TiM^2
Theatre In Mathematics

TIM^2 Methodology Manual

INDEX

DISCLAIMER

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

1. Introduction. The TIM^2 Project - Theatre in Mathematics: Addressing the Challenges of Mathematics Education in Europe

1.1 THE IMPORTANCE OF DEVELOPING MATHEMATICAL SKILLS AS KEY COMPETENCIES IN EUROPE

The TIM^2 project stems from the desire to promote the development of mathematical skills and systematically address the challenges that most determine the establishment of mathematics and STEM disciplines in Europe.

Basic skills and mathematical competence are now considered crucial for lifelong learning, employability, responsible citizenship, personal development, and leading a healthy and fulfilling life. The ability to critically analyze information and computational skills are considered one of the priorities of educational cooperation at the EU level (Eurydice, 2011). Being able to analyze, apply scientific thinking, understand the interconnection between nature and the world built by humans, and maintain a critical view of the reliability of information are all skills necessary for everyone in today's world to play an active and informed role as citizens, and thus have the opportunity to influence the social, political, and economic context in which they live, to be able to advocate in their community and be an active part of it.

Mathematical and scientific education plays a fundamental role in providing children and young people with the skills they need to become responsible and active citizens in our societies. However, the results of international surveys of students, such as the Programme for International Student Assessment (PISA) promoted by the Organization for Economic Cooperation and Development (OECD), which assesses the performance levels of 15-year-old students in reading, mathematics, and science, indicate that students' mathematical performance has deteriorated in all European education systems and that in the EU-27, a growing percentage of students do not reach basic levels in mathematics and science (European Commission / EACEA / Eurydice, 2025).

To complete the picture on the percentage of students with insufficient results, a similar problem is found for fourth-grade students (i.e., primary school students) based on the TIMSS survey. Students with insufficient results in fourth grade are those who do not reach the "International Intermediate Benchmark." In mathematics, this means that, although these students may have some basic mathematical knowledge, they have difficulty applying their knowledge in simple situations or performing more complex mathematical tasks, such as

calculating three- and four-digit whole numbers, or reading and interpreting information in graphs and tables (Mullis et al.,2020).

We also know that not all pupils have the same chances of success. Students' socioeconomic background continues to influence their academic performance. For disadvantaged students, the risk of underachievement can be significant, and this has been further exacerbated by the COVID-19 crisis.
This analysis clearly shows that the problem is a European one, affecting all 27 Member States, and as such must be addressed jointly in order to seek solutions and strategies that can be implemented at European level.

1.2 THE IMPACT OF MATH ANXIETY AND THE LIMITATION OF STEM CHOICES

Among the factors that have a decisive impact on student learning and achievement in mathematics, in addition to environmental and social factors, are emotional and motivational factors.
Math is often considered the most difficult subject. Students may encounter problems and difficulties in this subject in understanding concepts, remembering formulas, solving calculations, and using math in practical situations. This negative perception can have an impact on students' engagement with the subject and lead to negative consequences on test or exam results. This can result in a problematic relationship with the subject, characterized by intense fear and anxiety and, in some cases, the perception of not being "good at" it.

Difficulty with STEM subjects often begins with difficulty in mathematics. Often, having problems with mathematics means choosing an educational path that avoids it. But this means that students who are afraid of mathematics cannot choose all scientific paths (engineering, physics, chemistry, biology, etc.) and consequently have to give up a wide range of possibilities and careers for their lives.

Research suggests that appropriate teaching methods and new approaches can overcome students' anxiety and fear of mathematics, thereby improving learning outcomes and offering new learning opportunities. By approaching the subject in a new context (theatre workshop) with a holistic approach that engages students with their bodies, minds, and emotions, we already know (as revealed by the evaluation of the TIM - theatre in Mathematics project, https://old.theatreinmath.eu) that teachers feel more capable of teaching and students feel more confident about mathematics and STEM subjects.

Furthermore, there is a shortage of specialized mathematics teachers in Europe, where mathematics is generally taught by generalist teachers in primary schools. This lack of specialization often results in low-quality lessons and difficulty engaging those who are not naturally interested in mathematics and/or struggle with the subject. Supporting teachers with appropriate training is crucial. Supporting and improving the teaching profession is key to raising the quality of education in Europe, especially in mathematics (European Commission / EACEA / Eurydice, 2022).

1.3 THEORETICAL FOUNDATIONS TO THE TIM METHODOLOGY

The TIM^2 project aims to overcome these challenges by focusing on teaching and training through an intervention model, tools, and a methodology to support classroom teaching through inclusive, participatory, and active teaching methods.

Starting with the European TIM - Theatre in Mathematics project (2018 - 2021), TIM has worked on developing a methodology for teaching mathematics through the use of theatre. The TIM and TIM^2 projects have involved collaboration between educational institutions (schools, university training centers, universities), cultural bodies (theatre companies and theatre education networks) and research bodies. They have collaborated on devising, testing, structuring and evaluating a series of tools derived from the languages of theatre and the performing arts and designed for mathematics teachers and education professionals working with this subject.

The reflections developed in the TIM^2 project are based on the theories of Embodied Cognitive Science, which emerged in the late 1980s. According to these theories, thinking, even that relating to abstract ideas, is intrinsically a modal activity that shares most of its neural, sensorimotor, phenomenological, and cognitive resources with the actual dynamic physical being in the world.

Numerous experiments have shown that learning simple elements (such as letter recognition) and complex elements (such as physical laws) improves significantly when the body and the environment are actively involved in the process. Therefore, any aspect of cognition, starting with attention, cannot be understood by studying only the brain, as the body plays a strong and important role in learning.

Embodied Cognitive Science reflects on how the body and mind work in tandem to create human experience. The literature on these topics suggests that the physical actions we perform, as well as the actions performed around us, shape our mental experience. The idea that the people around us alter our cognitions has been revealed in the literature on mirror neurons, a group of motor neurons that activate when we observe another person

performing a certain behavior. The theory of Embodied Cognition assumes that thoughts and actions are influenced by sensory experience. Therefore, if embodiment becomes an element of teaching, it can have positive effects on classroom teaching (Sullivan, 2018).
The TIM methodology exploits this principle by using the body to improve mathematical skills and competences.

Based on this assumption, the TIM^2 project has developed a series of actions and tools (project outputs) that aim to have the widest possible impact through a multidimensional approach and synergistic work between three fundamental areas:

- The world of school: where the methodology is applied on a daily basis.
- The world of training: to ensure that users of the method are adequately trained.
- The world of scientific research: where the method is studied, monitored, and finalized, ensuring innovation.

1.4 OBJECTIVES AND RESULTS

The primary objectives that the project aims to achieve through its actions are therefore

- Training teachers to increase their methodological skills in teaching curricular activities in non-frontal settings, achieved through the training of trainers throughout Europe, who in turn have provided teacher training
- Reducing math anxiety through the development of a holistic method that improves students' attitude towards the subject and their sense of self-efficacy.
- Strengthening the methodology: improving the scalability and validity of the TIM methodology.
- Developing concrete tools to support the adoption of the methodology at European level and creating a system to support its sharing.

The tools and actions that the TIM^2 project has implemented are:

- A methodological manual (which you are reading right now), which provides a theoretical framework of reference, a description of the evaluation system implemented, with guidelines for applying the TIM^2 methodology.
- A toolkit that provides a detailed description of a series of theatrical and recreational activities to be carried out in the classroom, with suggestions for conducting them and details necessary to adapt the activity to one's educational context

- An e-learning platform (tim.coursevo.com) with an archive of materials and tools and a virtual space where teachers can discuss and share lessons and best practices
- The TIM^2 ontology: a digital tool for creating customized series of activities aimed at enhancing specific mathematical skills, based on the characteristics of your group of students and your teaching curriculum. The ontology is accessible through the e-learning platform tim.coursevo.com

The project was developed by six partners from four European countries, who created a multidisciplinary and multisectoral intervention: COREP - Center for Social and Community theatre of the University of Turin (IT), CNR-ITD (IT), Western Norway University of Applied Sciences - HVL (NO), Technical University of Crete (GR), TeNET-GR (GR), and the ASTA theatre company (PT).
The impact of the project included

- the involvement of 9,000 students
- the training of 600 teachers and future teachers
- the training of 28 trainers across Europe
- the publication of at least 5 scientific articles
- the organization of 6 conferences to disseminate the results of TIM^2 by each of the project partners

This manual is aimed at teachers, educators, and professionals involved in mathematics education, and has been designed as a tool through which readers can learn about the TIM^2 - Theatre in Mathematics project and the methodology on which it is based.

The manual begins with Chapter 2, which illustrates and explores the theoretical framework behind the project: studies on Embodied Cognition, explaining how thinking and learning, even in the application of abstract thought — as in the performance of mathematical functions — are intrinsically linked to physical action and interaction with the environment. It is from this premise that the TIM^2 project was developed, focusing on the use of theatre as a tool for engaging and activating the physical, cognitive, and emotional dimensions of students.

Chapter 3 focuses on Mathematical Literacy and its relationship with Mathematical Knowledge. Starting with a deconstruction of false myths about mathematics, the chapter provides a definition of Mathematical Literacy and introduces the four observational dimensions of the TIM^2 project, on which the project's evaluation design was built: Application, Reasoning, Metacognition, and Social Aspects (Collaboration). Chapter 3 explores one of the central aspects of the use of theatre in schools, namely its social value and its transformative potential in promoting the development of students' life skills, i.e., all

those transversal skills — cognitive, affective, relational — that enable us to cope with life's challenges: from problem solving and critical thinking to empathy and effective communication. In this way, theatre promotes students' well-being and improves their sense of self-efficacy, reducing performance anxiety.

Chapters 4, 5, and 6 describe the tools and working methods that make up TIM^2: Mathemart (an approach based on Social and Community theatre that uses theatrical and playful activities to address topics in the mathematics curriculum), Process Drama (a form of improvised and structured acting in which teachers and students explore a fictional world by taking on multiple roles to consider different perspectives and solve problems), and Role Categories (the use of specific role categories, such as the Curious, the Skeptic, the Democratic Leader, and the Initiator, to encourage discussion and mathematical argumentation among students).
The TIM^2 manual concludes with Chapter 8, which describes the design and procedure for evaluating the effectiveness of the TIM^2 methodology used within the project.

References

EACEA P9 Eurydice (2011), *Mathematics in Education in Europe: Common Challenges and National Policies.*

European Commission / EACEA / Eurydice (2025), *Addressing underachievement in literacy, mathematics and science. Policy changes in European school education since 2020.* Eurydice Report. Luxembourg: Publications. Office of the European Union.

European Commission / EACEA / *Eurydice, 2022. Increasing achievement and motivation in mathematics and science learning in schools.* Eurydice report. Luxembourg: Publications Office of the European Union.

Mullis et al., T*IMSS 2019 International Results in Mathematics and Science,* TIMSS & PIRLS International Study Center (2020), Lynch School of Education and Human Development,
Boston College and International Association for the Evaluation of Educational Achievement (IEA)

Sullivan, J. V. (2018). Learning and Embodied Cognition: *A Review and Proposal. Psychology Learning & Teaching,* 17(2), 128-143. https://doi.org/10.1177/1475725717752550

2. The Embodied Cognition as the framework to train mathematical skills through theatre activities

One of the fundamental traits of the TIM^2 project is to propose a new methodology that closely links the role of the body in learning and theatre techniques in the common aim of creating learning paths capable of stimulating certain well-defined mathematical skills. In order to accomplish this task, it (the TIM^2 methodology) takes the Embodied Cognition (EC) research programme and the different instances and perspectives that are part of it as its theoretical framework of reference. In this section, in order to allow the reader to fully benefit from the methodological rationale behind this manual, we will delve into the main features of EC.

