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## **Cultural values and prospective teachers' beliefs about success in mathematics and in its teaching**

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## **Cultural values and prospective teachers' beliefs about success in mathematics and in its teaching**

International literature is increasingly disclosing the relevance of cultural aspects within the processes of teaching and learning mathematics. Knowledge is inextricably linked to the activities in which the subjects engage, and must be considered in relation to the socio-cultural context wherein the activity takes place. Literature reveals the relationship between the background culture (e.g., language, nationality, etc.) of prospective elementary teachers and their beliefs about mathematics and its teaching. In this paper, we define culture with reference to the wider discussion from cross-cultural psychology literature about cultural values, and we investigate if and how differences in individuals' cultural values are related to prospective teachers' beliefs about being successful in mathematics and in its teaching. We adopt a questionnaire from the studies by Schwartz to measure participants' values. We assign each prospective teacher of our sample to a cluster of beliefs and we analyse how the beliefs of prospective teachers are related to their values. Results show that cultural values and beliefs about mathematics are related, while this is not the case for beliefs about the teaching of this subject.

Keywords: teachers' beliefs; cultural values; prospective teachers; cluster analysis; cultural aspects.

### **Rationale**

International literature is increasingly disclosing the relevance of cultural aspects within the mathematics teaching and learning processes (e.g., Presmeg, 2007). As Bruner (1996) points out, culture shapes the minds of human beings and provides them with the tools to construct not only 'their own' world, but also 'their own' conceptions of themselves and their powers. Therefore, culture should be considered as one of the main factors influencing the way people think about what is moral, what is legal, what is 'best' for the community and for individuals, and how a person should feel in certain circumstances.

According to Andrews (2010), cultural aspects permeate all the aspects of the educational milieu and cover an important and explicit role in the field. As is widely shown in the literature, within the process of teaching and learning mathematics, a further fundamental role is covered by teachers' beliefs (Philipp, 2007; Hannula, 2012). It is therefore of strong interest to analyse the link between beliefs and cultural factors. Mathematics teachers' beliefs influence their own classroom practice and their students' mathematical learning (Eichler & Erens, 2015; Skott, 2015). Studies in mathematics education in the field of beliefs have focused on the close connection with cultural aspects (Fives & Buehl, 2012) and there is a broad consensus on the extent to which teachers' beliefs are interrelated with the social, cultural, political, and historical context wherein teachers live (Skott, 2015). As underlined in the literature, teachers' beliefs seem to be strongly linked to the socio-cultural context in which they teach (Hofstede, 1986). Although most research emphasises the more marked differences between Eastern and Western cultures, some studies highlighted that even a seemingly homogenous cultural region may comprise cultural differences that are apparent in teacher' beliefs (e.g., Romijn et al., 2020). Some studies have refined their investigations by highlighting, for example, the difference in beliefs about mathematics between some European countries (Felbrich et al., 2012, Vieluf et al. 2013).

In a previous work (Eichler et al., 2021) we investigated how cultural influences are visible in prospective teachers' beliefs. To investigate this impact, we administered a questionnaire to Italian prospective teachers, German prospective teachers, and a small group of Italian prospective teachers who speak German as their native language. One main aim of the questionnaire was to investigate beliefs about being successful in mathematics learning and teaching. In the aforementioned work, we found differences in beliefs of mathematics prospective teachers belonging to nearby countries with

different cultures but we were assuming culture as defined by language. However, identification of culture with nation or language may be criticised (see section 2.1). For this reason, in this paper we present a new study that is carried out with Italian and German prospective teachers. We measure the teachers' beliefs and cultural values as proposed by Schwartz (1992). In particular, the present study aims to investigate possible connections between the cultural values of prospective teachers and their beliefs about success in mathematics and in teaching. Although our main purpose is not to emphasise the cultural differences of the countries of the participants, we consider it relevant to check any existing difference as a basis for further analysis, as shown in the following sections.

## **2. Theoretical framework**

### ***2.1. Culture and cultural values***

Before commenting on the role of culture, we need to first clarify what we mean by the word 'culture'. Indeed, culture is a very broad term that is used, roughly speaking, in any situation in which we refer neither to universal traits nor to idiosyncratic traits (Wallerstein, 1990).

In the educational field, one of the most influential works about culture was produced by Hofstede (1986) who refers to cultural differences from a global perspective, including the effect of high or low individualism that divides, for example, Western Europe from Eastern Asian countries. Hofstede identifies 'national cultures', referring to them as "the collective programming of the mind which distinguishes the members of one group or category of people from another" (Hofstede 1991, p. 5). The identification of culture with nationality has been widely criticised by other scholars from different research fields (e.g., McSweeney, 2002; Signorini et al., 2009). While we

recognise that the institutional organisations of a country/society may certainly play an important role in shaping culture, we also believe that in the modern world (in which borders are more and more permeable) it appears unreasonable to assume the binomial nation-culture. However, in educational research it is very common to see results of international comparative studies (often between Eastern and Western countries) interpreted in terms of culture (Signorini et al., 2009).

