



HAL
open science

Mathematics teachers' creativity for fostering inclusion and preventing early school leaving

Rosalia Maria Lo Sapio, Gemma Carotenuto, Cristina Coppola, Maria Mellone

► **To cite this version:**

Rosalia Maria Lo Sapio, Gemma Carotenuto, Cristina Coppola, Maria Mellone. Mathematics teachers' creativity for fostering inclusion and preventing early school leaving. Twelfth Congress of the European Society for Research in Mathematics Education (CERME12), Feb 2022, Bolzano (en ligne), Italy. hal-03747818

HAL Id: hal-03747818

<https://hal.science/hal-03747818>

Submitted on 8 Aug 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Mathematics teachers' creativity for fostering inclusion and preventing early school leaving

Rosalia Maria Lo Sapio¹, Gemma Carotenuto¹, Cristina Coppola¹ and Maria Mellone²

¹University of Salerno, Salerno, Italy; rlosapio@unisa.it; gcarotenuto@unisa.it; ccoppola@unisa.it

²University Federico II, Naples, Italy; maria.mellone@unina.it

In this paper we investigate mathematics teachers' creativity in offering problematising activities and promoting inclusion and positive attitude toward school in territories with worrying dropout rates. This is an initial study in which we interviewed four teachers working in this kind of territories and very active in designing and implementing inclusive and visionary mathematics activities. From the analysis of the answers to two particular questions, we outline the perceptions of these teachers on the sources of their educational creative work, identifying peculiarities and communalities. In particular, a common intention to achieve citizenship education objectives emerges.

Keywords: Mathematics teacher, creative teaching, inclusion, problematising education.

Introduction

Equity, inclusion, and fair opportunities were felt as crucial issues by researchers in mathematics education already before the pandemic and have become even more urgent issues during it (Bakker et al., 2021). In particular, the pandemic, as “a magnifying glass on issues that were already known” (p. 1), revealed even more clearly the inability of the school education to properly include pupils in disadvantaged contexts and its responsibility in creating several unacceptable phenomena of social marginalization and exclusion. Indeed, nowadays, the educational outcomes of younger generations are still determined to a large extent by the socio-economic background of their parents rather than by their own potential. Promoting inclusion¹ and equity in education and training is thus fundamental in breaking these patterns. In the suburbs of many cities, school lacks resources to properly include children and teenagers experiencing socio-cultural disadvantage and ends up losing its institutional value in the eyes of pupils and their families. Hence, there is risk of early school leaving and, in some particular contexts, also the consequent serious danger for children and teenagers to be approached by gangs and organized crime. For this reason, it is of fundamental importance that educational research reflects on the endogenous factors of early school leaving (Morgagni, 1998), i.e. factors that are internal to the educational system. An effective struggle against this phenomenon should aim to create the conditions for every student to create her own identity within the school. In particular, this possibly implies the need that the mathematical activities proposed at school should (re-) build a positive attitude towards mathematics (Di Martino

¹ Here, the term “inclusion” is used in a general sense, as in the Italian educational system. By inclusive educational environment we refer to the participation in mathematical activities both by students with claimed disabilities and by students with special educational needs. The latter group also includes students with very critical cultural disadvantages, such as limited Italian language proficiency or lack of cooperation, if not hostility towards the school, by their families.

& Zan, 2011) for the students which are most in difficulty. In socially disadvantaged contexts, this means proposing to pupils tasks which are meaningful in their eyes and improving their perceived competence in mathematics.

For several years our research group has been engaged in educational projects in collaboration with schools to implement highly inclusive mathematics education environments, aimed at preventing the phenomena of early school leaving. In these contexts, inspired by the vision of active pedagogy, we have tried to design mathematics education activities as engaging and captivating as possible, for example by activating students body movement inside schools, but and also in outdoor environments; by creating narrative frames that allow students to link the exploration of the mathematics worlds to the exploration of cultural and naturalistic city sites (such as museums, art galleries, parks, site of urbanistic interest and so on) and critically connect pupils to the territory in which they live. The theoretical background of reference for these mathematics education activities design has been the informal mathematics education (Nemirovsky et al., 2017), which concerns non-compulsory activities, with very fluid boundaries between disciplines and with no formal grading.