The central point of EC is that, in order to understand mind, cognition and learning, it is necessary to (a) examine mental processes as being in close connection with the world and (b) understand how interactions between an agent who knows, and the environment develop in experience and over time (Maturana, & Varela, 1991) (Rosh, 2002).
Human beings are not brains that assimilate ready-made information, but agents that interact with their environment through their senses and movements. This type of interaction is described within Enactivism (Di Paolo & Thompson, 2014), a specific theory of EC, as 'embodied action', emphasizing the importance of a theory of cognition that sees knowledge and learning as processes of construction rather than as 'objects' to be acquired. In this perspective, knowing does not primarily mean processing symbols, but is the result of a co-action between cognitive, motor and perceptual processes. The mind is not reduced to a collection of contents (concepts) organized uniformly, regardless of their nature and sensory origin, in amodal form. Nor is it a collection of static representations, whether spatial, temporal, causal or logical. In this view, the concept of agent becomes fundamental, redefined and reinterpreted as a 'bundle of actions and perceptions of a body in the world'.

According to this view, every action and reaction experienced by an organism has social and physical characteristics that continuously alter and transform its domain of notions and its domain of interactions. Based on these features, an embodied and enactive mind does not merely compute, but interacts, and each interaction modifies its environment, which in turn affects it. Enactivism, by attributing a crucial role to the body and the relationship between body, action and environment, and by expanding the concept of mind to a social dimension, redefines the idea of intelligence in terms of a dynamic trait that emerges from the relationship between agents and between agents and the world.
In this context, knowing and learning become formative activities that have little to do with the simple extraction and elaboration of symbols and allow us to think of the human mind

in terms of processes of constructing meanings and experiences, key dynamics that in the literature are expressed through the concepts of sense-making, situatedness and agency.

These three concepts represent the most original elements that Enaction theory, as part of EC research program, has to say about knowledge and learning in general. The structural coupling relationship between body and environment, in which each influences the other, produces an emergent result that can be defined as sense-making. In other words, an agent is physically immersed in a semiotic domain whose elements (words, images, symbols, gestures, actions) have their own, interconnected, meanings, forming what is commonly called "the domain of meaning"[1]. This represents the starting point from which each agent constructs socially shared meanings (participatory sense-making), rooted in physical experiences and which are, therefore, simultaneously sensory, linguistic, kinaesthetic and affective. These meanings are structured by each agent through purposeful actions (agency), being autonomous cognitive systems that continuously adapt to their environment (situatedness).

Theatre and educational activities within a theatrical context, when examined through the framework of described EC perspective (Shapiro, 2010), provide an excellent lens for exploring teaching and learning methods in STEM subjects, especially in Mathematics (Panagouli & Priovolou, 2012) (Madden et al., 2013). According to the perspectives of Embodied Cognition and its different perspectives intentional movements are a fundamental form of cognition (Smith & Thelen, 2003).

The interactions between the body's sensorimotor system and the physical environment are crucial elements in the processes of thinking, learning, and constructing knowledge. In light of this, theatre and its associated activities can be viewed as a form of social practice that, through its focus on movement—as a primary cognitive mode—and the blending of physical and motor aspects with elements of aesthetics, action, communication, and social interaction, enables the exploration of various skills. Additionally, it supports the release of creativity in experimental performers, encouraging the spread and application of learned behaviors to real-world situations and daily life. Therefore, theatre-based educational activities are particularly suitable for grasping specific mathematical ideas and presenting a novel STEAM approach centered around theatre (Land, 2013).

1 Incorporating liberal arts and humanities into STEM curricula is more than just adding an A to STEM; it involves integrating the Arts into STEM education to develop a broader, transdisciplinary perspective. This perspective challenges the notion that art is inherently creative but not logical, while scientific disciplines are logical but lack creativity. Art, in its various forms (such as theatre, dance, painting, and sculpture), offers diverse ways to engage with STEM, facilitating the creation and expansion of innovative and productive transdisciplinary fields.

References

Di Paolo, E. A., & Thompson, E. (2014). *The enactive approach. The Routledge handbook of embodied cognition,* 68-78.

Land, M. H. (2013). *Full STEAM ahead: The benefits of integrating the arts into STEM.* Procedia Computer Science, 20, 547-552.

Madden, M. E., Baxter, M., Beauchamp, H., Bouchard, K., Habermas, D., Huff, M., Ladd, B., Pearon, J., Plague, G. (2013). *Rethinking STEM education: An interdisciplinary STEAM curriculum. Procedia Computer Science, 20*, 541–546. doi:10.1016/j.procs.2013.09.316.

Maturana, H. R., & Varela, F. J. (1991). *Autopoiesis and cognition: The realization of the living (Vol. 42).* Springer Science & Business Media.

Panagouli, D., & Priovolou, M. (2012, October). *Let's go to the movies! Learning Math Through Creativity and Role Playing. In European Conference on Games Based Learning* (p. 378). Academic Conferences International Limited.

Rosh, E. (2002). *Principles of Categorization.* In Levitin, D. J. (Ed.). (2002). *Foundations of cognitive psychology.* The MIT Press.

Shapiro, L. (2010). *Embodied cognition. Routledge.*

Smith, L. B., & Thelen, E. (2003). *Development as a dynamic system. Trends in cognitive sciences,* 7(8), 343-348.

3. Mathematical literacy

3.1 AGAINST FALSE MYTHS ABOUT MATHEMATICS

Mathematics, as a school discipline, has always aroused strong emotions in students, whether positive or negative. It, in fact, in common perception seems to arouse either a strong attraction or substantial discomfort, if not fear, related to difficulties of different kinds but generated by the complexity of the subject. This dual attitude that eliminates a possible and balanced middle ground, according to the literature, is attributable in part to numerous common beliefs and stereotypes that surround mathematics and deeply influence the way it is taught and learned. These stereotypes relate to different traits of mathematics and altogether contribute to a distorted image of it (De Corte et al., 2002). In this section, we will explore only some of the false beliefs that, in our view, contribute not only to creating misperceptions of mathematics but also to "expelling" from the concept of mathematics such fundamental components as Mathematical Literacy. Such an action negatively affecting the construction of the perception of mathematics also transfers its negative effects to the processes of teaching and learning mathematics, risking precluding, at the school level, a deep understanding and practical application of the discipline as well as easy access to it.

3.2 MATHEMATICS AS ABSOLUTE CERTAINTY AND RAPID COMPUTATION

Among the most widespread conceptions of mathematics in common sense, there's the perception that it is the field of absolute certainty and the area in which the key skill is the ability to provide correct answers quickly. This view of mathematics is anchored in the highly prevalent ideas that on the one hand, mathematics as a field of knowledge is defined by rigid, unalterable and precise rules and, on the other hand, the skills that pertain to it consist primarily and simply in being able to learn mechanically these kinds of rules and being able to apply them equally mechanically. Such a perception is not only limited to thinking of mathematics learning in these terms, but also includes in such an image the processes of teaching this discipline. Put another way, with a dangerous, often unconscious but completely incorrect synecdoche, a small part of mathematics becomes, in the common imagination, the entire field. It is, in fact, very often identified exclusively with procedural work to be followed, or with indemonstrable truths to be accepted uncritically. It is clear that such an approach, identifying the entirety of the field only with some of its traits, is exceedingly limited and reductive. Mathematics is not computation to be performed automatically according to applications of rules. Mathematics is a field that requires constant exploration and grants every explorer satisfying discoveries. The operation of reducing mathematics to mere mechanical applications of rules within crystallised procedures produces negative consequences both in those who teach it and in those who learn it.

On the one hand, it prevents students from developing a deep and conscious understanding ofmathematical concepts and, perhaps more importantly, of the many complex relationships between them. On the other hand, it reduces a teacher's work to the mere transfer of "operational" skills (e.g., computational skills) that wither away the most authentic sense of being a teacher: teaching to learn independently. True mathematical competence, then, is not measured and cannot be identified in the ability to follow rules alone, but must be sought and fixed first and foremost in the skills of thinking critically, solving problems in creative ways, and gaining an understanding and awareness of the theoretical foundations on which these rules are based.

Stimulating the cultivation of these kinds of skills, along with those rooted in common sense as the only ones to be mathematical, enables students to free themselves from the role of passivity that atrophies their intellectual curiosity and their ability to deal with and solve complex problems while encouraging, conversely, an attitude of intellectual homologation.
What is generally called a mathematical truth is never the result of operations of calculation and memorisation of rules. It is, instead, as the history and pedagogy of mathematics teach us, the result of a process of discovery and critical and cognitively aware reasoning. Doing mathematics, teaching mathematics, and learning mathematics have and should have a common soul: the exploration, analysis, testing and development of hypotheses and development of theories and concepts based on evidence and argumentation. Such a teaching/learning process represents the ideal of the useful path to understanding mathematics in a deep and meaningful way.

Connected to the false belief of mathematics as a mechanical procedure performed according to rules derived from an unquestionable mathematical truth is the belief that "being good at mathematics" corresponds to being able to solve mathematical problems quickly and without particular difficulty. According to such a view, students who can give the correct answer to a mathematical question/problem are generally considered more capable, as opposed to those who need more time to think and reflect.
Let us imagine that we are in a classroom where this is the perception of the discipline. In such a context, what is favoured during the learning process? Superficial understanding or deep understanding of mathematical concepts? Memorisation or critical thinking?
In such a context, privileging one trait over others could also trigger feelings of exclusion and demotivation in those students who are unable to sustain certain rhythms. Moreover, emphasising the speed of performance may hinder key skills such as problem solving, the ability to reflect on problems, explore different possible solutions, and understand what the main implications of the results achieved are.

3.3 MATHEMATICS AS A SCHOOL SUBJECT DISCONNECTED FROM REALITY

A very widespread false belief and for this reason a potential source of great problems is the conception according to which the mathematics we learn at school is completely divorced from reality. That is, it does not have any type of possible application in the real world.
This idea of a profound disconnection between mathematics and everyday life causes many students struggling with learning the subject to perceive it as unimportant for their lives and of little use for their daily problems. Such a perception gives their awareness of their mathematical knowledge a form of extreme abstraction. In other words, such a perception gives an image of mathematics as a mnemonic collection of abstract concepts that are difficult to use in practical everyday life.

However, to avoid such an erroneous conception of mathematics, it is very important that one of the primary goals of teaching mathematics at school is to make students understand the profound connection between the theoretical concepts of mathematics and their practical application. Overcoming the disconnection of mathematics (as a school subject) from reality requires showing students how it can be used to provide a solution to concrete problems and to have a deeper and more conscious understanding of the reality that surrounds them. Ignoring, or even underestimating, the connection between mathematics and reality represents a great limitation of the students' ability to attribute a practical value to the discipline, with consequent further negative effects on its perception.

Among all, the one according to which, being conceived as an abstract subject, it is a subject practised only intellectually and in "solitary speculation".

Conceiving mathematics as a solitary and isolated activity places it as an exclusive field of study, approached individually, without social exchanges, without collaboration with others.
From this stereotype arises the isolated mathematician, detached from reality and immersed in the abstractness of numbers and symbols. From here, the association of mathematics with the social stereotype of the so-called "nerd" socially isolated and detached from reality (Mendick et al., 2008). But it is enough to go not too deeply into the literature to discover that those who deal professionally with mathematics frequently collaborate with others to solve complex problems, share ideas, develop theories collectively and propose solutions developed in collaboration with others. Mathematics is not only individual work, mathematics is a social exchange. Teaching and learning mathematics should therefore be approached as real social practices that involve fundamental abilities of every human being that are only apparently distant from mathematics, or, perhaps, it is more correct to say, distant from an untrue image that we risk having of mathematics.