In our previous studies about prospective teachers' beliefs (e.g., Eichler et al., 2021), we compared linguistic groups (within and between two countries) conceiving language as “the vehicle of culture” (Hofstede, 1986, p. 314). Indeed, language (for instance, the available pronouns) may have important effects on our conceptualisation of general cultural values such as the centrality of self versus other (Kashima & Kashima, 1998), which may also affect our vision of mathematics (Barton, 2008).

In this study, we refine our framework by adopting the perspective of Schwartz (1992; 2011). According to him, “Culture itself is a latent variable measurable only through its manifestations” (Schwartz, 2011, p. 470). Cultural values (values shared by an entire culture) are goals that derive from the needs that societies must address in order to survive. Cultural values do not coincide with the individuals' basic values but

[t]he value orientations that are the central aspect of societal culture in my theory influence the minds of individual people [...]. To rephrase Hofstede's metaphor, culture is the 'programmer' of the mind, not its programming. By virtue of living in particular social systems, individuals experience the normative value emphases of their society's culture as a press to which they are exposed, a press that influences their attitudes, beliefs, behavior, and thought. [...] Most individuals develop, adopt, and/or internalize modes of thinking, behaviors, attitudes, and personal value priorities that enable them to function effectively and feel comfortable in the societal contexts to which they are exposed (Schwartz, 2011, p. 470).

Basic values are defined as trans-situational goals, varying in importance, which serve as guiding principles in the life of a person (Klassen et al., 2010; Schwartz, 2011). Thus, these values are expressions in relation to self. Evidence from several analyses suggests that the basic individual values identified by Schwartz (see Figure 1) can be considered to be near-universal values (Schwartz, 2011). As shown by several studies in the field of cross-cultural psychology, such values “form a continuum of related motivations that allows generating systematic, integrative hypotheses that link multiple values to other variables, such as behaviors, attitudes, emotions, or stable individual variables” (Knafo et al., 2011, p.181). Schwartz (2011, p. 45) suggested higher order values including types of values that structure the motivational continuum reproduced in Figure 1.

In this continuum, people may show differences in their cultural values. Schwartz (2011) suggests that Self-enhancement values (power, achievement) encourage and legitimise the pursuit of one’s own interests, as opposed to Self-transcendence values (universalism, benevolence) which emphasise concern for the welfare of others. Openness values (self-direction, stimulation) welcome change and encourage pursuit of new ideas and experiences opposed to Conservation values (security, tradition, conformity).

Starting from the premise that seemingly homogenous cultural regions may comprise cultural differences apparent in a teacher’s cultural values and beliefs, the present contribution better specifies cultural differences concerning teachers’ beliefs towards mathematics and the teaching of mathematics that we already observed (Eichler et al., 2021) in two nearby countries, namely Italy and Germany.

## ***2.2. Beliefs and culture***

There is a wide consensus in educational research that it is almost impossible to define teachers’ beliefs consistently (e.g., Fives & Buehl, 2012; Leder, 2019; Schoen &



LaVenia, 2019). However, it is possible to provide a specific understanding of teachers' beliefs, and apply this understanding to the body of research on teachers' beliefs (Fives & Buehl, 2012; Hannula, 2012). We understand beliefs as "psychologically held [...] propositions about the world that are thought to be true" (Philipp, 2007, p. 259).

Following Pajares (1992) and in line with Eichler and Erens (2015), we consider beliefs to be propositions about a specific topic which affect the ways of receiving information about said topic and of acting in a specific situation.

Topics on which teachers hold beliefs are described by Fives and Buehl (2012, p.472): "(a) self, (b) context or environment, (c) content or knowledge, (d) specific teaching practices, (e) teaching approach, and (f) students". The latter topic includes teachers' beliefs about students' thinking (e.g., Philipp, 2007), but also general beliefs about the acquisition of mathematics knowledge (Muis, 2004) or giftedness (e.g., Pitta-Pantazi et al., 2011). Furthermore, teachers' beliefs about the teaching approach also comprises beliefs "about a holistic approach to teaching such as [...] developmentally appropriate practices" (Fives & Buehl, 2012, p. 472).

The importance of researching mathematics teachers' beliefs is often stated (e.g., Calerhead, 1996; Hannula et al., 2016). One reason for this significance is the way beliefs act as a filter for both receiving information and acting (mathematically) in a specific situation (Fives & Buehl, 2012; Pajares, 1992). Beliefs acting as a filter for information also influence the learning and teaching of mathematics (Pajares, 1992; Törner, 2002) and thus potentially influence the results of a university programme for teacher education. Furthermore, teachers' beliefs are of importance because they seem to influence their teaching practices (Chan & Elliot, 2004; Vesga-Bravo et al., 2021). Although research also yielded ambiguous results referring to the relationship between

mathematics teachers' beliefs and their classroom practice, Skott (2015, p. 22) concluded that teachers' beliefs are "the default explanation for classroom practice".