Working on these educational projects, we have also tried to involve the school teachers in the design and implementation of these visionary informal mathematical activities. Indeed, our main research interest in informal mathematics education projects is to investigate how to create an intertwining between the highly engaging approach of mathematical activities implemented within them and curricular teaching. We recognize the centrality of school teachers in these transformation projects: they are called to be guides capable of creative inclusive mathematics education activities, in a continuous dialogue with the territories in which they work. With this gaze, in this paper we present a first research attempt to capture and describe the kind of mathematics education creativity needed for teaching in socio-cultural disadvantaged contexts, and elsewhere. Our research aims to investigate teachers' creativity, both in design and implementation of mathematics activities responsive to students' interests, in order to foster inclusion and thus prevent early school leaving.

Theoretical framework

Our research is framed in active pedagogy, born at the end of the 19th century, that considers the student as the active protagonist of the educational process and the relationship between the subject and the environment as central. Therefore, according to this point of view, it is essential to organise educational and school contexts in such a way that the environment can foster creativity, plurality of opinions and the freedom of pupils to experiment on their own. Moreover, the educational experience cannot disregard the everyday life in which the subject lives.

In this scenario, the educational proposal of Paulo Freire was to create an emancipatory pedagogical process aimed above all at that part of society that lives in a situation of oppression (Freire, 1970). According to Freire, the action of the educator is characterised by two essential moments: the preparation of the lessons and the meeting with the students; it is by analysing these two practices that it is possible to distinguish a *depositary education* from a *problematizing education*. In the first case, the educator, during the preparation of her lessons performs an act of knowledge in relation to the knowable object. Then, during the meeting with the students, she narrates and discusses the

object on which she has performed her act of knowledge. The task of the students, in this perspective, is to know or learn by heart what is narrated and delivered by the educator (student seen as a patient or a docile recipient of content). Depository education does not allow the students to perform a true act of knowledge, since what is delivered or deposited to them is a possession of the educator and not a mediator of the critical reflection of both (Freire, 1970). In the case of problematising education, on the other hand, there is not a clear distinction between the moment of preparing the lessons and the moment of meeting the students. The latter is characterised by dialogue, which is fundamental for the educator in order to review – through the re-visioning of the students – what was objectified in the preparation of the lesson. Problematising education becomes an act of knowledge: both when preparing the lesson and when meeting the students, the educator is a *knowing subject*. With the problematising practice, the educator makes the students become *critical researchers*, in a permanent dialogue with the educator, who is a critical researcher herself. According to Freire (1970), it is only through a problematising education that it is possible to carry out an emancipatory pedagogical process that pushes the students for learning to face their world by putting knowledge into play, developing creativity and constant reflective critical capacities. The educator, therefore, has to reflect on what to propose to her students and, from the constant dialogue with them, imagine original themes to be returned as concrete problematic situations, challenging and motivating for the students, which allow them to reflect on significant dimensions of reality, promoting a critical understanding.

In this frame, our research aims to explore teachers' creativity in the strictly intertwined processes of designing and implementing mathematical problematising education activities (Freire, 1970) in socio-cultural disadvantaged contexts. In literature, there are several studies on the mathematical creativity of professional mathematicians. For example, Hadamard (1945) in his seminal work collected the perceptions of contemporary mathematicians on the mechanisms by which they produce new mathematics. He outlined the existence of unconscious mental processes and tried to capture the phenomenon of illumination in doing mathematics. Later, Liljedahl (2004) updated Hadamard's work, focusing on the specific context of mathematical problem solving. In particular, he confirmed the experience of mathematical illumination, perceived as caused by a sudden coming to mind of an idea. He analysed preservice teachers' logbooks, together with reflective anecdotal accounting from undergraduate mathematics students and prominent mathematicians of our times. Here our focus is on mathematics teachers' creativity and very few studies can be found about it (see for example Levenson, 2021).

Methodology

Participants

In order to investigate the particular kind of creativity of the mathematics teachers we are interested in, we identified two Italian informal education projects that offered very innovative mathematical problematising education activities (Freire, 1970) to primary and secondary students from socio-culturally disadvantaged areas of two different cities, Naples and Turin. Within these projects, we involved four teacher-researchers, as they are responsible for educational design: Perla, Nadia, Riccardo and Claudia (pseudonyms). The first two are high secondary school math teachers in