3.4 MATHEMATICAL LITERACY

What are we referring to when we use the expression "Mathematical Literacy"?
We have seen in the previous section how a deep and conscious concept of mathematics cannot be reduced to just some of its parts, and that the practical and social aspects of mathematics, if neglected, make the discipline lacking and incomplete.
Mathematical competence identifies exactly that competence necessary to learn, understand, and practically use mathematics in today's society and everyday life (Niss & Højgaard, 2019). It is a capacity that greatly expands the narrow and rigid concepts/perceptions of mathematics, but which is shown to be necessary to have a deep understanding of the complexity of this field of knowledge (Jablonka, 2003).
In literature, different components of Mathematical Literacy have been identified.
Specifically, a recent and well-established definition described Mathematical Literacy as

"an individual's capacity to reason mathematically and to formulate, employ, and interpret mathematics to solve problems in a variety of real-world contexts. It includes concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to know the role that mathematics plays in the world and to make the well-founded judgements and decisions needed by constructive, engaged and reflective 21stCentury citizens" (OECD, 2023, pg. 24).

Building on this, mathematical literacy can be conceived as a set of abilities that allows individuals to mobilise their mathematical knowledge, thinking, and skills in real-life situations. These abilities are essential for solving problems and for deliberating in complex situations in a society where people are constantly exposed to numerical information and quantitative data.
Among these abilities, we can cite communication, which concerns the ability of individuals to express problems and communicate solutions to others; mathematization, understood as the ability to transform real-world problems into mathematical terms; and representation, defined as the ability to interpret different mathematical representations, both of objects and situations. Other fundamental skills include reasoning and argumentation, expressed in the ability to think logically and connect the elements of problems and their solutions, the development of problem-solving strategies, which focuses on the ability to select and apply different strategies to address and solve mathematical problems, and the use of symbolic, formal and technical language and operations, which represents the ability to interpret, understand, manipulate and use symbolic expressions in various contexts to solve problems. Finally, the use of mathematical tools concerns the ability to use these tools to support mathematical activities effectively.

Therefore, mathematics is not limited to the procedures for performing calculations or solving specific mathematical operations (e.g., equations). Rather, as stated in the PISA f

ramework (OECD, 2023), mathematical literacy is centred on fostering students' capacity to use mathematics meaningfully in contextualised situations. Such a reference implies a way of seeing and approaching mathematics, which, as mentioned, justifies its fascinating complexity. Mathematical Literacy can be described as the ability or, better, a set of abilities that allows the adoption of one's mathematical knowledge, one's mathematical thinking, and one's mathematical skills in the context of real situations (Manfreda Kolar & Hodnik, 2021). It is a set of fundamental skills for solving problems or for deliberating in complex situations in a society in which one is constantly exposed to numerical information and quantitative data.

The ability to solve problems is one of the fundamental skills of Mathematical Literacy. Solving a problem, even a mathematical one, does not translate into a simple application or mechanical execution of a calculation based on a rule. Solving a problem means being able to understand it in its complexity, being able to inscribe it in the context/situation in which it occurs, having the ability to build a model of the problem-situation and to interpret the numerical data that constitute it and the results that will be achieved from working on it. For example, imagine the problem-situation of an 8-year-old child who is involved by his parents in organising his birthday party. This type of situation will stimulate his planning and resource management skills (money, number of guests, available seats in the space available). Or imagine the very common situation of a 16-year-old boy who is planning to buy a new bike or a new console with the gains from his part-time job.
Or again, imagine the situation in which a couple has to manage the family budget. In this case, the basic arithmetic skills of the members of the couple are not sufficient, but reality directly solicits their ability to predict future expenses, to evaluate and establish orders of priority in the family finances, to make decisions that are well thought out based on multiple, or in some cases limited, information available. Dealing with any of these examples of everyday life requires skills closely related to Mathematical Literacy, and that seem closely connected to the achievement of practical goals.

The analysis and interpretation of quantitative information is also a full-fledged skill to be written for Mathematical Literacy. Just think how many times every day the media and, in general, our daily activities expose us to graphs, statistics and numerical data. Let's imagine, for example, the problem-situation in which a child of primary school age is organising a snack at home with his friends and wants to divide the biscuits he has at home equally among his friends. Or, the problem-situation in which a teenager must monitor his telephone plan and analyse whether the daily consumption of gigabytes in the last days of the month will leave him without internet traffic. Or again, let's imagine an adult struggling with the reading and interpretation of a political poll to understand which of his favourite candidates has the best chance of winning. The skills solicited by these everyday life situations are crucial skills for making informed and conscious decisions, for deliberating thoughtfully, and for participating consciously and actively in social life. Such situations, in fact, actively stimulate the ability to think critically and interpret data, evaluate strategies, a sample, and

the implications deriving from the results obtained, all skills that fall fully under the umbrella of Mathematical Literacy.

A further trait should be included under the same umbrella: the ability to communicate and explain mathematical concepts. If you think about it, knowing how to solve a problem or interpret a graph is not enough to have a conscious mastery of such a complex area. It emerges as equally fundamental to face and solve everyday problems, to be able to explain one's reasoning to others and oneself, and to present it even with different codes in a comprehensible way. The ability to effectively communicate mathematical ideas is an essential component of Mathematical Literacy. It is the manifestation of that social component of mathematics that allows people to share their knowledge to arrive at an adequate solution to complex problems.

As a melting pot of skills, Mathematical Literacy is not an innate trait of the human mind but an emergent ability that can be learned, trained and refined through experience and formal and non-formal educational paths (Suciati et al., 2020; Umbara & Suryadi, 2019). These should be designed and implemented in such a way as to highlight the sphere of application that Mathematical Literacy opens to the world of mathematics.

3.5 THE RELATIONSHIP BETWEEN MATHEMATICAL LITERACY AND MATHEMATICAL KNOWLEDGE

The expression "Mathematical Knowledge" refers to a concept that plays a fundamental role both in mathematics education paths and in the practices of its application. "Mathematical Knowledge" essentially identifies a group of skills and processes that allow each individual to manage mathematical problems and to work effectively on their solution.

As mentioned, it is a complex concept composed of two different main traits that bring out two primary descriptions: mathematical knowledge as a structured sequence of actions, and mathematical knowledge as analysis and description of contexts of mathematical problems. According to the first description, conceiving mathematical knowledge as a structured sequence of actions with-and-on mathematical contents allows us to think of educational paths for the non-mnemonic learning of mathematics as paths within which the student's ability to recall mathematical concepts, learned in practical situations, and to use them in different contexts is stimulated.

According to the second description, instead, outlining mathematical knowledge as an ability and practice of analyzing the contexts of mathematical problems means highlighting the fact that it (mathematical knowledge) is not exclusively the result of an additive collection of numerical or quantitative information, but a real competence that allows its owner to find solutions to mathematical problems through deep reflective processes that can be adapted

to the context. These two important traits show, ultimately, a dual perspective on the same construct that lives on dense and deeply intertwined stratifications.
Van den Heuvel-Panhuizen (2003) divides mathematical knowledge into 4 main steps or components:

- intuitive knowledge
- concrete knowledge
- computational or procedural knowledge
- principle-conceptual knowledge

The first step of mathematical knowledge is represented by intuitive knowledge. It is also described as informal knowledge of mathematics. This is a phase closely linked to everyday experiences and knowledge learned outside of school. It is the phase in which one is confronted with those problems that are personally relevant.
The next step corresponds to the so-called concrete level of knowledge that includes mathematical representations and the use of manipulative tools for mathematics (e.g. fraction circles, pattern blocks, Cuisenaire rods). In this phase, an initial concrete understanding of mathematical concepts is structured and is fundamental to help students visualise and internalise a practical and physical reflection of mathematical concepts.

The acquisition of a tangible internalisation of mathematical concepts precedes and prepares the way for what is described as the procedural or computational step of mathematical knowledge. This is the component during which, in the context of solving a problematic situation, the student is encouraged to develop skills related to the application of mathematical procedures through the use of formal representation systems (e.g. algorithms for solving mathematical problems). The procedural part is fundamental in the learning paths of mathematics because it allows one to work on the accuracy of the execution of one or more operations.

Finally, the most advanced step is represented by that part of mathematical knowledge defined as the conceptual principle. Moving easily in this phase means knowing how to invent procedures mathematically appropriate to the problem and the specific context. This is a sign of a deep and articulated understanding of mathematical concepts from all points of view from which they can be approached. A sign of a skill that functions easily even in new and/or complex contexts.

Why are Mathematical Literacy and Mathematical Knowledge closely linked to each other?
Conceiving mathematics as a fundamental practice for tackling the problems of everyday life requires mathematical knowledge that is solid and coherent in all its features. This contributes crucially to ensuring that each individual in his/her daily life can act based on informed choices, and can solve problems by deeply understanding their logic.

3.6 MATHEMATICAL CONTENT IN MATHEMATICAL LITERACY

As widely described in the previous sections, Mathematical Literacy emerges as an essential concept for a deep understanding of how people use mathematics and interact with it in the different situations of their daily lives. Literally, "literacy" refers to a continuum of learning and proficiency in reading, writing and using numbers throughout life, but with this term, as it now seems clear, we do not refer to a simple and monolithic concept. Such literacy, in this case Mathematical Literacy, does not correspond to the mere knowledge of numbers and mathematical operations that can be done with numbers, but welcomes as its hardcore a group of analytical, manipulative and applicative skills of mathematical content in the real world. Far from being a monolithic skill, therefore, Mathematical Literacy is configured as a complex of skills that puts the individual in the condition to analyse, recognise and solve problems that in everyday life require the manipulation of mathematical content in different forms. According to PISA (OECD, 2006; Stacey & Turner, 2015), there are 4 main dimensions/categories of problems/situations that every day challenge our Mathematical Literacy ability: space and form, change and relations, quantity, uncertainty. Each category would stimulate the set of traits of Mathematical Literacy in a peculiar way.

Space and form

The world in its entirety (from a snowflake to a map) offers us geometric shapes and models and identifying, analysing and understanding their properties and orientations in space are, in everyday life, of vital importance.
The skills that allow us to orient ourselves expertly and autonomously in space and to recognise and manipulate its shapes are strictly connected to the concept of Mathematical Literacy, and an educational path from its early years cannot ignore them.

It is of fundamental importance that a student is constantly stimulated to discern what is similar and what is different between two or more objects; that he is adequately prepared to interpret the visual information contained in visual objects such as maps or diagrams; that he is stimulated to understand the various and possible relationships between this type of representations and that of which they are representations; that he can interpret and manage the possible changes in forms that he encounters daily; that he becomes aware of the fact that space and forms are not necessarily static entities and that they, consequently, can be manipulated, modified and transformed; that he is adequately educated to move (to navigate) physically and conceptually in space and through the forms of space using coordinates and points of reference.

Change and relationships

A fundamental component of Mathematical Literacy is the ability to understand, represent and instantiate changes and relationships. Part of it is to be identified in the awareness that, in reality, there are different forms of change (e.g. linear, exponential) and that each of them has peculiar characteristics that influence the relationships between the objects involved and the relationship with the reality that surrounds us. If we take linear change as an example, it will be characterised by a constant increase or decrease. If, on the other hand, we take exponential change as an example, it will have the peculiarity of being a change characterised by growth that proceeds with very rapid progression, with multiplicative progression. These are two types of mathematical concepts that everyday life offers us to manage, for example, economic decisions such as evaluating the purchase of an object based on the increase in its price, based on the comparison with the price of a similar object.
Another fundamental trait of the "change and relationships" category concerns the ability to translate the concepts of change and relationship into different mathematical representations (e.g. numerical tables, graphs, formulas, geometric representations) and to move through different representations. Encouraging such a capacity even at the school level not only allows one to handle a useful skill in everyday life but also allows one to apply these concepts to more strictly mathematical elements: e.g. identifying the relationship between two variables using an equation, analyzing the dependence of a variable, monitoring the change of a variable. In the educational context, this translates into the cultivation of functional thinking, that is, the ability to think in terms of relationships and changes.

Quantity

The dimension of "quantity" is linked to skills that are crucial in the definition of Mathematical Literacy. Among these are the ability to recognise numerical patterns in everyday life contexts and the ability to use numbers to represent, on the one hand, quantities, and on the other hand, quantifiable attributes of objects encountered daily. These skills translate into everyday abilities such as being able to perform counts and make measurements.
The focus of this dimension, which is fundamental for every human being, is quantitative reasoning, whose "core actions" lie in the ability to represent numbers in different ways, understand the meaning of basic mathematical operations, perceive and be aware of the magnitude of numbers, perform mental calculations, and make estimations based on quantitative analyses of reality.