Generally speaking, the institutional and societal context in which teaching and learning take place (the 'noosphere', in the sense of Chevallard 1990) may play a key role in shaping students' and teachers' beliefs about mathematics. We can agree with the several scholars who noticed how "teachers' understanding of teaching, learning, children, and the subject matter" (Calderhead, 1996, p. 709) is interrelated with a teacher's cultural background (Felbrich et al., 2012; Halse & Baumgart, 2000; Hofstede, 1986; Romijn et al., 2020). For example, Klassen et al. (2010) found differences between Eastern countries (Korea) and Western countries (the US, Canada) regarding beliefs about their job in terms of satisfaction and stress: teachers from the US and Canada rated items about these beliefs systematically higher than Korean teachers. Vieluf et al. (2013) observed that teachers from collectivist countries tend to show less strong beliefs about their own capabilities of teaching than teachers from individualistic countries. In addition, their study showed differences between countries in northern Europe (higher levels of beliefs about their own capabilities of teaching) and southern Europe (lower levels of beliefs about their own capabilities of teaching). Felbrich et al. (2012) found that teachers in collectivist countries view beliefs about mathematics as being a static body of established knowledge whereas teachers in individualistic countries view the same beliefs as a process of developing a science. Shin and Koh (2007) found that American teachers tended to have stronger beliefs about controlling the instructional management as well as their students' learning processes in comparison to Korean teachers. From these studies, Klassen et al. (2010) defined culture not only in terms of nationality/place of birth, but also by measuring cultural

values, namely, collectivistic values. Similarly, Felbrich et al. (2012) used an individualism scale for measuring a cultural variable.

### **3. Previous findings and research question**

In recent studies (Eichler et al., 2021), we studied German and Italian prospective teachers' beliefs. We investigated the prospective teachers' beliefs about people's characteristics that are important for learning mathematics in terms of being successful in the subject and that are important for teaching mathematics in terms of being successful as a mathematics teacher. The measurement was based on multiple-answer questions taken from the study presented by Maffia et al. (2020). The prospective teachers were asked to select the three most important characteristics for successfully learning mathematics, or for successfully teaching mathematics, from a list of 12 characteristics (Table 1).

The answer-options for the beliefs about mathematics (question B2) were designed according to the model of mathematical giftedness (Pitta-Pantazi et al., 2011). In this model, mathematical ability is an expression of Creativity and Learned Abilities. Both Learned Abilities and Creativity are enhanced by Natural Abilities. In addition, three options were added to include the affective dimension (options E, F, and I in Table 1), which is deeply connected with beliefs (Hannula, 2012). The answer options to features that are important for being a "good" teacher of mathematics (question B4 in Table 1) followed the model of the so-called 'knowledge quartet' by Rowland and colleagues (2005). The 'knowledge quartet' is a framework – originating from a research study aimed at investigating the mathematics content knowledge of pre-service primary teachers and the ways that this knowledge becomes visible in their planning – used for describing knowledge and beliefs highlighted in mathematics teaching, categorising events in mathematics lessons with particular reference to the subject

matter being taught and the mathematics-related knowledge that teachers call upon. According to this model, actions made by mathematics teachers can be grouped into four macro-categories: *Foundation*, *Transformation*, *Connection*, and *Contingency*. In the ‘Foundation’ category there are trainees’ knowledge, beliefs, and understanding acquired during university studies, in preparation (intentionally or otherwise) for their role in the classroom. ‘Transformation’ concerns knowledge-in-action as demonstrated both in preparing to teach and in the act of teaching itself. ‘Connection’ binds together certain choices and decisions that are made regarding optional mathematical content, and it concerns the coherence of the planning or teaching displayed across an episode, lesson or series of lessons. ‘Contingency’ concerns classroom events that are almost impossible to plan for, calling for a readiness to respond to children’s ideas and a consequent willingness, when appropriate, to deviate from a lesson plan (in Table 1 the sub-categories are connected to the provided answer-options).

The answers of the teachers in our previous study (Eichler et al., 2021) were analysed using a cluster method. We observed that some of the obtained clusters were formed by a prevalence of Italian speakers, while others were composed mainly of German speakers. We therefore inferred that culture may be interrelated with prospective teachers’ beliefs about mathematics and its teaching. However, the identification of culture with language has been questioned and here we develop our analysis by adopting a different approach in defining culture by means of individuals’ basic values. Based on our previous research, we investigated the interrelation between teachers’ beliefs and culture from the perspective of teachers’ beliefs. Thus, the main research question investigated in this paper is: What differences in individuals’ cultural values can we observe in the clusters determined by prospective teachers’ beliefs about mathematics and its teaching?

#### **4. Methods**

The sample consisted of 112 German prospective teachers, who were enrolled in a mathematics course at the University of Kassel, and 112 Italian prospective teachers. From the Italian group, 104 teachers were enrolled in a mathematics course at the University of Bologna while 8 teachers were enrolled at the University of Bozen-Bolzano.

The prospective teachers completed an online questionnaire that included items, (among others) referring to cultural values. To measure cultural values, we used the questionnaire by Schwartz (2011), consisting of 43 items. We also used the original scale proposed by Schwartz (2011), comprising of a Likert-like scale from 0 (neutral to a value) to 7 (full agreement with a value). A further answer option expresses a refusal of the value (disagreement with the value). In this paper, we explicitly follow the work of Schwartz (2011) when modelling the cultural values. Based on his empirical study, Schwartz assigned 43 items to so-called types of values (Figure 1): self-direction (5 items), stimulation (3 items), achievement (4 items), power (4 items), security (5 items), conformity (4 items), tradition (5 items), benevolence (5 items), and universalism (8 items). Furthermore, Schwartz proposed so-called higher order types of cultural values that combine two or three types of individual basic values (Figure 1). In our study, we used these higher order types of cultural values: Self-transcendence (benevolence and universalism), Conservation (tradition, conformity, and security), Self-enhancement (power and achievement) and Openness (self-direction and stimulation).

