

# Upper secondary mathematics teachers' beliefs expressed through metaphors

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*This study investigates 10-12 grade mathematics teachers' beliefs about their roles as mathematics teachers through metaphors. These mathematics teachers' metaphors were analysed using the categorization developed in the context of NorBa-TM project. Most of these mathematics teachers described their teaching role as didactics experts. A closer investigation of these mathematics teachers' metaphors and their teaching experience revealed some variation although not statistically significant.*

*Keywords: Upper secondary education, mathematics, teachers' metaphors*

## Introduction

The study of mathematics teachers' beliefs and their influence on their teaching practices has gained considerable research attention. Research on teachers' thinking reveals that teachers hold coherent educational beliefs that shape their teaching practices (Handal, 2003; Thompson, 1992; Zhang & Morselli, 2016).

Metaphors offer insights into beliefs that are not obviously or consciously held (Oksanen & Hannula, 2012). A teachers' creation of a metaphor could be the result of his/her attempt to conceptualize his/her teaching. As Martinez, Sauleda and Huber (2001) state there is a need for a "shared system of interpretation and classification" of the metaphors teachers and prospective teachers hold, in order to communicate these metaphors and thus to develop them further.

Recent studies in mathematics education (Haser, Aslan & Celikdemir, 2015; Oksanen & Hannula, 2012; Oksanen, Portaankorva-Koivisto & Hannula, 2014) have used an extended version of the categories proposed by Beijaard, Verloop and Vermunt (2000) to investigate pre-service and in-service mathematics teachers' (grades 7-9) beliefs as expressed through their metaphors. The present study aims to explore whether the extended categories suggested by Löfström et al. (2010) can be used to describe and categorize Cypriot mathematics teachers' beliefs expressed through metaphors.

## Theoretical framework

### Mathematics teachers' beliefs

Teachers' mathematical beliefs refer to those belief systems that teachers hold regarding the teaching and learning of mathematics (Handal, 2003). These beliefs seem to be derived from personal experience, experience with schooling and instruction, and experience with formal knowledge (Zhang & Morselli, 2016).

Studies have shown that each teacher holds a specific belief system which consists of a range of beliefs about teachers, learners, teaching, learning, school settings, resources, knowledge and curriculum. The importance of them is that they act as a filter through which teachers make their decisions and they do not rely solely on their knowledge about pedagogy and curriculum (Handal, 2003).

### **Beliefs and metaphors**

An important trend on research regarding teachers' mathematical beliefs is the issue of teacher belief change (Zhang & Morselli, 2016). Researchers suggested a variety of methods and activities in order to investigate teachers' beliefs and also to support teachers reflect upon their experiences. One efficient way is through metaphors. Cooney et al. (1998) found that reflection played a significant role in prospective secondary teachers' growth. Researchers aiming to capture the meaning teachers ascribed to their educational experience, assessed preservice teachers' beliefs by collecting multiple data, including teachers' choice and responses to metaphors (e.g. a mathematics teacher is like an entertainer, a doctor, a gardener, a coach etc.).

### **Metaphors**

Metaphors provide a unique way to represent the world by helping people frame the meaning of their experiences (Kasten, 1997; Zhao, Coombs & Zhou, 2010). As Martinez et al. (2001) state, metaphors are not just "figures of speech" but compose an important mechanism of the mind. The word "metaphor" is derived from the Greek word 'metaphora' (transfer) (Kasten, 1997). Metaphors refer to the understanding of one kind of object or experience in terms of a different kind of object or experience which is more familiar, concrete or visible (Lakoff & Johnson, 1980; Zhao et al., 2010). As Lakoff and Johnson (1980) emphasized, a major part of the human conceptual system is structured by metaphorical relations, which are rich and complex.

In educational settings, educators are "unconsciously guided by images and metaphorical patterns of thought as recurring in the field, which can be seen as "archetypes" of professional knowledge" (Martinez et al., 2001, p. 966). In this way, metaphors reflect teachers' understanding of teaching and learning which is difficult to access in a verbatim language providing a deeper and more profound insight into teachers' beliefs and affect in relation to their teaching and the wider social context (Zhao et al., 2010). Teachers' beliefs about teaching and learning are associated with teaching roles and in this way metaphors are used to encapsulate the teaching roles (Kasten, 1997). A metaphor is characterized as "blueprints" of professional thinking (Martinez et al., 2001).