Uncertainty

One of the constants that everyday life presents us with is the absence of absolute certainty in all its aspects. Even the mathematical sphere of our existence is marked by this same constant. Just think of incorrect forecasts of certain events, or models that do not fully align with reality, and so on.
What does this mean? Should we abandon the proverbial and historical trust in the infallibility of mathematics? No, not at all. On the contrary, such a state of affairs suggests that, from an early age, each of us should be educated to manage uncertainty, even in the realm of numbers. This uncertainty generally arises from specific relationships between the use of numbers and particular contexts.

The Mathematical Literacy of every human being, constantly interacting with the real world, therefore includes the mathematical concepts and skills needed to face everyday problems related to uncertainty. Being able to collect data (defined as "numbers in specific contexts"), analyze them, construct clear visualizations for oneself and others, draw inferences from data, and calculate the probability of one or more events—these are the abilities that make up that kind of Mathematical Literacy which enables us to deal with the challenges of everyday life.

3.7 THE OBSERVATIONAL DIMENSIONS RELATED TO MATHEMATICAL LITERACY IN THE TIM^2 PROJECT

Within the context of the TIM^2 project, we have attempted to translate the multiple facets of Mathematical Literacy discussed above into observable dimensions to have a clear understanding of how the project's activities relate to Mathematical Literacy.
For this reason, we have identified four main dimensions, which will be observed in different ways (see Chapter 7), and which encapsulate the fundamental aspects described above. Of these, two are directly connected to Mathematical Literacy and to the problem-solving processes that engage this competence, while two are indirectly connected, yet they play a full and essential role in explaining the complex dynamics involved in solving problems within specific contexts.

The first two, developed by Philpot et al. (2021), are the "applying dimension" and "the reasoning dimension". The other two are about, respectively, the metacognitive processes that are activated during problem-solving (metacognition), and the social and collaborative processes that take place during the stages of solving an everyday problem.

APPLYING

The "applying" dimension refers to the ability to apply mathematical concepts to various everyday situations. The core of this dimension lies in the ability to solve a problem that involves numbers in some way. Focusing on this dimension will allow us to observe the operations students select to solve a problem, the strategies they develop or choose to follow, and the appropriateness of the tools they select to address a real-life problem that requires Mathematical Literacy.
Philpot et al. (2021, p. 16) provide a comprehensive table of the skills involved in the "applying" dimension. The table is shown below:

Formulate	Determine efficient/appropriate operations, strategies, and tools for solving problems.
Implement	Implement suitable strategies and operations to produce solutions to problems
Represent	Represent data in tables or graphs; create equations, inequalities, geometric figures, or diagrams that model problem situations; and generate equivalent representations for a given mathematical entity or relationship.

REASONING

When approaching the solution of a problem that requires mathematical reasoning, logical thinking is systematically involved. This form of thinking implies mental processes that rely on deductions, inductions, patterns, and regularities that are useful in guiding the problem-solving process toward an appropriate solution. Mathematical and logical thinking enable individuals to precisely identify methods and strategies for solving a problem, to make inferences based on data or information, to analyse quantitative relationships, and, when necessary, to generalise them.
Philpot et al. (2021, p. 17) provide a comprehensive table of the skills involved in the "reasoning" dimension. The table is shown below:

Analyze	Analyze, describe, or use relationships among numbers, expressions, quantities, and shapes.
Integrate	Link different elements of knowledge, related representations, and procedures.
Generalize	Make statements that represent relationships in more general and more widely applicable terms.
Justify	Provide mathematical arguments to support a strategy or solution.

METACOGNITION

The dimension of metacognition includes the ability to retrace one's reasoning, identifying the key steps of a process and describing it using various codes (Schoenfeld, 1992). Another essential ability concerns the ability to recognise constraints, such as those related to context, time or resources, that can influence performance, as well as the ability to identify internal factors, such as affective, motivational and cognitive ones, that can affect performance. Monitoring and evaluating one's performance and recognising and considering possible alternatives to one's working method are also skills that fall within the dimension of metacognition.

SOCIAL ASPECTS (COLLABORATION)

An educational aspect of great interest is the analysis of the degree of shared participation among class members in the teaching and learning dynamics, with the aim of continuously observing the factors that favor effective communication and harmonious cooperation, in addition to the progressive maturation of students' communication skills. Essential skills in

this context include the ability to empathise with others, grasping their needs, adopting attitudes of respect towards people and diversity, and actively collaborating with others to achieve a common goal. Constructive management of dissent and criticism, consideration of other people's points of view, and acceptance of different roles and rules complete the set of skills that structure collaboration and participation.

Reference

De Corte, E., Op't Eynde, P., & Verschaffel, L. (2002). *"Knowing what to believe": the relevance of students' mathematical beliefs for mathematics education.* In B. Hofer & P. Pintrich (Eds.), Personal epistemology: The psychology of beliefs about knowledge and knowing. Mahwah, NJ: Lawrence Erlbaum.

Jablonka, E. (2003). *Mathematical literacy. In Second international handbook of mathematics education* (pp. 75-102). Springer, Dordrecht

Manfreda Kolar, V., & Hodnik, T. (2021). *Mathematical Literacy from the Perspective of Solving Contextual Problems.* European Journal of Educational Research, 10(1), 467-483.

Mendick, H., Epstein, D., & Moreau, M. P. (2008). *End of award Report: Mathematical images and identities: Education, entertainment, social justice.* Swindon: Economic and Social Research Council.

Niss, M., & Højgaard, T. (2019). *Mathematical competencies revisited. Educational studies in mathematics,* 102, 9-28.

OECD (2006), Assessing Scientific, *Reading and Mathematical Literacy: A Framework for PISA 2006*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/9789264026407-en.

OECD (2023), PISA 2022 *Assessment and Analytical Framework*, PISA, OECD Publishing, Paris. https://doi.org/10.1787/dfe0bf9c-en.

Philpot, R., Lindquist, M., Mullis, I. V., & Aldrich, C. E. (2021). *TIMSS 2023 Mathematics Framework.* TIMSS 2023 Assessment Frameworks, 5.

Schoenfeld, A. (1992). *Learning to think mathematically: Problem-solving, metacognition and sense making in mathematics.* In D. A. Grouws (Ed.), Handbook of research on mathematics teaching and learning (pp. 334–370). New York: Macmillan.

Stacey, K., & Turner, R. (2015). *The evolution and key concepts of the PISA mathematics frameworks.* In K. Stacey & R. Turner (Eds.), *Assessing mathematical literacy* (pp. 5-33). Springer international Publishing.

Suciati, Munadi, S., Sugiman, & Febriyanti, R. W. D. (2020). *Design and Validation of Mathematical Literacy Instruments for Assessment for Learning in Indonesia.* European Journal of Educational Research, 9(2), 865 - 875. https://doi.org/10.12973/eu-jer.9.2.865

Turner, R. (2014). Assessing mathematical literacy. K. Stacey (Ed.). Springer International Publishing AG.
Umbara, U., & Suryadi, D. (2019). *Re-Interpretation of Mathematical Literacy Based on the Teacher's Perspective*. International Journal of Instruction, 12(4), 789-806.

Van den Heuvel-Panhuizen, M. (2003). *The didactical use of models in realistic mathematics education: An example from a longitudinal trajectory on percentage.* Educational Studies in Mathematics, 54(1), 9–35.

4. Using drama in school to promote students' current and future well-being

Nowadays educational systems are more and more aware of the necessity of a school that allows students to acquire knowledge as well as developing competencies that allow them to cope with the challenges and complexities of the contemporary world, and competencies that will remain pertinent in the rapidly changing world that awaits them.
For this reason, teaching approaches are more and more designed for enhancing abilities that will allow students to be effective in their personal and professional sphere and resourceful in promoting their wellbeing and those of the communities they will be part of.

From this perspective, those skills that the WHO has defined as "life skills" are crucial for the development of young people. These are the psycho-social skills that allow an individual to deal incisively and effectively with the needs and changes in daily life (WHO, 1993a). These are cognitive, emotional and relational skills, through which individuals can trigger health promotion processes, by increasing control over, and improving, their health, by identifying and realising aspirations, satisfying needs, and to changing or coping with the environment (Ottawa Charter for Health Promotion, 1986). These competencies, identified by the WHO as factors central to the promotion of health and well-being of children and adolescents, are: problem solving, critical thinking, effective communication skills, decision-making, creative thinking, interpersonal relationship skills, self-awareness building skills, empathy, and coping with stress and emotions.

There is a growing body of theory and research behind the rationale for describing the benefits of skills-based health education. Through decades of research and experience, the behavioural sciences, pedagogy, and child development have amassed information about the processes of growth, knowledge, learning, and the means to acquire skills, attitudes, and behaviours in children and adolescents. Prominent in this field is Albert Bandura's theory of social learning or social cognitive learning (1977).

The decision to prioritise the promotion of life skills at school derives from the awareness that these competences will become part of a shared repertory of the psychosocial skills children and young people will need to confront the difficulties that will come with the changes and expectations awaiting them (Bombi, Baumgartner, 2002).

It has been shown that life skills training within the school curriculum has a positive influence on the development of all levels of communicative skills (with peers, teachers, parents). The development of life skills improves psychological well-being and enhances self-esteem. Besides this, life skills training reduces aggression and depression and increases self-confidence and sense of responsibility (Nabors et al., 2000), and among the

personal factors that enable individuals to determine events and express their own potential, a "sense of self-efficacy" is the strongest and most pervasive in many life situations (Bandura, 1997). Within its social cognitive paradigm, Bandura's constructivist learning theory provides the framework for programs in skills-based health education (WHO, 2003) through interactive and participatory approaches to teaching and learning.[2]

The use of theatre practices in the classroom provides a precious opportunity to implement such approach, as they promote the development of cognitive, relational and affective life skills through a vast series of practices, including the use of the body and training of bodily and emotional awareness, the work of creative co-construction with others and in the group, the use of creative thinking and imagination in a playful context, the exploration through storytelling of new points of view.
The theatre workshop setting therefore allows to train a vast number of transversal skills that will be crucial for the students' personal development, both for their future success in the professional and social sphere, and for their well-being and that of the community to which they are part of.

A teacher who is aware of how drama and performing arts practices can be used in the classroom, can play a crucial role in the development of these competencies.
The teacher is the principal agent in classroom learning, a mediator of knowledge and teaching experience, as well as a facilitator of emotional aspects that can facilitate or inhibit students' learning processes (Feuerstein, 2005; Ravizza, 2008). Given the emotional variables in learning, a range of evidence indicates that the emotional sensitivity the teacher demonstrates toward a student's learning difficulties is one of the major variables that predicts the onset of anxiety in students (Niss et al., 2011; Pantziara et al., 2011). Studies have shown that a teacher's theoretical and practical knowledge, and so the use of certain techniques for teaching maths (e.g., problem solving, individualised support, error correction at the end of the lesson, etc.) can increase positive feelings in class (Caviola et al., 2017). An outstanding teacher is one who develops the ability to motivate critical thinking in others (colleagues, students, etc.) in order to take on individual changes and complex challenges, and draw together the resources of students and the school community to create contexts of creative and innovative learning (Fullan, 2002; Inchley, Guggleberger & Young, 2012; Griebler, Rojatz & Simovska, 2012; Saraanen, 2012).[3]

[2] TIM - Theatre in Mathematics Methodology Manual - http://old.theatreinmath.eu/wp-content/uploads/2022/03/TIM-methodology-English_compressed.pdf

[3] TIM - Theatre in Mathematics Methodology Manual - http://old.theatreinmath.eu/wp-content/uploads/2022/03/TIM-methodology-English_compressed.pdf

5. Introduction to Mathemart and the Social and Community Theatre methodology

5.1 INTRODUCTION TO MATHEMART [2]

Mathemart is an innovative pedagogical approach to mathematics created by Maurizio Bertolini in 2011, as part of the action-research of the Social and Community Theatre Centre of the University of Turin. This approach was developed in order to tackle the challenges faced by many students and teachers, who associated maths teaching and learning with feelings of stress, fear and discomfort.
Learning difficulties and the fear of mathematics can have different causes and origins. *Mathemart*'s approach is based on the fact that difficulty in learning maths can derive from content-related and emotional difficulties (Haciomeroglu, 2019). Maths anxiety is a negative emotional reaction to mathematics that can interfere with a person's ability to tackle maths problems. It manifests through feelings of apprehension, tension, and distress when confronted with number manipulation and solving mathematical problems in real life situations. Recent studies have shown negative correlations between anxiety and maths performance (Devine et al., 2012; Carey et al., 2019; Hill et al., 2016). If students are scared of mathematics, they cannot allow themselves to make mistakes. Their fear freezes their brain and logic skills, and they cannot think rationally.