The items concerning cultural values were translated from English into German and Italian, and the translation was checked by a native speaker. For the higher order types, we computed the reliability of the related scales as shown in Table 2. Due to the

high reliability detected, we used the sums and means for these four scales for the subsequent analyses.

We analysed prospective teachers' beliefs about successfully learning and teaching mathematics through cluster analysis, as already performed in our previous research (Eichler et al., 2021; Maffia et al., 2020). Thus, the prospective teachers were asked to select the three most important features for being successful in mathematics learning (question B 2) or for successfully teaching mathematics (question B4) out of 12 features (Tab. 1). Afterwards, every teacher of the sample in this research study was assigned to a cluster of beliefs using an agglomerative hierarchical algorithm; the number of clusters was chosen to minimise the absolute maximum deviation from the median of the number of participants per cluster (Maffia et al., 2020). As noted in the previous sections, beliefs about success in mathematics may differ from those about success in the teaching of the subject, so two different clustering methods were implemented for the two sets of beliefs.

For the principal analysis, we investigated the relations of the independent variable (clusters of beliefs) with the four higher order types of values, with a MANOVA with one factor (Field et al., 2012). For both clusters of beliefs (beliefs about being successful in mathematics and beliefs about being successful in teaching mathematics), we proved the prerequisites for a MANOVA (Field et al., 2012).

Referring to both clusters of beliefs (about mathematics learning and mathematics teaching):

- we found one outlier concerning clusters of beliefs about being a successful mathematics teacher and 'Self-enhancement' as higher order types of values. We kept this case in our analysis.

- Concerning ten clusters of beliefs about mathematics and four higher order types, we found three violations of normality while, referring to seven clusters of beliefs about mathematics teaching and four higher order types, we identified four violations of normality. Referring to the clusters of beliefs about success in mathematics teaching, violations of normality are concentrated within 'Self-transcendence' as a higher order type of values. However, following Finch (2005), who found a MANOVA to be robust against violations of normality (Shapiro-Wilk test), we did not change the method.

- We found the correlations between dependent variables to be below  $r < .70$ , indicating that multicollinearity was not a confounding factor in the analysis.

- We found no multivariate outliers (assessed by the Mahalanobis distance,  $p > .05$ ).

In running the MANOVA, we excluded cases who rated one item in the four higher order types of values with -1 (refusal of a value).

We further used an ANOVA and pairwise tests as post-hoc tests for a differentiated analysis of our data. Referring to the analysis concerning beliefs about mathematics, we used a Games-Howell test, since the covariance matrices (Box-test) are significantly different. Referring to the analysis concerning the beliefs about mathematics teaching, we used a Tukey test exploratory study.

## **5. Results**

Considering the four higher order types of values, we can observe that there is no significant difference between the linguistic groups except in the category of Self-enhancement. One difference we can observe is that, for all the scales, Italian speakers tend to systematically rate cultural values higher than German speakers. This is a phenomenon that we already observed in the rating of emotional traits (Eichler et al., 2021) and which we will explore further in the discussion section. We obtained 10

different clusters in relation to the beliefs about success in mathematics (question B2) which are detailed in Table 3. Briefly, most of the clusters are characterised by the choice of two answer-options, with 'Flexible Thinking' featuring in the most popular selections. The 'Affect' dimension is often considered as important, especially in the larger clusters. On the contrary, 'Learned Abilities' are not the focus of most students, with the exception of just one cluster.

The answers related to beliefs about the teaching of mathematics (question B4) yielded to 7 clusters, which are listed in Table 4. The option 'Knowing several teaching methods' was often considered. More in general, 'Foundation' appears to be very important in most of the clusters, while 'Contingency' and 'Connection' appear more rarely with only two clusters respectively characterised by these categories. The 'Contingency' cluster is also the smallest.

### ***5.1. Beliefs about mathematics and individual cultural values***

Question B2 asked subjects to select important factors for achieving success in mathematics (Tab. 1). Following our previous research (Eichler et al., 2021; Maffia et al., 2020), participants have been assigned to one out of ten clusters among those listed in Table 3.

A one-way MANOVA showed a statistically significant difference between the clusters of beliefs about mathematics on the combined dependent variables concerning higher order types of values,  $F(9, 188) = 2.632, p < .01, \text{partial } \eta^2 = 0.112$ , Roy's largest root = .126 (proportion of unexplained variance to unexplained variance for the first discriminant function; cf. Field et al., 2012; descriptive statistics are given in Table 7 in the appendix). In this case, the effect is based on differences concerning Self-transcendence, as an ANOVA concerning 'Self-transcendence' implies. Post-hoc univariate ANOVAs were conducted for every dependent variable. However, only with



regard to Self-transcendence, the ANOVA yields a significant interaction effect of belief-cluster and higher-order cultural values:  $F(9, 188) = 2.353$  ( $p < 0.05$ ; partial  $\eta^2 = 0.101$ ). We did not obtain a significant result with the one-way MANOVA referring to other statistics such as Wilks  $\lambda$ .