Naples (Italy) and partners of the cultural association “Matematici per la Città” (MPC). The association was born in 2013 with the aim of realising urban math walks through the suggestive and fascinating streets of Naples, bringing mathematics out of the classroom, in a less formal, more comfortable and enveloping scenario. Currently, MPC collaborates with several primary and secondary schools in Naples, often located in disadvantaged districts of the city. It promotes extra-curricular educational paths with the aim of stimulating and encouraging children and teenagers to observe reality with curiosity and critical sense. In all its activities mathematics is strongly intertwined with other disciplines, such as art, music, history, chemistry, and above all with citizenship education. The other two teachers, Riccardo and Claudia, are lower secondary school math teachers in Turin (Italy) and both took part in the design of the educational activities of the “Next-Land” project. The project, promoted by the cultural association Next-Level, started in 2020 and is still underway. So far, it has involved lower secondary school students from the most disadvantaged Turin’s neighborhoods. Next-Land offers educational paths on STEM disciplines, which are intertwined with the arts. It is characterised by a widespread, laboratorial educational action, which is hosted in the city’s museums, open spaces, research places and in digital environments. Among the transversal aims of the project there is the fight against the gender gap in study and work contexts.

Data collection and analysis

Data collection consisted of oral and semi-structured interviews, inspired by the Explicitation Interview method² (Vermersch, 1994), audio-recorded and transcribed. Due to space constraints, in this paper we present only the analysis of the responses to two particular questions, which we consider to be the most interesting in the context of an exploratory study of teacher creativity. Here we refer to the selected two questions as Question 1 (Q1) and Question 2 (Q2):

Q1. In designing a teaching activity, do you feel more like ideas emerge all of a sudden or that they originate from a process of investigation?

Q2. Referring to your design choices, do you think that, in general, they also consider your personal background and the social and cultural dimension? If so, to what extent do you think that the personal, social and cultural dimension can influence the creation of educational activities? Could you refer to a specific anecdote or a particular moment to support your thinking?

Q1 is inspired by a particular question used by Hadamard (1945) and later by Liljedahl’s (2004). This question refers to the dichotomy, already emerged in the community of mathematicians at the beginning of the 20th century, between a vision of mathematical activity that emphasizes intuition and another one that tends to emphasize the rigour and formalism of deductive reasoning. In our context, in which we are not reflecting on mathematical activity but on the design of teaching activities in mathematics, we ask teachers whether they attribute their creative acts to a spontaneous arising of ideas or to a work of reflection that we might consider more methodical and goal-

² The Explicitation Interview is a method based on techniques for the formulations of the re-launchings aimed at facilitating and attending the a posteriori verbalization (in the sense of putting into words) of a particular experience (Vermersch, 1994).

oriented. By this question we want to collect the teachers' perceptions on how the creative acts at the basis of their educational work originate.

Q2 aims to investigate teachers' perceptions about the causes behind such creative acts, and in particular whether and how they would connect them to the social and cultural dimension of their lived lives. The answers to this question could provide some information about the teacher's personal and professional experience, which she relates to her work in instructional design. Therefore, with this question we expect to outline some aspects that are at the origin of the creativity of the interviewed teacher, which determine her uniqueness.

At this stage of the research, we have analysed the answers, highlighting commonalities and peculiarities. Next, we will move on to enlarge the sample of teachers and, alongside this type of analysis, we will analyse the recurring themes.

Findings

Answers to Question 1

Q1 asked to choose between two alternatives: the teacher could attribute her creative acts to a spontaneous arising of ideas or to a more methodical process of investigation. All four teachers chose the first alternative and all shared, as an argument to their answer, what they believe to be the sources behind what is currently a spontaneous arising of ideas in their design activity. As we will show shortly, the reasons that the teachers identified are all different from each other. We draw attention to the fact that the other question, Q2, was formulated precisely for the purpose of investigating the origin of the creativity of the interviewed teacher. However, in the analysis we preferred to keep the answers to Q2 distinct from the argumentations accompanying the answers given to Q1, because of the characteristic of spontaneity of the latter

Perla: So look, I'll tell you that I usually get ideas all of a sudden [...] with an association, which is often instinctive, of elements that are apparently very far away. [...] I am quite convinced that this fact, which is quite easy for me, more than anything else I find it instinctive to put together apparently distant worlds, is a consequence of my mathematical education, in the sense that it is a bit like when you have the data of a problem or the hypothesis of a theorem and you have to put them together and arrive at the final result or proof of the theorem, I have the feeling that when I come up with a project idea, in the end, I actually think in this way [...]

Perla attributes what she considers a "sudden" and "instinctive" emergence of ideas in her design work to her mathematical education, which taught her to put seemingly distant elements into communication with each other, as when from the data of a problem one seeks a solution or from the hypotheses of a theorem one arrives at its thesis.