Mathemart consists of teaching mathematics through the theatre workshop, using Social and Community Theatre (SCT), a methodology developed in the early 2000s within the action-research of the Social and Community Theatre Centre of the University of Turin (see paragraph 5.2).
The setting of the theatre workshop within the SCT methodology is used to allow participants to immerse in the game of mathematics by means of a global approach involving mind and body, inborn creativity and engagement. The theatrical setting creates a creative, playful and trustworthy atmosphere, thus enabling students to freely explore what they are doing without judgement. It encourages learning from mistakes in a sequence of trial and error.

A good theatrical setting can help students to forget their fear and to enjoy the possibility of learning by playing. In fact, in the *Mathemart* training, participants do not talk about mathematics, but rather experience the subject by playing with mathematical relations and rules. Only after experiencing one concept, will they be formalising it.
Mathemart as it is included in the TIM^2 Methodology, is the result of a research work that started in 2011 and has undergone testing in primary and secondary schools in Italy for over 20 years before the further research of *TIM - Theatre in Mathematics.*
The approach has been developed in different settings: a Social and Community Theatre professional also expert in math teaching working alone with a class group, or together with

mathematical relations and rules. Only after experiencing one concept, will they be formalising it.
Mathemart as it is included in the TIM^2 Methodology, is the result of a research work that started in 2011 and has undergone testing in primary and secondary schools in Italy for over 20 years before the further research of *TIM - Theatre in Mathematics.*
The approach has been developed in different settings: a Social and Community Theatre professional also expert in math teaching working alone with a class group, or together with a teacher developing the math curriculum. In each of the experimentation, teachers observing the classes during and after the workshop stated the intervention affected positively the group class especially concerning some aspects:

- The workshop was effective in improving the understanding of topics that some of the students could not understand during a standard lesson;
- New curricular topics introduced through Mathemart and only later discussed in a standard lesson were understood much more easily than usual;
- Students who feared mathematics and would normally be reluctant to participate actively in a standard lesson, would feel comfortable during Mathemart workshops and were proactive and engaged;
- All students of the class group would show a high degree of involvement and enjoyment;
- The teachers involved were motivated to continue the Mathemart experiment.

Since 2014, a series of teachers' trainings started in the North of Italy, in order to provide teachers with the tools to create, plan and conduct a math lesson using drama and the Mathemart activities autonomously. The trainings would develop methodological competencies related to drama and Social Community Theatre, knowledge of Mathemart activities and their functioning and skills to conduct these activities and the competencies necessary to creating a lesson using these activities and to creating new Mathemart activities.
The main results that teachers participating to these training declared to have achieved are:

- The acquisition of new tools for personal awareness: body awareness, stress management and class management;
- A decrease in the perception of stress levels during the training;
- The acquisition of new tools, practices, activities for teaching;
- The acquisition of new tools related to class management and facilitation;
- The acquisition of tools for creating new lessons combining mathematics and drama in order to expand the set of activities learned during the training.

Some of these feedbacks collected from students and teachers who experienced *Mathemart workshops*, is reflected in the evaluation carried on during the *TIM - Theatre in Mathematics* project, that can be retrieved in the article "Counteracting the fear of mathematics through theatre: an innovative teaching methodology" on[4] the *TIM - Theatre in Mathematics* website (https://old.theatreinmath.eu).

5.2 THE SOCIAL AND COMMUNITY THEATRE METHODOLOGY

Mathemart has been developed within the framework of the theatrical approach of Social Theatre in Italy, which originates from the international experiences of social animation, theatre animation and drama therapy in the second half of the XX century. The first experiences of Social Theatre aimed at using drama to support and promote the wellbeing and the empowerment of individuals belonging to disadvantaged or vulnerable groups (Rossi Ghiglione, 2011). Progressively, Social Theatre interventions started to become increasingly more focused on the educational impact of capacity building based on theatre approaches and on the "promotion and development of communities as a way to support processes of individual and collective empowerment and as forms of expressive and communicative research starting from the identities of groups" (Rossi Ghiglione, Pagliarino, 2011).

The general theory of Social Theatre was developed in the 1980s at the Catholic University of Milan, with a focus on drama workshops with groups as well as performative and festive dramaturgy. These studies analysed the theatrical process – from training to performance – and its pedagogical and social interaction potential. Research also focused on the transformational power of the ritualistic and symbolic dimension of theatre, and on the personal and relational resources that can result from its socio-affective dynamics.
Starting from these studies, in the early 2000s the Social Community Theatre Centre of the University of Turin further explored these concepts and experiences, creating the Social Community Theatre methodology, which is mainly focused on the communitarian dimension and on the intention of Social Theatre to include the local community in their work with groups (Rossi Ghiglione, Fabris, Pagliarino, 2019).
The Social Community Theatre methodology uses performing arts and performative languages (singing, playing, music, dance, words, etc.) as well as processes or events (workshops, celebrations, etc.) to create cultural activities where individuals can express themselves artistically, work on the development of interpersonal and intrapersonal relationships and promote the participants' wellbeing. Social and Community Theatre allows participants to create symbolic representations of themselves or the world through shared experiences in order to produce a transformation of reality and themselves.
The approach of Social Community Theatre originates from the following core principles of theatre:

[4] http://old.theatreinmath.eu/wp-content/uploads/2022/10/4.-Counteracting-the-fear-of-mathematics-through-theatre.pdf

BODY: SELF-AWARENESS AND WELLBEING

In theatre, just like in other performing arts, the human being has a central role.
Starting from the 1960s, theatre research has focused on how theatre professionals must train in order to prepare for their artistic performance. Social Community Theatre workshops do implement these techniques, especially during the initial work with the group. These activities stimulate self-perception, foster creativity, promote physical and mental awareness, thus allowing the rethinking of one's personal habits and promoting the communicative and expressive potential of the body. These activities are used by Social Community Theatre to promote the participants' wellbeing. Training self-awareness and body expressivity allows us to effectively use energies, build a positive self-image, foster the ability to build relationships and promote emotional and relational wellbeing. A stronger self-awareness means a more solid emotional literacy and therefore, the promotion of empathy, which is the foundation of social skills.

THE "CHORUS": DIVERSITY AND TRUST

The collective nature of theatre determines its ability to allow and promote the inclusion of different points of view. In Social and Community Theatre the natural ability of theatre to create a "chorus", is used to build bridges between cultural, social and personal differences and therefore represents the possibility to work for an inclusive community.
The trust that is built within a theatre group allows free expression and the acceptance of differences. In fact, creating a safe space is the first concern of a Social Community Theatre facilitator. In such an environment, participants become aware of their having rights as well as responsibilities, and as a consequence, they can grow both from a social and personal point of view.

PLAY AND RITUALS

Play is a central element in theatre: it has rules, specific timings and spaces, it is enjoyable and free from judgment. In the theatre workshop, participants play to have fun and, at the same time, they are aware that throughout play you also learn. Playful activities are a place of cognitive and moral development that allow participants to train for real life's challenges: they can discover new alternatives, dive into new experiences without fear, forget the psychological pressure of performing efficiently and unlock their creativity.

ROLES AND STORIES

Many theatre activities consist of "as if" games where participants play with different identities or engage in role playing. Taking on a different role allows participants to explore other experiences and perspectives. In Social Theatre these activities are used to foster the ability to imagine new possibilities in real life and to accept and understand the other and their point of views. At the same time, roles taken up by participants often interact in story telling activities where new realities or current situations are enacted. Thus, they can either

build a new common vision or further understand a certain reality, strengthening the identity of the participants and their relationship with each other.

THE SOCIAL AND COMMUNITY THEATRE WORKSHOP

In Social and Community Theatre, experiential theatre workshops are the best tool to meet the purpose of enabling participants to develop skills and competencies through the educational potential of theatre.

The theatre workshop follows a precise structure where time, interactions and actions are exactly defined and need to be carefully planned and reflected upon by the person who conducts the workshop. This person must have full awareness of these principles in order to take them into account both before and during the workshop sessions (Rossi Ghiglione, Pagliarino, 2011).

An SCT workshop has a precise structure characterising the phases of the workshop as a whole, as well as the different moments in the individual workshop session. The group works in a dedicated place, usually empty or as "neutral" as possible, so that it can be perceived as different from the places the participants are usually in. The group (a maximum of 30 participants) is engaged in a sequence of activities and games for a variable amount of time (from 1,30 hours to one full day). The activities are carried out both individually and in group, and involve the physical, cognitive and emotional sphere (Rossi Ghiglione, 2019).

THE STRUCTURE OF A SCT WORKSHOP

An SCT workshop normally includes 10 to 20 sessions. The first sessions will be mainly dedicated to group building, the exploration of relationships among participants, creating an atmosphere of trust through playful activities. In the following sessions more space can be dedicated to exploring the expressive potential of the body (both for individuals and the group), as well as activities that promote creative listening skills within the group. This requires a higher level of trust that should be developed in the first part of the workshop. The final sessions include activities that allow the exploration of specific themes and new artistic languages. This phase is usually also dedicated to the creation of a final artistic product.

THE STRUCTURE OF AN SCT WORKSHOP SESSION

During the first part of the workshop, the group is accompanied into the session's space and time dimension through a series of activities, such as a moment of informal welcome, a formal contact with the beginning ritual, the creation of a "contract" with the group. Here, some contents and times of the session can be shared and negotiated with participants, the facilitator communicates working times and allows participants to share specific needs.

The second part is dedicated to exploration through activities that might include different artistic languages, techniques, etc. For example:

- individual training activities where participants, conducted by the facilitator, explore and become aware of their voices and bodies as a tool for expression and interaction with others;
- group training, where the whole group is involved in a collective exploration to understand how group harmony and reciprocal under- standing can increase the expressive potential of both groups and individuals;
- dramaturgical exploration and scenic creation, with activities that al- low the group to represent and bring to life their visions and ideas on specific themes. These can include improvisation, the creative use of spaces and objects, storytelling, etc.

In the third part of the session, the facilitator leads activities to collect feedback on the workshop session and elements on how the group experienced it (e.g., wellbeing, new insights, reflection on the experience as a whole).

The session ends with a closing ritual that, just like the opening one, allows the group to cross the threshold between the extra-ordinary and the ordinary world, thus defining the confines of the experience.

5.3 THE MATHEMART WORKSHOP

Being based in the SCT methodology, both a Mathemart workshop and a single Mathemart workshop session follow the main principles of the SCT methodology described above.
The tools provided by TIM^2 are meant to allow the teachers trained in the methodology, to autonomously create, plan and conduct new activities and new lessons, specifically tailored on the characteristics of their classes, and on the topics they are addressing in class. The Mathemart activities described in the TIM^2 Toolkit are intended to either be used by the teacher as guidelines or inspiration, or to be used in class as described in the Toolkit. The following description is meant to provide the teachers with some guidelines that might support them in the implementation of these activities.

