the emergency, and the missing of the physical classroom. Albeit we do not go through this category in this paper, three main directions can be observed along the data:

- Missing of the physical classroom and feelings related to the lockdown. This direction is the only one strictly related to the closure of the school buildings and the emergency.
- Beliefs related to: the use of technologies in the classroom, Mathematics, the role of the school, of the teacher, of the student, of the parents...;

- Identity and the use of digital technologies: how the mediation of technologies relate with personal characteristics. For instance, it strongly emerged how shy students that were usually not participating to class discussion or interacting with the teacher has in this context revealed themselves. This remark came up not only from the teachers' perspective but also from the students' point of view. We report here a short extract of a 12th grade student's talk that is particularly meaningful, even though the excerpt has solely an anecdotal meaning and has not to be considered part of the analysed data:

I'm less anxious to talk. To me it's really a good thing to be able to talk through the screen with ease. Before I was not a person who always intervened ... also in other subjects in general I found it very good to speak without problems. In front of the class...let's say that... one thing I would keep is this: not having the impression of the whole class looking at you, maybe the teacher who makes a strange face and seems to judge you ...

The third category regards Didactical aspects and it can be refined in different sub-categories:

- The technological scenario, which, during the emergency, shaped the entire classroom and all the didactical processes.
- The extreme potential to reach each single individual involved in the didactical process, which shifts the unit of measurement to them opening new forms of individualization.
- The didactical transposition which, regards the discovering of new possible relation between the teacher and the knowledge (Chevallard & Joshua, 1982).
- The didactical practices, which regards new way of actions in the virtual classroom environment.
- The evaluation and assessment process, that due the forcing digital context had to be completely re-thought and re-designed.

The noosphere, intended as the link between school system and the more extended context of the teachers and students that influence their teaching and learning, is the macro-category more strictly linked with the emergency:

- The role and the behavior of parents: their direct intervention in the T\L processes - e.g. help during the lesson, with the homework or during the assessment or with the activities proposed to the students by the teacher – or simply their presence during the school time due to the fact that it was happening in private spaces.
- Students' and teachers' personal context: their owned devices, the space of the house, the possibility to connect to the lesson...
- Scattering: this category emerged in many answers and it has different causes interrelated - e.g. personal context, intentional avoiding strategies...
- Politics: the choices of the minister of education as well as the political choices regarding the facing of the crisis were strongly influencing the T\L practices.

These are factors that must be taken in account during the planning of every T\L practice, but in a situation of exclusive LDL can determine of the loss of some students. Engelbrecht, Llinares, & Borba (2020) refers to this phenomenon as *Panic-gogy* (Kamanetz, 2020). Panic-gogy, relates panic with pedagogy and

means understanding students' practical resources and problems, including availability of devices and the internet, family responsibilities, students sent home who need to find a new place to live, and financial constraints. But it also means how teachers are going to move into this environment with their teaching approaches.

(Engelbrecht, Llinares, & Borba, 2020, p. 12 online version)

Conclusions and further issues

In this paper we face the reorganization of the T/L process in the Italian context during Covid-19 emergency using a Grounded theory approach. The aim of the study is to shape the dimensions of the deconstruction process caused by the use of digital technologies in order to both understand the LDL emergency period and to encounter the post Covid-19 needs in T\L context in a more structured way.

When a T/L environment is enriched with the presence of digital technologies, the subtle design of lessons and practices assumes a major role.

As LDL during lockdown has showed, in a digital environment teachers and students cannot just “act” the lesson planned by the teacher, but every aspect of the T\L process must be taken in account and shaped along the possibilities offered by the interaction between different technologies.

Our work wants to be the starting point in this direction, defining what are the different dimensions to work with: both for the teachers ‘design of the lesson and for mathematics education researchers’ planning of classroom observations. For instance, the interaction in online environments can happen through many different channels in different ways and between different actors. During the observations we noticed that, whether the communication from teacher to students was guaranteed by a spontaneous use of a videoconference tool, the institutional communication between students has to be planned in detail preparing the tools and the environment in advance.

Notwithstanding the study is still ongoing, we achieved to define a categorization – described in Figure 1 and commented in the Discussion section - that in our perspective can frame and organize the most involved dimensions of T\L practices in a digital environment. Every macro-category can be exploited separately: during the phases of the study here described we have been able to expand the category related to evaluation, other work is required for the other categories in the same direction. At the same time, within the context of Grounded theory, we are working on the finding and shaping the connections between the categories and their mutual relationships. We are planning an additional data collection with a sub-set of the teachers involved in the second phase in order to apply our categorization to observe the effects of LDL and to analyse the use of digital technologies during next year practices. Indeed, the next phases will start another re-thinking of the T/L practices which will imply a further deconstruction that could be faced in a structured way using the proposed categorization.

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