Figure 2 shows the scores for the higher order type of value ‘Self-transcendence’. Apparently, some clusters show significant differences, whereas other clusters seem to be similar in rating values representing ‘Self-transcendence’. Specifically, clusters 3 and 8 show noteworthy differences, but the differences between cluster 3 and the clusters 5 and 6 are also significant (Table 5).

Actually, cluster 3 and cluster 8 are also significantly different concerning values representing openness, although the ANOVA for this higher order type of values did not show a significant interaction effect between belief cluster and higher order type (Table 6).

Figure 2 shows differences between clusters 3 and 8 in terms of selection of the twelve given options. We can notice that prospective teachers in cluster 8 believe that ‘Natural Abilities’ play a major role in achieving success in mathematics. In particular, this cluster differs significantly from cluster 3 concerning the importance given to predisposition, while motivation and originality are considered as much more important by members of cluster 3. Thus, differences in the beliefs about the role played by predisposition (over motivation and originality) are related to differences in cultural values on both the dualities indicated by Schwartz (e.g., 1992): Self-transcendence vs Self-enhancement and Openness vs Conservation (Fig. 1). Prospective teachers who pay more relevance to predisposition appear to be less open and self-transcendent.

## ***5.2. Beliefs about the teaching of mathematics and individual cultural values***

In a second step, we investigated the relationship between clusters of beliefs about the

characteristics necessary for being a successful mathematics teacher and the higher order types of cultural values. In this regard, a one-way MANOVA showed a statistically significant difference between the clusters of beliefs about being successful in mathematics teaching and the combined dependent variables concerning higher order types of values concerning every statistic (descriptive statistics are given in Table 7 in the appendix). We report only Wilks  $\lambda$ :  $F(24, 657) = 2.013, p < .01, \text{partial } \eta^2 = 0.80$ . Therefore, the clusters of teachers differ significantly with reference to a combination of higher order types of values. However, the clusters of teachers do not differ with reference to a single higher order type of values. Thus, post-hoc univariate ANOVAs were conducted for every dependent variable; none of the analyses yielded a significant interaction effect of belief-cluster and higher-order cultural values. Nevertheless, we also exploratorily checked the post hoc-test concerning pairwise differences between clusters regarding a specific higher order type of values, but did not find any significant difference.

One interesting finding in this analysis regarded not the differences between clusters and the rating of higher order types of values, but the similarities. For example, the teachers in the different clusters rated values representing the higher order type 'Self-transcendence' in a very similar manner. Differences in the mean score were lower than 0.1 (cf. also Fig. 3).

## **6. Discussion**

When we define culture in terms of values, we do not find differences between the two linguistic groups in question as regards a preference for specific cultural values. This suggests that cultural values transcend language and nation within our sample. The only observed difference is that Italian-speaking prospective teachers tend to value every higher order cultural value higher (and generally significantly higher) than German-

speaking prospective teachers. Since this phenomenon is apparent for higher order values such as Openness and Conservation that are positioned at the opposite ends of a continuum (Schwartz, 2011; Figure 1), we interpret this result not as an expression of different cultural values, but as the tendency of Italian prospective teachers to value propositions higher than German prospective teachers. This result agrees also with our former investigations showing that Italian teachers rate emotional traits concerning mathematics and mathematics teachers higher than German prospective teachers, independent of whether the items represent positive or negative emotional traits (Eichler et al., 2021). Klassen et al. (2010) found similar systematic differences in the rating of cultural values. In their research, Korean teachers rated all cultural values (even collectivist values) lower than teachers from Canada or the US. The authors explained this phenomenon as the result of a response bias between different cultural groups. A similar phenomenon may have occurred in our case.

Defining culture on the basis of Schwartz' (1992; 2011) work, we found a relationship between cultural values and beliefs about having success in mathematics. We found that teachers of one cluster (cluster 3) rated cultural values representing 'Self-transcendence' as significantly higher than prospective teachers of other clusters. One of the main differences between the highest-variance clusters concerns the belief about the role played by predisposition in achieving success in mathematics. We noticed an increased adherence to values of 'Openness' and 'Self-transcendence' for those who do not attribute much importance to predisposition. Indeed, predisposition could be considered a very stable trait (as opposed to 'Openness' values which are related to the possibility of change) and a very individual one (as opposed to 'Self-transcendence' values which focus on the development of collectivity).

Differences disappeared in the case of beliefs about the teaching of mathematics. In this case, the clusters of teachers differ only concerning a combination of higher order types of values, but seem to be similar when a single higher order type of values is concerned. For instance, we showed that ‘Self-transcendence’ was rated almost in the same way by all seven clusters; results are similar for other cultural values. Hence, while these results substantiate that cultural differences may result in different beliefs about mathematics, they add new insights to our previous research (Eichler et al., 2021) by highlighting that the same phenomenon may not apply to the teaching of this subject. It is possible that close geographic regions (like Italy and Germany) share some common values that are related to beliefs about the teaching of mathematics. Significant differences in cultural values may become observable in the case of more distant countries, as highlighted by other studies (e.g., Felbrich et al., 2012; Klassen, 2011).