A set of *Mathemart* lessons is usually composed of 10 to 20 workshops of 1-2 hours each. At the beginning of the process (for the first 3-4 meetings) the main aim is to make the group familiar with the games and the theatre activities proposed, as well as to develop a common theatre language. During this phase the mathematical part is less important; the group is preparing the ground for the mathematical seeds that will be planted later. The main goal of this phase is to make the group comfortable with the theatre languages we want to use, before using that language to play with mathematics. Furthermore, this phase starts the process of group-building and the creation of trust between the facilitator and the group.
After this first phase, mathematics will take more and more space, and the workshop will be focused on activities that imply the use of it. The same games and activities previously introduced will be adapted to mathematical concepts.

Nevertheless, every time the conductor decides to use a new theatrical language or a new game, the purely theatrical part needs to be trained before introducing the mathematical one. Even though the main goal of Mathemart is to help students overcome their fear of mathematics, the facilitator should not underestimate the risks connected to the fear of theatre. The students should be able to focus only on the maths part as this makes the task easier for them and ensures pleasure in carrying on the activity.

While planning a Mathemart workshop or a sequence of workshops, it is important to remember that both theatre and mathematics build competencies on top of other competencies. For example:

- for mathematics, one needs to teach maths operations before the can teach expressions;
- for theatre, exploring the expressive possibilities of the body comes before exploring the expressive possibilities of the gesture; and it is important to explore the sound before exploring the use of words. This is why the facilitator needs to proceed gradually.

A MATHEMART WORKSHOP SESSION

The Mathemart lesson is developed according to the specific structure of a Social and Community Theatre workshop.
Since it is built on a specific methodology (the SCT Methodology, see paragraph 5.2) it has a well-defined structure that can support teachers to plan the activities and to create new activities within a clear framework. Furthermore, a repeated structure helps students to understand what they are doing, to gain confidence with the setting and the workshop's flow, and to feel more comfortable during the whole process. This facilitates the learning process.

A single workshop has a clear structure where each phase has a specific goal. This structure helps the facilitator to build a coherent experience where the participants are accompanied step by step. It is an extra-ordinary practice, where ordinary life is left outside, giving the participants the possibility to experience a new way of learning with body, emotions and the cognitive level.

Contact and contract - First phase: the facilitator meets the group and shares the structure and goals of the activity with them. This is a way to engage them and foster active learning, as well as making them responsible for their own learning process. It also communicates a sense of care for their needs and promotes trust between learners and teachers.

Warm up – Developing a common theatre language. Before approaching a math topic, the trainer must be sure that participants are comfortable with the theatre techniques, activities or artistic languages he/she wants to use. If they are comfortable with the theatrical language, they can have fun and enjoy the activity and approach to mathematics in an environment that is perceived as positive.

Main activity (main topic) - Here the group addresses and explores the maths topic.
There are mainly three kinds of main activities:

- mathematical Games, which come from theatre training activities. These games are adapted so that participants need to use maths to be able to play;
- drama or performative activities, where the participants experiment a mathematical topic: the participants play a role or perform a scene creating a metaphor or a representation of a mathematical concept;
- third: activities that make the participants reflect on mathematics as a language where each word has a very well-defined meaning

Cool down - In this phase the facilitator helps students to go from action to reflection by explaining, expanding or formalizing the mathematical concepts addressed during the main activity.

Feedback - In this phase the facilitator creates an environment of mutual attention and listens to the students' needs and feelings. Here the group elaborates the workshop experience from an emotional and cognitive point of view in order to become aware of the whole process.

5.4 POINTS OF ATTENTION

Tailor your lesson: In order to ensure a pleasant experience for your group of students, you need to consider its characteristics and build your lesson around those. Furthermore, it is important to remember that in a Mathemart lesson there are at least two levels of learning: mathematics and theatre, and the group should always be comfortable with both.

Observe and adjust: Each workshop and each sequence of workshops is different. This is due to the fact that each group has different characteristics. It is important for the facilitator to be able to change plans based on the characteristics of the group, its individuals, and any factor that might become known during the workshops.
Many aspects can influence a workshop: the space, the internal dynamics of the group, the characteristics of certain individuals, the energy of the group on the specific day or time period, etc.

Break down the activity: Before introducing an activity, it is important to make sure the group has the competencies to do it without moving too far away from their comfort zone. Otherwise, the activity can become tiring, stressing or even frustrating. If a certain activity requires many competencies to be carried out, you can start by training those skills separately, and only later introduce the full activity. To make sure you understand the activity's level of difficulty, you can break it down into the competencies it requires. For example, if you want the group to work in subgroups and create scenes that will be perform-

ed in front of other group members, you can ask yourself the following questions: *Are they able to work in subgroups? To negotiate? To co-create? Have they experienced performing in front of an audience? Are they able to act like an audience and still be engaged in the activity? Are they able to stay focused during a less dynamic activity?* etc. Based on your answers to these questions, you can plan many different activities to prepare the group for the subgroup activity/performance.

References

Carey E., Devine, A., Hill, F., Dowker, A., McLellan, R. & Szucz, D. (2019). *Understanding Mathematics Anxiety Investigating the experiences of UK primary and secondary school students.* Centre for Neuroscience in Education.

Devine, A., Fawcett, K., Szűcs, D. & Dowker, A. (2012). *Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety.* Behav Brain Funct, 8 (33).

Haciomeroglu, G. (2019). *The relationship between elementary students' achievement emotions and sources of mathematics self-efficacy.* International Journal of Research in Education and Science (IJRES), 5(2), 548-559.

Rossi Ghiglione, A., Pagliarino, A., (2011*) Fare teatro sociale. Esercizi e progetti,* Dino Audino (ed.), 49.

Rossi Ghiglione, A. (2011) *"La formazione in teatro sociale e di comunità all'università di Torino: un progetto culturale regionale" in «Comunicazioni sociali»*, n. 2, © 2011 Vita e Pensiero / Pubblicazioni dell'Università Cattolica del Sacro Cuore, 229-240.

Rossi Ghiglione, A., Pagliarino, A. (2011) *Fare teatro sociale. Esercizi e progetti. In Dino Audino (ed.), 11. Translated from Italian by the author of the present contribution. "promozione e lo sviluppo di comunità come sostegno a processi di empowerment individuali e collettivi e come forme di ricerca espressiva e comunicativa a partire dalle identità dei gruppi."*

Rossi Ghiglione, A., Fabris, R., Pagliarino, A., (2019) *A Social Community Theatre Project. Methodology, Evaluation and Analysis,* Franco Angeli, Milano (ed.) Open Access http://ojs.francoangeli.it/_omp/index.php/oa/catalog/book/394, 37.

Rossi Ghiglione, A., (2019), *Arte, benessere e cura. La potenza del teatro in "Lo scandalo del corpo. Studi di un altro teatro per Claudio Bernardi"* a cura di C. Bino, G. Innocenti Malini, L. Peja, 251-262 in © 2019 Vita e Pensiero / Pubblicazioni dell'Università Cattolica del Sacro Cuore p.255.

6. Process Drama

6.1 INTRODUCTION TO PROCESS DRAMA

Process drama is a structured, improvised acting form where teachers and students agree to examine a fictional world together: 'It is structured so that participants take on multiple roles, not just one character throughout the drama experience. It is framed this way to allow participants to consider multiple perspectives' (Landy and Montgomery 2012, p. 19). Through process drama they will explore together in collective creative processes over a longer time and through different drama conventions. In this way, process drama differs from other kinds of drama, such as basic role-plays and dramatization.

Process drama is a genre of educational drama which focuses on collaborative investigation and problem-solving in an imaginary world. Process dramas use 'pre-texts' (photographs, newspaper articles, music, artefacts, narratives etc. …) to frame the investigation and raise questions for the students (DICE Consortium, 2014).

The concept 'process drama' was introduced by Brad Haseman (1991, p. 19), defining it as "the distinctive form of improvisation which has emerged from schools", one of the characteristics being that the improvised drama was structured to arouse an artistic response from the participants. According to O'Neill process drama proceeds without a script, its outcome is unpredictable, it lacks a separate audience, and the experience is impossible to replicate exactly (O'Neill, 1995, p. xiii). In the 1990s the concept "process drama" was referred to and used by Cecily O'Neill or Gavin Bolton about what in Scandinavia was used to be called "drama pedagogy".

Dramatic action is always a physical and concrete expression of a role. By playing a role, the acting participant transforms thoughts and feelings into form, which make the action significant and symbolic (Schonman, 2000). A process drama thus allows for the experience of being in someone else's shoes. According to Viv Aitken (2013, p. 50) role-taking implies more than just being someone else for a while. The exploratory and immersive character of such learning processes include expressing one's own thoughts, formulating in writing, asking your own questions, and answering questions from others, and participating in a dialogue with other participants.

Shifra Schonman adds that being in role also requires the avoidance of stereotypes and learning to interpret the fiction of drama in imaginative ways. "When students act in drama, they are typically involved in learning new ways of thinking and doing things. The activity of moving in and out of the 'as if' role helps students gain an understanding of different levels of meaning in dramatic actions (Schonman, 2000, p. 951). The learning potential of drama is thus

the interplay between the actual and the fictitious world and the reflection about how the two worlds are related, sometimes mixed, and sometimes the differences blurred.

One important characteristic of process drama is the break with the distinction in classical theatre between actors and audience, which also is found in late-modern performance theatre. Participating in role-plays and process drama can exercise the ability to set one's own egocentric attitudes aside, and for a while identify with another role and its attitudes. To play a role also implies a change of perspective: 'Transformation of the persona gives us a new perspective on an event: We learn more about it and this changes our knowledge about it' (Courtney, 1990, p 14). According to Dorothy Heathcote (1985, p. 61), this requires 'suspension of disbelief'.

The International EU-supported project DICE (DICE Consortium, 2014) concluded that students who regularly participate in drama and theatre activities develop more empathy and are better capable of changing their perspective. They are better at both solving problems and dealing with stress. They are more likely to be key persons in the class. They show significantly more tolerance towards both minorities and foreigners, and they are more active as citizens, demonstrating more interest in elections and participating in public issues (DICE Consortium, 2014). These are important findings that nevertheless do not exclude the possibility of opposite tendencies. Participating in art-based processes gives no immunity against developing destructive thoughts (Allern, 1999, p. 197–202).

Gavin Bolton (2007, p. 53) shows that cultural and ethnic differences may create conflicts in drama, and that ideological and political interests of teachers and governments may influence drama work. He refers to Grady (2000), who warns against assuming that drama can do nothing but good, and he adheres to our warning that drama may be a part of destructive movements. Theatre can also be used as a tool for suppression – such as in British colonialism (Kerr, 1995), theatre in Nazi Germany (London, 2000) and the Nazis staging children's opera, cabaret and plays in Theresienstadt among other things (Landy & Montgomery 2012, p. xxv).

However, because the fiction points to a meaning beyond what is immediately explicit, drama and theatre provide openings for moral experiences, and may thus reveal our daily coldness and indifference towards others. Therefore, emotions play a more significant role in aesthetic experiences than in real life (Løgstrup, 1995, p. 49). Several of the students in the process drama *Out of Syria (*Allern & Drageset, 2017, p. 117) seem to have had such strong, emotionally engaging experiences, such as a boy who stated, 'It has made me share more with others because I want to give them the same joy that I receive'.

6.2 STRUCTURING PROCESS DRAMA IN THE TIM^2 METHODOLOGY

The idea of using drama to change the fear of mathematics and traditional teaching in mathematics is both related to exploring mathematics through drama and the need to change traditional teaching in math with teacher asking questions, students answering and teacher evaluating (Allern & Drageset, 2017).

In the process drama *The Outlaws*, referred to below, we apply a dialogical, epic dramaturgy using the convention Teacher-in-role (TIR): arranging the incidents in episodes, switching between acting and reflections on the acting, and with elements from classical and contrasting dramaturgies. There is often, however, a classical tendency in the dramaturgy, with its linearity of the progress of actions, but also a contrasting dramaturgy in creating change of perspectives and applying parallel actions.