### **Categories of metaphors**

Löfström et al. (2010) investigated university students' metaphors in Estonia using the Beijaard et al. (2000) model of teacher identity. This initial model identifies three distinct knowledge bases of teacher knowledge reflecting teachers' professional identity. According to the model, teachers' professional identity can be described in terms of the teacher as a *subject matter expert*, the teacher as a *pedagogical expert* and the teacher as a *didactics expert*. The results of the study indicated that the categories suggested by Beijaard and colleagues could be expanded to include three additional categories. *Self-referential metaphors*, *contextual metaphors* and *hybrids*. A description of each

category of this extended model of teacher identity follows: (a) A teacher as a *subject matter expert*: The teacher has a deep and full understanding of his/her subject area and is a transmitter of knowledge to the students. (b) A teacher as a *pedagogical expert*: The teacher is someone who supports the child's development as a human being. Emphasis is on relationships, values, and the moral and emotional aspects of children development. (c) A *teacher as a didactics expert*: The teacher has knowledge about how to teach specific subject-related content so that students can capitalise on their learning. This kind of knowledge is referred to as knowledge of didactics, and it is discipline- and subject specific in nature. (d) *Self-referential metaphors*: Self-referential metaphors do not refer to acts central to teaching, students or classroom instruction. These metaphors focus on what teaching represents for the respondents as individuals. They describe features or characteristics of the teacher's personality, with reference to the teacher's characteristics (self-referential) without reference to the role or task of the teacher. One might say that these metaphors describe who the teacher is. (e) *Contextual metaphors*: These metaphors describe features or characteristics of the teacher's work/work environment or in other ways refer to characteristics of the environment (contextual). (f) *Hybrids* may include elements of more than one of the above categories.

The above categorization was employed in recent studies investigating teachers' beliefs through metaphors. Specifically, Oksanen and Hannula (2013) used this categorization to investigate 70 Finnish 7-9 grade mathematics teachers' beliefs regarding teaching and teachers as expressed through metaphors. The results revealed that the teacher as a didactics expert was the most frequently used metaphor (49%). The results showed no statistical significant associations between metaphors and age or gender. In the study by Oksanen et al. (2014) including 72 Finish pre-service teachers and 65 Finish in-service (grade 7-9) mathematics teachers, the most common metaphor used by pre-service teachers was self-referential (46%) while the most frequently used metaphor by in-service teachers despite their teaching experience was the category didactics expert (51%). The researchers explained that as in-service teachers gain more teaching experience, this does not affect the metaphor they use to describe their mathematics teachers' role. Finally, in the study by Haser et al. (2015) with 249 Turkish pre-service students, 29.6% used didactic expert metaphor while 26.5% used self-referential metaphors to express their beliefs.

The purpose of the current study was to explore if the categories proposed by L fstr m et al. (2010) can be used to categorize upper secondary school teachers' beliefs expressed through metaphors in Cyprus and whether the categories proposed are exhaustive enough to cover all metaphors.

## **Context**

According to the Annual Report of the Cyprus Ministry of Education and Culture (2014) the Public Secondary General Education in Cyprus is offered to students between the ages of 12 - 18, through two three-year levels - the Gymnasium (Grades 7-9) and the Lyceum (Eniaio Lykeio)(Grades 10-12). The curriculum includes common core subjects, such as Modern Greek and Mathematics and Optional Subjects. Some subjects are interdisciplinary such as Health Education and Environmental Studies. In the academic year 2000 - 2001, the institution of the Eniaio Lykeio was introduced in all public secondary schools in Cyprus. All subjects in Grade 10 are common core subjects. In Grades 11 and 12 students attend common core subjects and at the same time select optional subjects for

systematic and in depth study. In Cyprus there are 38 Lycea and 7 joined Gymnasia and Lycea. Approximately 280 mathematics teachers work in Lycea. These mathematics teachers are also responsible for the preparation of students for their entrance exams in the public University of Cyprus and the public universities in Greece.

## **Methodology**

### **Data collection, instruments and participants**

Data for this study was gathered from mathematics teachers working in Lyceum (Eniaio Lykeio) during the school year 2015-2016. The study was conducted in the context of the international comparative study New Open Research: Beliefs about Teaching Mathematics (NorBa-TM) investigating mathematics teachers' beliefs in more than 15 countries.