Nadia: [...] Some conditions have been created, even with the association I belong to [MPC], to design together, to reflect together, so when I find myself alone in designing an activity, I don't know how much it is accidental or how much it is actually the result of this continuous process of sharing and building together and so, sometimes, I say: "Is it mine? Did it come to me spontaneously?" and maybe, even this approach of building activities in this way, in my opinion, leads me to think spontaneously about things, but it is a spontaneous in some way conditioned.

Nadia talks about a "conditioned" spontaneity. This conditioning leads her back to the experiences of collective reflection and shared planning, within the association MPC. Moreover, in the

interview, Nadia links her design choices also to post-university education. In particular, she refers to courses for teachers or conferences on mathematics education that over the years she has carefully selected because they gave space to collective design activities and because they promised to provide first-hand experience of laboratories.

Riccardo: Most of the ideas that come to me come out of the blue while I'm doing something else. [...] while I'm shopping, while I'm jogging, while I'm reading a book that has nothing to do with anything, I get ideas and then I try to develop them later. So, I can't tell you whether actually, I mean whether to classify them as ideas that come out of the blue or that are the result of a process. They are certainly, in some way, the result of a process of which, however, I am not always aware here. It seems to me that they happen suddenly, but I also wonder how much this suddenness is due to the stimulations I had, to the thoughts I had [...].

Riccardo relates the spontaneous arising of ideas, during the preparation of the lesson or the meeting with the students, with a process of which he is not always aware, but which he recognizes as being conditioned by external stimuli and previous reflections.

Claudia: It depends! Maybe we need to distinguish between the planning of the mathematical activity itself (a longer process of investigation, which leads me to search among books, websites, ideas from notes taken during conferences...) and the [laboratory] methodology to be used (more improvised creative ideas).

Finally, Claudia prefers to distinguish between the spontaneity of some ideas, which initiate the planning – which at the beginning of the interview she recognizes to be connected with the places or the artefacts she has available – and the work of defining the activities, which she considers a work of investigation for which she uses different sources.

Answers to Question 2

In reference to Q2, the answers of the teachers interviewed return some salient aspects of their personal and professional experience.

Perla: [...] my dimension of life has a profound influence on the creation of the activities, that is, in those activities there is really me! This is a certain fact and often, I try to put in what I think is important for children to discover, to know, that is, that can form them in some way as citizens. [...] the example of the project on the enlargement of the map of municipalities, where did that come from? It came from the fact that over the last ten years, for personal reasons, I have interfaced a great deal with the administrative bodies of my city [...] and I have realized how important it is for a citizen to know how the administrative machine works [...]

In answering Q2, Perla asserts that what she proposes to students is strongly determined by personal interests and curiosities – the books and articles she reads or the movies she watches – but also by a range of social and cultural experiences that she has collected over time. The excerpt contains one of the examples she gave us, in which she recounts how her political commitment led her to instructional designs in which mathematical goals were intertwined with goals of citizenship education she recognized to be of crucial importance for her students.

Nadia: All the activities that we realize with the association [MPC] always try to work on breaking distances in some way: breaking distances within the city, within a territory, within a class, this is a climate that I feel I always carry inside. I experience it externally in the places I frequent and it also influences the type of activity.

Nadia, as in her answer to Q1, refers first of all to her activity within the association MPC. She claims that the sharing of “educational responsibility” and the possibility of experiencing it as a “collective process” offered by the association influences the way she relates to her students and the dialogue she strives to create in the classroom. She also finds that her teaching choices have been influenced by her movement from a small town to a big city like Naples, where she currently lives and works. Naples gave her the opportunity to relate to a broader cultural environment and meet people from different cultures, drawing her attention to issues such as migrant rights, gender equality, or what it means to be a citizen. As shown by the excerpt, this influenced her goals as an educator and in particular her desire to educate to “break the distances” among individuals.

Riccardo: Certainly, personal background comes up a lot in the design of activities. [...] To make students feel good in school, to make them feel good together with others and to make them feel free to express their opinion [...] is something that I, in some way, trace back to my personal background, to my life experience, to my school experience as a student, [...] but maybe also to the very motivation for which I decided that I would be a teacher in life. More than teaching math, really more about having the opportunity to interact with students to help them bring out their potential to interact with others.

Riccardo believes that his personal experience as a student and his own motivation in wanting to become a teacher- which is characterized by the desire to educate students in comparison with others and in collective living – greatly influences his design choices.

Claudia: I have been a researcher in the history of mathematics, and most of the activities created by me take cues from my knowledge in this discipline and my passions. I love history! And I really enjoy doing activities that can leave my students surprised, because I myself love finding myself fascinated by mathematical content when it has been presented to me in a “creative” way!