Roles in the drama

The Australian drama practitioners and theorists, Brad Haseman and John O'Toole (2017, p. 3), argue that you do not need to be a skilled actor playing a role. We all play roles in our social lives, in the sociological sense of the word role, referring to the specialized capacity or function we have in our social lives (Goffman, 1986, p. 129) as fathers, mothers, teachers, artists, astronauts, trainers, drivers, etc. But this is not enough to describe the meaning of a role in drama. The roles in a play are a part of a relationship. Acting the role means to represent a viewpoint, and to represent viewpoint you do not use costumes or props or change your voice or create funny ways of walking.

To pretend to be a role is to identify with the values and attitudes defined to the role, and they might very well be quite different from your own values and attitudes. What you do when you play a role is to take on and experience a situation in another's shoes.

According to Viv Aitken (2013, p. 50) role-taking implies more than just being someone else for a while. The exploratory and immersive character of such learning processes include expressing one's own thoughts, formulating in writing, asking your own questions and answering questions from others, and participating in a dialogue with other participants.

We change roles as we interact with different people in different situations that can include activities in the imagined worlds of theatre, play, and drama. More significant than whether we are in role is whether participants assume that activities are happening solely in the everyday world. We may take on an imagined role, but we don't need fictional roles to create drama; what we must imagine is that we are elsewhere, in an imagined world. [i]

References

Aitken, V. (2013). *Dorothy Heathcote's mantle of the expert approach to teaching and learning: A brief introduction.* In Fraser, D., Aitken, V., & Whyte, B. (eds), Connecting Curriculum, Linking Learning. NZCER Press, 34–56.

Allern, T.-H. (1999). *Drama and aesthetic knowing in (late) modernity.* In Miller, C. & Saxton, J. (eds), Drama and Theatre in Education: International Conversations. IDIERI Publications, 196–203.

Allern, T.H. & Drageset, O. G. (2017). *Out of Syria: A process drama in mathematics with change of roles and perspectives.* In Applied Theatre Research, 5 (2), 113-127. Group Processes. Josiah Macy Jr. Foundation

Bolton, G. (2007), *A history of drama education: A search for substance.* In Bresler, L. (ed.), International Handbook of Research in Arts Education. Springer, 45–66.

Courtney, R. (1990). *Drama and intelligence : a cognitive theory.* McGill- Queen's University Press.

DICE Consortium (2014). *The DICE has been cast A DICE resource research findings and recommendations on educational theatre and drama.* DICE Consortium, http://www.dramanetwork.eu.

Goffman, E. (1986). *Frame Analysis. An Essay on the Organization of Experience.* Northeastern University Press.
Grady, S. (2000). Drama and diversity: a pluralistic perspective for educational drama. Heinemann.

Haseman, B. (1991). *Improvisation Process Drama and Dramatic Art.* In Drama Magazine, 19-21.

Haseman, B. & O'Toole, J. (2017). *Dramawise reimagined: learning to manage the elements of drama.* Currency Press.

Heathcote, D. (1985). *Subject or System? In Johnson, L. & O'Neill, C. (Eds.), Dorothy Heathcote. Collected Writings on Education and Drama (pp. 61-79).* Hutchinson. (Reprinted from 1984).

Kerr, D. (1995). *African Popular Theatre: From Pre-colonial Times to the Present Day.* James Currey.

Landy, R. & Montgomery, D. (2012). *Theatre for Change: Education, Social Action and Therapy.* Palgrave Macmillan.
London, J. (2000), *Theatre Under the Nazis.* Manchester University Press.

Løgstrup, K.E. (1995): *Kunst og erkendelse. Kunstfilosofiske betraktninger. Metafysikk II.* Gyldendal.

O'Neill, C. (1995). *Dramaworlds. A framework for process drama.* Heinemann.

Schonman, S. (2000): *Theatre and Drama Education: themes and questions.* In Ben-Peretz, M., Brown, S. & Moon,

B. (ed) (2000). *Routledge International Companion to Education.* Routledge

7. Role categories

7.1 THE USE OF ROLE CATEGORIES IN MATHEMATICS TEACHING AS A TOOL FOR DEVELOPING STUDENTS' MATHEMATICAL DISCUSSIONS

In mathematics teaching, communication and oral skills play a central role, as reflected in curricula worldwide. Developing a precise mathematical language through discussions, argumentation, and reasoning is an essential part of the students' learning process in mathematics. In order for pupils to learn to express themselves orally in mathematics, arrangements must be made for students to practice this at school, starting from the earliest grades. To support this work, using role categories in the classroom can be an effective tool. By assigning students specific roles during group work on mathematical problem solving, teachers can encourage more active participation and exploratory discussions among students, contributing to a deeper understanding of mathematical concepts (Røsseland et al., 2022).

The use of role categories is rooted in both drama pedagogy and positioning theory. Drama, known for its focus on roles and fiction, offers insights into how roles can be shaped and developed. Brad Haseman and John O'Toole (2017, p. 3), argue that you don't need to be a skilled actor to play a role. We all play roles in our social lives, in the sociological sense of the word "role," referring to the specialized capacity or function we have in our social lives (Goffman, 1986, p. 129).

In the TIM project (theatre in Mathematics), this understanding was used to develop specific role categories for mathematics teaching, with the aim of changing the classroom discourse. By integrating roles such as "curious," "skeptic," "democratic leader," and "initiator," students are encouraged to participate in various ways, and to develop an exploratory and argumentative classroom culture.

When individuals engage in interactions with others, they position themselves and others through speech, facial expressions, body language, and other forms of communication (Davies & Harré, 1990). Positions can be self-assigned or assigned to a participant by the others in the social interaction (Harré & van Langenhove, 1999). Positioning theory seeks to understand social phenomena by considering the positions and associated storylines that emerge through interaction with others (Drageset & Ell, 2023). In the TIM project, role categories are used to make students aware of the different positions that can occur in group work, as well as to provide them with experience in adopting and switching between these roles (Røsseland et al., 2022).

The various role categories are designed to promote specific forms of participation and discussion in the classroom. Each role has a unique function that contributes to the overall mathematical discourse.

- **Curious:** The role 'curious' involves ensuring that the whole group understands what is going on, that everyone keeps up and that things do not progress too quickly. 'The curious' asks questions not only to learn and understand but also to ensure that the entire group gets answers to what they are wondering about. Moreover, 'The Curious' also asks questions about the solution and methods to find out how the others in the group think. This role promotes an active and exploratory discussion, where students are encouraged to ask questions and seek explanations.

- **Skeptic:** In the role of 'skeptic', one must encourage the group to explore multiple ways and approaches to solve the task. The 'skeptic' must also carefully evaluate the solutions that come up and often double-check them. When assigned the role of 'the Skeptic,' one assumes the position of critic, seeking explanations, exploring alternatives, and being critical of whether the answer is correct (Barnes, 2004). By critically engaging with others' reasoning, the skeptic contributes to a deeper exploration of mathematical concepts and a more thorough understanding.

- **Democratic leader:** As the 'democratic leader', one is responsible for keeping the group focused on the task, supporting progress in the work, ensuring that all members are heard, and bringing everything together to achieve a common solution. The role also requires making decisions on behalf of the group. This involves elements of both being an expert and a facilitator, and ensures that all group members' voices are heard.

- **Initiator:** The initiator is responsible for starting the group work and supporting other members in getting started. This role helps keep the group engaged and on track throughout the work process. As an 'initiator', one engages in collaboration within the group and supports others, thus naturally assuming the position of a partner in the collaboration, which involves actively participating in discussion and working closely with others in the group (Barnes, 2004).

By using role categories as a structured tool in mathematics teaching, teachers can change the dynamics of classroom discourse. Previous research indicates that role categories can increase student participation and foster more exploratory discussions (Allern & Drageset, 2017; Allern et al., 2022; Røsseland et al., 2022; Tvedt et al., 2024).

For example, studies from the TIM project[5] have shown that students who take on the role of the Curious drive the discussion forward by asking questions that require explanations, evaluations, and arguments (Røsseland et al., 2022). This results in discussions that are more interactive and exploratory, which is essential for students' reasoning and learning outcomes.

7.2 POTENTIAL ADVANTAGES OF USING ROLE CATEGORIES

The use of role categories can offer several potential benefits in mathematics teaching:

- **Enhanced Focus and Accountability:** Assigning specific roles can help students stay focused on their tasks, as each student knows their responsibilities and contributions to the group. This can lead to more efficient and organized group work.

- **Increased student participation and balanced participation:** Role categories can promote collaboration by making students more aware of the different perspectives and skills that each member brings to the group. By giving students specific roles, the fear of making mistakes or being criticized can be reduced, potentially leading to increased activity and a greater willingness to express themselves more freely. With clearly defined roles, students may feel more confident in contributing to the group, as they understand their specific duties and the expectations tied to their role. By assigning roles, educators can ensure that all students participate equally in the activity, reducing the likelihood of some students dominating the conversation while others remain passive.

- **Improved communication:** Students develop a more precise mathematical language through discussions and argumentation, which in turn contributes to a deeper understanding of mathematical concepts and processes.

- **Enhanced problem-solving skills:** Students might learn to critically assess and evaluate different solutions, particularly by adopting the role of the skeptic and actively exploring various strategies, which can promote a culture where critical thinking and evaluation are highly valued.

- **Promoting exploratory conversations:** Classroom conversations have the potential to become more exploratory and collaborative, encouraging students to ask questions, challenge each other, and build on each other's ideas.

[5] http://old.theatreinmath.eu/wp-content/uploads/2022/10/4.-Counteracting-the-fear-of-mathematics-through-theatre.pdf and http://old.theatreinmath.eu/wp-content/uploads/2022/10/2.-Role-role-categories-and-role-aspects-in-using-process-drama.pdf

- **Establishing social and sociomathematical norms:** The use of role categories could help establish norms that promote long-term exploratory conversations and collaboration, potentially creating a classroom culture where students feel safe to share their thoughts and ideas.

By using role categories, teachers can create a classroom culture that enhances not only students' mathematical skills but also their critical thinking and collaboration abilities—skills that are valuable both academically and in lifelong learning. This structured approach helps students navigate complex mathematical discussions while building essential life skills, making mathematics more dynamic and engaging, and helping to alleviate the fear of the subject that many students experience.

Reference

Allern, T. H., & Drageset, O. G. (2017). *Out of Syria: A process drama in mathematics with change of roles and perspectives. Applied Theatre Research,* 5(2), 113-127. https://doi.org/10.1386/atr.5.2.113_1

Allern. T., Eriksson, S.A. & Drageset, O. G (2022). *Role, role categories and role aspects – in using process drama for learning processes in mathematics.* https://www.theatreinmath.eu/wp-content/uploads/2022/10/2.-Role-role-categories-and-role-aspects-in-using-process-drama.pdf

Barnes, M. (2004). *The use of positioning theory in studying student participation in collaborative learning activities. Social Positioning Theory as an Analytical Tool,* 1- 18. https://www.aare.edu.au/data/publications/2004/bar04684.pdf

Davies, B., & Harré, R. (1990). *Positioning: The discursive production of selves. Journal for Theory of Social Behaviour*, 20 (1), 43-63. https://sci-hub.se/10.1111/j.1468-5914.1990.tb00174.x

Drageset, O.G., & Ell, F. (2024). *Using positioning theory to think about mathematics classroom talk. Educational Studies in Mathematics,* 115, 353–385. https://doi.org/10.1007/s10649-023-10295-0

Goffman, E. (1986). *Frame Analysis. An Essay on the Organization of Experience.* Northeastern University Press.
Harré, R., & Langenhove, L. van. (1999). Positioning theory: moral contexts of intentional action. Blackwell.

Haseman, B. & O'Toole, J. (2017). *Dramawise Reimagined: Learning to Manage the Elements of Drama.* Currency Press Pty Ltd.