The main aim of this study, at this stage of our research, was to identify relations between cultural values and beliefs about mathematics and mathematics teaching within culturally similar nations. In doing so, we contribute to the field that focuses on differences in culturally diverse groups such as the Eastern and Western worlds (e.g., Felbrich et al., 2012; Klassen, 2011) by providing a differentiated insight. For further analysis of how a certain value is related to certain beliefs, the results of our research should be replicated and further investigated in qualitative designs.

We believe that these results enrich the comparative research about mathematics teachers’ beliefs by proposing a new perspective, derived from the research field of cross-cultural psychology. As has often occurred in the past, research in mathematics education can still be positively affected by recent developments in nearby research fields.

Our results can also offer useful suggestions for the increasingly informed design of training paths for future mathematics teachers. Research shows the extent to which the view of mathematics and mathematics teaching influences the teaching professionalism of future teachers, and the characterisations provided in our study can provide valuable information in this direction.

### **Disclosure statement**

The authors declare that they have no conflict of interest.

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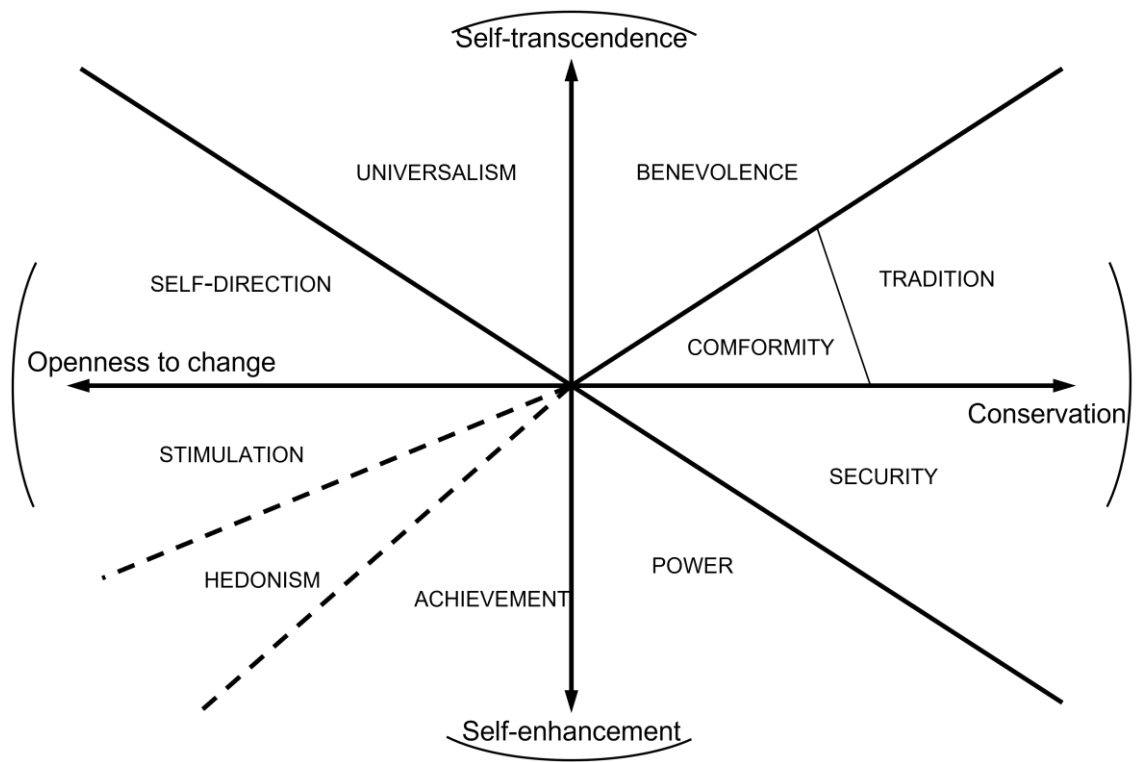


Figure 1. Structure of the motivational continuum, including higher order cultural values. Reproduction from Schwartz (1992; 2011).

Table 1. List of possible answers to questions B2 and B4. Letters indicate the order of presentation in the questionnaire.

Answers to question B2: ‘Select THREE features that, in your opinion, are important for achieving success in mathematics.’	Answers to question B4: ‘Select THREE features that, in your opinion, are important for being a “good” teacher of mathematics.’
<b>Learned Abilities</b>	<b>Foundation</b>
B. Organised work methods	B. Knowing several teaching methods
C. Language appropriateness	E. Knowing mathematics
H. Analytic thinking	N. Using technical terms
<b>Natural Abilities</b>	<b>Transformation</b>
G. Predisposition	C. Giving effective explanations
L. Memory	F. Using several representations
M. Control	L. Selecting appropriate examples
<b>Creativity</b>	<b>Connection</b>
A. Fluency	A. Planning with awareness
D. Flexible thinking	I. Knowing students’ abilities
N. Originality	M. Relating different topics
<b>Affect</b>	<b>Contingency</b>
E. Motivation	D. Valorizing students’ interventions
F. Perseverance	G. Giving feedback about errors
I. Confidence	H. Adapting lessons to contingencies

Table 2. Reliability of the scales representing the higher order types of cultural values.