As shown in the excerpt, Claudia believes that her previous experience as a researcher in the history of mathematics and her personal tastes as a student, fascinated by creative and surprising didactic actions, have influenced her design work the most. Moreover, answering to Q2, Claudia recognized that her creative attitude in didactical design was influenced by the successful professional experience in a particular school, situated in a poor neighbourhood of the city of Turin, which is characterized by the presence of many families of recent immigration. She said: “Once I figured out how to ‘catch’ these guys (each in their own way, of course), my creative streak increased, because I could see how much my effort paid off.” Finally, she noted that the presence of students from different countries motivated her to design mathematical activities involving different cultures, such as one on number-words to reflect on the decimal number system.

Although in different ways, all four teachers believe that their personal backgrounds and their social and cultural dimensions influence the work of creating teaching activities.

Discussion

In this first study we tried to inquire the way in which these four mathematics teachers, which are responsible for the educational design inside two very innovative informal mathematics projects, tell about their experience of creating mathematical activities and how they link it with their personal and cultural background. Looking at the interviews, in particular at the answers to Q1, it is possible to recognize in their description that the way in which the design of the mathematics

activities emerges is characterized by illuminating moments, but also by a “conditioned” spontaneity, as Nadia says. Moreover, the answers to Q2 helped to catch how the different teachers’ personal, professional and cultural experiences play a key-role in the realization of the very innovative mathematical activities they propose, both during the preparation of the lessons and during the meeting with the students (Freire, 1970). Perla referred to her personal interests and to her experience of collaboration in the administrative bodies of her city. Nadia told about the influence of her social commitment, through the militant activity in the association MPC, and beyond. Again, Riccardo referred to his school experience as a student and his educational objective of educating for collective living, which he sees as a priority. Finally, Claudia told about her research experience in the history of mathematics field and about her professional experience in a challenging reality, which required great effort on her part to engage the students. The answers to Q1 and Q2 show a very varied picture on these teachers’ perceptions regarding the sources of their creative educational work. Nevertheless, the same answers reveal a point of contact in the teachers’ pedagogical goals. All of them aim at educating at democratic citizenship through mathematics. Perla spoke about a project exploring with students the administrative bodies of the cities; Nadia referred to her (and her association) action of breaking distances, at all social levels; Riccardo declared his desire to educate at a collective living; finally, Claudia told how she used mathematics to create meeting among different cultures. In this sense it is worth to emphasize how Freire’s ideas were of great inspiration for the field of critical mathematics education (see, e.g., Skovsmose, 1994). One of the most recognized pedagogical aims in this field is the intertwined development of critical citizenship consciousness and mathematical competencies:

[...] mathematics should be a vehicle for students to deepen their grasp of the sociopolitical contexts of their lives, and through the process of studying their realities -using mathematics- they should strengthen their conceptual understanding and procedural proficiencies in mathematics. (Gutstein, 2007, p. 109).

References

- Bakker, A., Cai, J., & Zenger, L. (2021). Future themes of mathematics education research: an international survey before and during the pandemic. *Educ Stud Math* 107(2), 1–24.
- Di Martino, P., & Zan, R. (2011). Attitude towards mathematics: A bridge between beliefs and emotions. *ZDM Mathematics Education* 43(4), 471–482.
- Freire, P. (1970/1998). *Pedagogy of the oppressed*. (M. B. Ramos, Trans.). Continuum.
- Gutstein, E. (2007). Connecting community, critical, and classical knowledge in teaching mathematics for social justice. *The Montana Mathematics Enthusiast*, Monograph 1, 109–118.
- Hadamard, J. (1945). *The psychology of invention in the mathematical field*. Dover Publications.
- Levenson, E. S. (2021). Exploring the relationship between teachers’ values and their choice of tasks: the case of occasioning mathematical creativity. *Educ Stud Math* 109(6), 469–489.
- Liljedahl, P. G. (2004). *The AHA! experience: Mathematical contexts, pedagogical implications* [Unpublished doctoral dissertation] Simon Fraser University.
- Morgagni, E. (1998). *Adolescenti e dispersione scolastica*. Carocci.

- Nemirovsky, R., Kelton, M.L. & Civil, M. (2017). Towards a vibrant e socially significant informal mathematics education. In J. Cai (Ed.), *Compendium for Research in Mathematics Education*, (pp. 968-980). National Council of Teachers of Mathematics.
- Skovsmose, O. (1994). *Towards a philosophy of critical mathematical education*. Kluwer Academic Publishers.
- Vermersch, P. (1994). The explication interview. *French original ESF*.