Røsseland, M., Drageset, O. G., Sjåstad, S., Cangemi, E., & Bertolini, M. (2022). *Using roles and positions to foster explorative talk in mathematics.* In Twelfth Congress of the European Society for Research in Mathematics Education (CERME12). https://hal.science/hal-03745677/document

Tvedt, E.E, Røsseland, M. & Drageset, O.G. (2024). *How being assigned the role of initiator influences a silent student's participation in a problem-solving group discussion.* Proceedings of NORMA 24: The tenth Nordic Conference on Mathematics Education, Copenhagen, 2024.

8. Monitoring and evaluation

The current chapter describes the procedure that is implemented to evaluate the hypothesized effect of the TIM^2 methodology on students' skills and participants' (teachers and students) satisfaction with the implemented activities.
Two different pilots are implemented to evaluate effectiveness of and users' satisfaction level with the TIM^2 methodology. Specifically, a main study is implemented with teachers and students attending fourth-grade classrooms; this study aims at evaluating the effect of TIM^2 methodology on students' 1) attitude towards math learning and 2) learning gains. An additional secondary study is conducted enrolling teachers and students of all grades of primary and low secondary schools to evaluate the impact of the TIM^2 methodology on participants' satisfaction with the educational activities.
The following sections give a detailed description of the two pilot studies mentioned, in terms of research design and measurement tools.

8.1 MAIN STUDY

This study focuses on the assessment of the impact of the TIM^2 methodology on students' attitude towards mathematics and Mathematical Literacy skills. Accordingly, the main research questions can be expressed as follow:

- *Does the TIM^2 methodology exert a positive effect on the way students approach math lessons (in terms of attitude towards mathematics and perceived self-efficacy)?*
- *Does the TIM^2 methodology exert a further positive effect on students' development of basic mathematical skills?*

In this regard, we hypothesize that participating in math lessons as designed by the TIM^2 methodology can reduce students' anxiety towards the subject and, also for this reason, facilitate the learning of content and skills related to mathematics.

8.1.1 RESEARCH DESIGN AND PARTICIPANTS

In order to answer the two research questions concerning the impact and effectiveness of the project methodology on students' outcomes, a pre-test/post-test between groups research design has been selected. Specifically, two educational conditions are compared in terms of students gains: 1) an intervention condition, where participating classrooms are asked to implement the TIM^2 activities during regular lessons and 2) a control condition, where classrooms cover their mathematics curriculum as usual. Measures of students' outcomes are administered to participants (both teachers and students) of both conditions before the beginning and after the end of the TIM^2 intervention.

For the aims of this pilot study, only students attending fourth-grade classrooms are selected with an average age of 9 years. This study recruits around students from the four country (i.e., Greece, Italy, Norway, Portugal) of participating consortium

partners. The classrooms are equally divided into the two educational conditions: the intervention condition (the TiM^2 methodology) versus a control condition (class as usual).

8.1.2 MEASURES

Below are the tests and questionnaires that are administered to students and teachers to evaluate the effect of the TIM^2 methodology.

ATTITUDE TOWARDS MATHEMATICS, ADMINISTERED TO STUDENTS:

In order to assess students' attitude towards math learning, a selection of questions from the Trends in International Mathematics And Science Study (TIMSS) 2019 Context Questionnaires[6] has been chosen (Mullis and Martin, 2017). Specifically, MS16 e MS19 questions of the section "Mathematics in School" of Student Questionnaire will be used. Section MS16 contains 9 items assessing students' attitude towards mathematics in terms of pleasure, interest, and engagement in attending classes or doing homework (e.g., "I enjoy learning mathematics", or "I like to solve mathematics problems"). Items are rated on a 4-point Likert-scale from 1 = Agree a lot to 4 = Disagree a lot; a total score can be derived summing the values indicated for each single item to obtain a measure of their overall attitude towards math learning. Greater scores indicate a more positive attitude toward the subject.
Section MS19 includes nine items that ask students to self-rate their perceived efficacy in math learning on a 4-point Likert scale ranging from 1 = Agree a lot to 4 = Disagree a lot. Example items are as follows: "I usually do well in mathematics" and "I am good at working out difficult mathematics problems". As for the previous section, a total score can be obtained summing all the items values with greater scores indicating higher perceived self-efficacy.

The questionnaires are administered before and after the TIM^2 intervention to children in both the educational conditions of the study.

MATHEMATICAL LITERACY, ADMINISTERED TO STUDENTS:

Two tests have been selected to assess students' learning gains on Mathematical Literacy skills, consisting each of 10 items. The 20 items are selected and adapted from the Trends in International Mathematics and Science Study (TIMSS) 2019 Mathematics Achievement items for 4-grade students. The TIMSS achievement items are designed and validated as indicators of three dimensions related to Mathematical Literacy: Knowledge, Applying, and Reasoning (Mullis and Martin, 2017).

[6] Available at the link: https://timssandpirls.bc.edu/timss2019/questionnaires/index.html

Accordingly, the two tests have been assembled for the purposes of the current study by selecting and adapting 10 items for each test — 5 for the Applying dimension and 5 for the Reasoning dimension — of comparable difficulty. Including items of similar difficulties, the two tests can thus be considered as two parallel forms of a test designed to measure the two fundamental dimensions of Mathematical Literacy: Applying and Reasoning, respectively. The items are scored dichotomously (0 = correct, 1 = incorrect), and the total number of correct responses, both by dimension and overall, serve as indicators of students' performance in Applying, Reasoning, and Mathematical Literacy skills, respectively.

One test is designed to be administered prior to the intervention, and the other upon its completion, to the children in both the educational conditions of the study.

SATISFACTION WITH THE INTERVENTION – ADMINISTERED TO TEACHERS AND STUDENTS:

Both students and teachers are asked to complete a questionnaire consisting of a number of items assessing their satisfaction with the TIM^2 methodology implementation in the classroom. Items of both the versions of the questionnaire (i.e., for teachers and students) were derived and adapted from the Intrinsic Motivation Inventory[7] (IMI; e.g., Markland and Hardy, 1997).
The teachers' version consists of 20 items rating participants' perceived competence, interest/enjoyment and value/usefulness of the experience on a 5-point Likert scale from 1 = totally disagree to 5 = totally agree. Example items are: "I would describe these activities as very interesting", "After working at these activities for a while, I felt pretty competent", and "I think these are important activities".
The students' form includes 8 items assessing interest/enjoyment and value/usefulness of the experience on a 5-point Likert scale from 1 = totally disagree to 5 = totally agree, e.g., "These activities were fun to do" and "I think that these activities are useful for math learning".

MATHEMATICAL LITERACY, ADMINISTERED TO TEACHERS:

The rating scale asks teachers to indicate the percentage of students of their classroom which manage the skill indicated by each item. Two specific dimensions of students' Mathematical Literacy are evaluated: Metacognition and Social Aspect. Following, the complete rating scale.

[7] https://selfdeterminationtheory.org/intrinsic-motivation-inventory/, last accessed in February, the 1st 2024

Metacognition	SKILL	0%-100%
Reconstructs one's own reasoning and identifies the essential steps of a process, describing it through different codes (verbally, with the body, with images, etc.).	Reasoning path reconstruction	
Identifies constraints (contextual, temporal, and resource-related) that influence performance.	Identification of external constraints	
Identifies internal factors (affective, motivational, cognitive) that influence performance	Identification of internal factors	
Recognizes errors in the process, and is able to correct them in the course of the work	On-going error detection and correction	
Monitors and evaluates one's own performance	Monitoring	
Recognizes and assesses possible alternatives to the procedure	Recognition alternatives	
Social aspects (collaboration)	**SKILL**	**0%-100%**
Puts oneself in the shoes of others by understanding their needs	Empathy	
Assumes respectful behaviour towards others and diversity	Respect for others	
Actively intervenes and cooperates with others in the pursuit of a common goal	Collaborative team spirit	
Handles criticism and takes the other person's point of view into consideration	Constructive handling of criticism	
Recognises and accepts different roles and rules	Recognition of roles and rules	

8.1.3 PROCEDURE

Before the beginning of the TIM^2 intervention, based on the project methodology, students and teachers enrolled in both the conditions (TIM^2 intervention vs control) are asked to complete the following measures (t0 evaluation session):

Students

- Questionnaire assessing attitude towards Mathematics
- Test assessing Mathematical Literacy (form 1)

Teachers

- Rating scale assessing students' Metacognition and Social Aspect (collaboration)

After the first assessment session, students enrolled in the intervention condition participate in the project activities; specifically, they participate in drama sections during their regular lessons according to the provided schedule. At the end of the drama-based intervention, students of both the conditions will undergo a second round of outcome evaluation.

Measures to be completed at this final evaluation session are as follows:

Students

- Questionnaire assessing attitude towards Mathematics
- Test assessing Mathematical Literacy (form 2)
- Questionnaire assessing satisfaction with the intervention

Teachers

- Rating scale assessing students' Metacognition and Social Aspect (collaboration)
- Questionnaire assessing satisfaction with the intervention.

8.2 SECONDARY STUDY

This secondary study is intended to assess the impact of the TIM^2 methodology in terms of students and teachers' experience and satisfaction with its use in the classroom. Essentially, the current study aims to address the following research question:

- *To what extent do students and teachers of all grades of primary and low secondary education value and perceive the TIM^2 methodology as effective for the teaching of mathematical topics?*

8.2.1 RESEARCH DESIGN AND PARTICIPANTS

To answer the research question, teachers and students of all grades of primary and low secondary education are enrolled in this secondary pilot study. Given the descriptive nature of the study (no specific hypotheses will be tested), the size of the sample was not identified in advance. As a consequence, the number of participants across nations and grades of

each educational level (primary vs. low secondary) and the total amount of collected data exclusively depend on the willingness of teachers (and therefore students), recruited during the teachers' training, to participate in the study. As for the main study, participation in the study is expected to be based on individuals' consent.
All participating teachers are required to implement a number of mathematical lessons according to the guidelines provided by the TiM^2 methodology.

8.2.2 MEASURES

Teachers and students participating in the current study are required to only complete a questionnaire evaluating their satisfaction with the intervention at the end of educational intervention. The questionnaires are the same as those used in the main pilot to evaluate participants' satisfaction:

Satisfaction with the intervention – teachers and students

The teachers' version consists of 20 items rating participants' perceived competence, interest/enjoyment and value/usefulness of the experience on a 5-point Likert scale from 1 = totally disagree to 5 = totally agree. Example items are: "I would describe these activities as very interesting", "After working at these activities for a while, I felt pretty competent", and "I think these are important activities".
The students' form includes 8 items assessing interest/enjoyment and value/usefulness of the experience on a 5-point Likert scale from 1 = totally disagree to 5 = totally agree, e.g., "These activities were fun to do" and "I think that these activities are useful for math learning".

8.2.3 PROCEDURE

With regard to the implementation of the TIM^2 methodology, teachers are not asked to follow a specific program; on the contrary, they are free to implement the methodology in the way that best suits their class needs, based on the specific educational needs of their class. This methodological choice was made in order to evaluate the TIM^2 approach in a way that reflects how it is most likely to be used in real classroom settings — that is, without strict constraints as in the case of the main pilot study.

8.3 FOCUS GROUPS AND/OR INTERVIEWS

A series of interviews and/or focus groups across the four participating countries are designed to be held after the end of the two main studies, as the most suitable method to gather in-depth insights from teachers, allowing for the exploration of their perceptions, experiences, and reflections on the educational methodology in a dynamic and interactive setting.

Reference

- Markland, D., & Hardy, L. (1997). On the factorial and construct validity of the Intrinsic Motivation Inventory: Conceptual and operational concerns. Research quarterly for exercise and sport, 68(1), 20-32.

- Mullis, I. V., & Martin, M. O. (2017). TIMSS 2019 Assessment Frameworks. International Association for the Evaluation of Educational Achievement. Herengracht 487, Amsterdam, 1017 BT, The Netherlands.