	Openness	Conservation	Self- enhancement	Self- transcendence
Cronbach's $\alpha$	.819	.847	.854	.769

Table 3. Clusters of beliefs about success in mathematics (question B2).

	Label	Description of the Cluster	Size	% of German speakers
1	Organised work methods and Motivation	This cluster is characterised by the selection of options B (Organised work methods) and E (Motivation) - more than 2 SD than other clusters	5%	91%
2	Analytic and Flexible thinking, but with Predisposition	This cluster is characterised by the selection of options D (Flexible thinking), G (Predisposition) and H (Analytic thinking) are selected 1SD more than the other clusters.	18%	77%
3	A bit of everything is important	In this cluster, strong importance is awarded to one option of each category, two options are considered for the Affect dimension.	5%	18%
4	Be original and confident, but use an appropriate language	This cluster is characterised by the selection of options C (Language appropriateness), I (Confidence) and N (Originality) - more than 1 SD than other clusters.	8%	25%
5	Perseverance and Flexible thinking	This cluster is characterised by the selection of options D (Flexible thinking) and F (Perseverance). Almost all the other options are selected 1SD less than the other clusters.	9%	74%
6	Affect first	Affect options are considered more than other clusters; also, the option Flexible thinking is chosen by many	16%	41%
7	Motivation and Flexible thinking	This cluster is characterised by the selection of options D (Flexible thinking) and F (Perseverance) - more than 1 SD than other clusters	16%	33%
8	Natural and Learned Abilities	This cluster is characterised by the selection of all the options of Natural Abilities and Learned Abilities	7%	47%

categories. In particular, the option Predisposition is selected almost 2 SD more than the other clusters.

9	Analytic Thinking and Perseverance	This cluster is characterised by the selection of options H (Analytic thinking) and F (Perseverance) (more than 1 SD than other clusters).	8%	70%
10	Affect and Control	This cluster is characterised by the selection of all the options of Affect and of the option Control.	7%	65%

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Table 4. Clusters of beliefs about success in teaching mathematics (question B4).

Cluster	Label	Description of the Cluster	Size	% of German speakers
1	Effective explanations	This cluster is characterised by the selection of option B (Knowing several teaching methods). Many members of this cluster also selected options G (Giving feedback about errors) and H (Adapting lessons to contingencies) belonging to the Contingency category. The option Knowing Mathematics is selected 1SD less than other clusters.	19%	62%
2	A bit of everything is important	In this cluster most of the options are selected. A notable exception is the option Valorizing students' interventions, which is selected 1SD less than the other clusters.	14%	66%
3	Knowing mathematics and how to teach it	In this cluster, the option B (Knowing several teaching methods) and E (Knowing mathematics) (both in the Foundation category) are selected 1SD more than the other clusters. The options 'Using several representations' and 'Relating different topics' are selected by many.	13%	42%
4	Know teaching methods and give feedback	This cluster is characterised by the selection of option B (Knowing several teaching methods) and G (Giving feedback about errors) - more than 1 SD than other clusters .	17%	36%
5	Know teaching methods and students' abilities	This cluster is characterised by the selection of options B (Knowing several teaching methods) and D (Valorizing students' interventions) - more than 1 SD than other clusters.	15%	68%
6	Contingency first	'Contingency' options are considered more than other clusters; in particular, the option 'Valorizing students' interventions' is chosen almost 2 SD than other clusters.	7%	44%

7	Connection, with representations	Connection options are considered more than other clusters. Moreover, the options 'Using several representations' and 'Using technical terms' are selected more than the other clusters (almost 2 SD)	14%	55%
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Table 5. Differences of cluster 3 from other clusters, referring to values representing Self-transcendence.

Difference of cluster 3 from	p-value	Mean difference	Confidence-interval (95%)
Cluster 2	.033	+0.55	[0.03;1.08]
Cluster 5	.007	+0.89	[0.18;1.59]
Cluster 6	.027	+0.61	[0.04;1.17]
Cluster 8	.025	+0.92	[0.08;1.76]

Table 6. Differences between cluster 3 and cluster 8 from values representing Openness.

Difference between cluster 3 and 8 referring to	p-value	Mean difference	Confidence-interval (95%)
Openness	.020	+1.01	[0.11;1.92]