A questionnaire was developed and culturally adapted in the participating countries in the context of the project NorBA-TM. The questionnaire comprised of seven parts: one of them qualitative and six quantitative (86 items). The current study used data only from two parts of the aforementioned questionnaire: Part A, that collected data on teachers' background variables (age, gender, education, teaching experience, teaching maths at Lyceum etc.) and Part H that collected data on metaphors. Specifically, Part H included two questions that invited the teachers to think and write down a metaphor characterising themselves as upper secondary level mathematics teachers and to explain their metaphor: "As a mathematics teacher I am like....." and "My brief explanation of the metaphor is as follows:....". We assume that the metaphor research is a useful social science methodology that can be used for generating authentic case study evidence in mathematics teaching.

Data collection took place in June 2015. First, informative letters along with the questionnaire and prepaid envelopes were sent to mathematics teachers in all Lyceums inviting them to participate in the study on a voluntary basis. Teachers who wished to participate in the study completed the questionnaire and returned it to the Cyprus Pedagogical Institute without disclosing their personal data (name and school). A total of 147 out of 280 (53%) mathematics teachers completed and returned the questionnaire. Out of these 147, only 49 (33%) completed Part H by presenting a metaphor and providing an explanation.

The metaphors and the explanations provided formed jointly the unit of analysis. Data analysis was performed using the categorization of L fstr m et al. (2011) which was explained in detail in the manual developed for the NorBa project. The metaphor categorization was judged on a case-to-case basis using three independent raters whose coding was compared at the end. The raters compared their codes and discussed their differences. In the majority of cases, agreement between the three raters could be reached. In three cases though, consensus between raters was not reached and external researchers with experience in mathematics teachers' metaphors were involved.

## **Results**

### **Categorizing teachers' metaphors**

The distribution of metaphors used by the Cyprus in-service mathematics teachers is presented in Table 1.

Teacher as a subject matter expert	Teacher as didactics expert	Teacher as Pedagogical expert	Self-referential	Contextual	Hybrid
8 (16,3%)	12 (24,5%)	6 (12,2%)	9 (18,4%)	7 (14,3%)	7(14,3%)

**Table 1: Distribution of metaphors used by Cypriot mathematics teachers**

Teacher as didactics expert was the most common metaphor used (24,5%). Mathematics teachers in this category used metaphors like “a coach”, “a builder”, “an electrical wire”, “a gardener”, “a playmate, play-maker”. In their explanations, teachers referred to their role as facilitators of students’ learning process, as mediators between students and the discovery of the new mathematical knowledge, as contributors to the construction of the new mathematical ideas. They referred to the communication of ideas and the team spirit, emphasizing a more constructivist view of learning and teaching. They made also reference to the active role of the students in the learning process.

As a mathematics teacher I’m like a playmate in a team game that usually has the role of the play-maker. I’m trying to arrange the learning activities because we function as a team with a preset schedule of the game. I encourage initiatives but I control for the application of certain rules.

Self-referential was the second most common metaphor used (18,4%). Mathematics teachers in this category used metaphors like “a painter”, “a musician”, “a hard-working bee”, “a perfect circle”, “an angle”. In their explanations these teachers refer to their individual characteristics and their personality traits without reference to the role or task of the teacher.

As a mathematics teacher I’m like an angle. Sometimes acute, sometimes obtuse, sometimes convex and sometimes non-curved.

Teacher as Subject matter expert was used by 16,3% of the teachers. Mathematics teachers in this category used metaphors like “a machine of knowledge”, “a guide in a journey”, “a vocation backpack”, “a well of knowledge”. In their explanations these teachers refer to their teaching role as transmitters of ready-made knowledge to the students and organizers of routines. Mathematical knowledge is conceived as a determined procedure by the teacher.

As a mathematics teacher I’m like a well of knowledge. When I’m in class I find ways and examples to transmit the mathematical knowledge to students.

A percentage of 14,3% of the teachers provided metaphors that fell within the category Contextual. Mathematics teachers in this category used metaphors like “an actor”, “a salesman”, “the guy for every job”. In their explanations these teachers refer to the characteristics of the teachers’ work, or the characteristics of the environment the teacher works stressing that it is too demanding and multifunctional. They refer to the teacher in a social context but they do not refer to any specific aspect of the teachers’ professional knowledge or teaching.

As a mathematics teacher I'm like a guy for every job. Mathematics teachers are like ping pong balls. They are involved in many tasks and processes in the school setting but these efforts do not lead to something recognizable or efficient.

A percentage of 14,3% of the teachers provided metaphors that fell in more than one category thus they were categorized as Hybrid. Most of the metaphors in this category include the didactics expert's characteristics along with another category. The following metaphor was categorized as both didactics expert and contextual metaphor.

As a mathematics teacher I'm like a director who writes a movie and participates in it. As a mathematics teacher I design the teaching of a lesson, I decide for the way to implement it in different faces and last like as an actor I perform different roles.

Finally, 12,2% of the teachers provided a metaphor that fell in the category teacher as pedagogical expert. Mathematics teachers in this category used metaphors like "a parent", "a mother", "an eagle", "a priest". In their explanations these teachers emphasized the values, the moral and emotional aspects of students' development. They reveal a more affectional relationship and communication with the students.

As a mathematics teacher I'm like a spiritual father (e.g. a priest). I believe that my main goal is to advice students that with hard work, healthy competition and honesty they can be better in mathematics and in society. Just by hard work.

### Metaphors and background characteristics

No statistically significant differences were detected between gender, teaching experience and metaphors. Table 2 presents the distribution of metaphor used according to teaching experience.

Teaching experience	n	Subject-matter expert	Didactics expert	Pedagogical expert	Self-referential	Contextual	Hybrid
0-10	9	2 (22.2%)	2 (22.2%)	3 (33.3%)	1 (11,1%)	0 (0%)	1(11.1%)
11-20	26	2 (7.6%)	9 (34.6%)	3 (11.5%)	4 (15.3%)	5 (19.2%)	3 (14.2%)
21 and more	14	4 (28.5%)	1(7.1%)	0 (0%)	4 (28.5%)	2 (14.2%)	3 (21.4%)

**Table 2: Teaching experience and categories of metaphors**

As it can be observed, the most common category for teachers with the least years of experience is the teacher as pedagogical expert. The most common metaphor category for the second group of teachers is the teacher as a didactics expert. For the group of mathematics teachers with 21 years of experience and over, the most common categories are teacher as subject matter expert and self-referential metaphors. Contextual and hybrid categories are most frequently met in teachers with more years of teaching experience than those with 0-10 years of experience.

### Discussion

The results revealed that the categories proposed by Löfström et al. (2010) can be applied to classify the metaphors provided by the in-service Cypriot mathematics teachers in upper secondary

education (Grades 10-12) and that these categories were collectively exhaustive. The results showed that these teachers prioritize *didactics knowledge, self-reference and subject matter metaphors*. In particular, the findings showed that the teacher as didactics expert was the most common metaphor provided. This finding is in line with the results of other similar studies (Oksanen & Hannula, 2013; Oksanen et al., 2014) which reported that this category was the most common among mathematics teachers teaching Grades 7-9. However, in the current study the percentage of teachers who used metaphors which described them as didactics expert (24.5%) was not as high as in the other two studies (46% and 51% respectively). Self-referential metaphors were also used by participants of the current study (18.4%). This percentage is higher than the percentages reported by the other studies in the literature, which state that this category reflects the multi-functionality of teachers' role (Oksanen & Hannula, 2013; Oksanen et al., 2014). The emergence of hybrid metaphors has been explained in other studies (Oksanen & Hannula, 2013; Oksanen et al., 2014) by the complexity of a teachers' job.

The investigation of these teachers' metaphors in relation to their teaching experience revealed no statistically significant differences similar to the results of the study by Oksanen et al. (2014). In that study the researchers described that the most common metaphor for all groups of teachers was the teacher as didactics expert. In the current study, pedagogical expert and didactics expert were the most common metaphors for the group of mathematics teachers with the least years of experience, didactics expert was the most common metaphor for the group of teachers with 11-20 years of experience and subject matter expert and self-referential were the most common metaphors for the group with 21 and more years of experience. However, these relationships were not statistically significant. Modifications in mathematics education at the university level, as well as modifications in the work context related to the Cyprus Educational Reform of 2011 could be associated with these groups of teachers' perceptions about their roles as teachers of mathematics.

The results indicated that the categories suggested by Löfström et al. (2010) are useful and can be used to categorize teachers' metaphors. These teachers' metaphors mapped their similes of current practice and understanding of teaching and learning and revealed what they are and how they feel about their work (Zhao et al., 2010). But how stable are these imageries provided? Will these teachers provide the same metaphor if they are asked again under different conditions, working in different school with other students or if they are under the pressure of their students' entrance exams or at the end of a stressful day? How the methodology used could be developed to include teachers' current state? Further studies investigating the stability of these metaphors are needed. Moreover, further studies could investigate the relation between mathematics teachers' beliefs and mathematics teachers' use of metaphors.

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