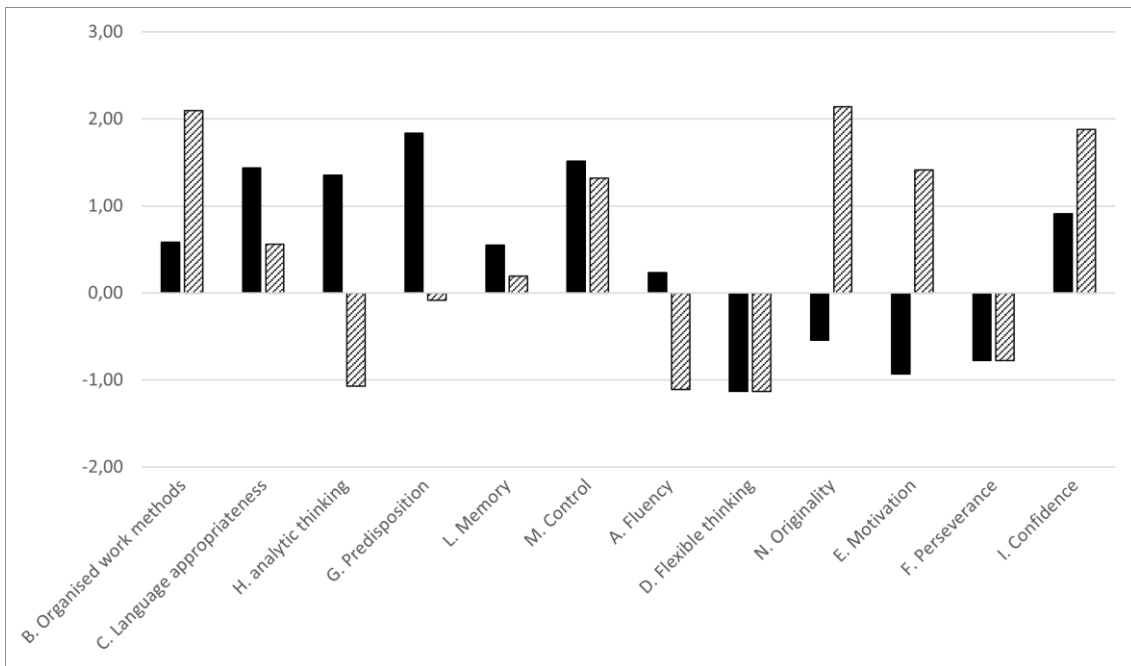


Figure 2. Standardised percentage of selection for each possible answer to question B2 in clusters 3 (black bars) and 8 (striped bars). The bar height represents deviation (in standard units) from mean value.

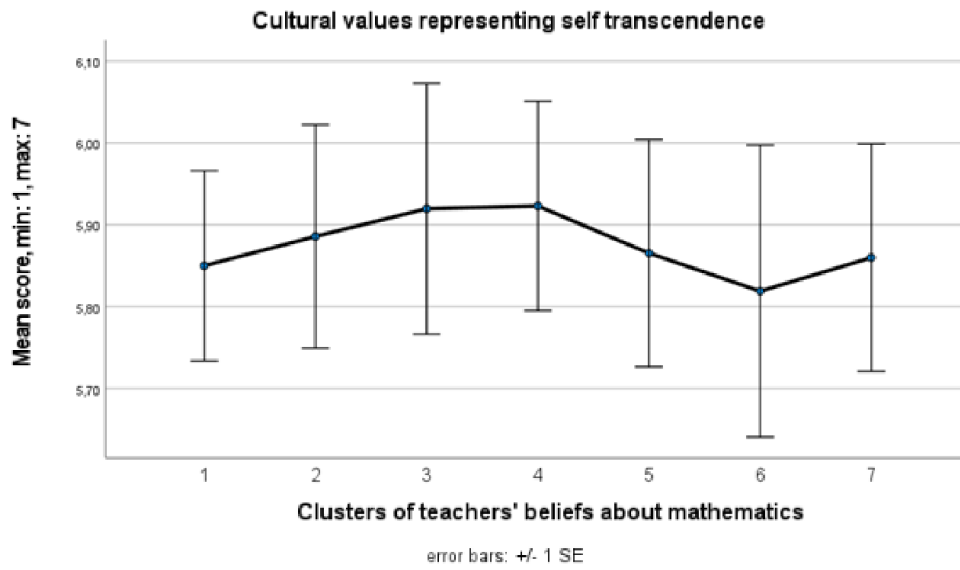


Figure 3. Average value and standard error of the Openness index in the clusters derived from belief about the teaching of mathematics.

## Appendix

Table 7. Means and standard deviations (SD) of the higher order types of values for every cluster of beliefs about success in mathematics and success in teaching mathematics.

Beliefs about achieving success in mathematics								
Cluster	Openness		Self enhancement		Conservation		Self transcendence	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	5.35	0.82	4.03	1.06	5.25	0.59	6.00	0.54
2	5.46	0.87	4.59	0.89	5.04	0.92	5.84	0.70
3	6.18	0.50	4.87	0.87	5.69	0.62	6.39	0.33
4	5.55	1.10	4.69	0.88	5.30	1.12	5.97	1.03
5	5.43	0.64	4.52	0.78	5.00	0.87	5.51	0.80
6	5.43	0.90	4.25	0.84	4.93	0.58	5.79	0.70
7	5.75	0.90	4.60	1.05	5.19	0.87	6.05	0.61
8	5.16	0.83	4.40	1.02	4.82	0.95	5.47	0.86
9	5.50	0.88	4.51	0.81	5.15	0.79	5.95	0.54
10	5.62	1.04	4.59	0.87	5.2426	0.84	6.12	0.65

Beliefs about having success in teaching mathematics								
Cluster	Openness		Self enhancement		Conservation		Self transcendence	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	5.56	0.84	4.57	0.76	5.01	0.82	5.85	0.78
2	5.41	0.83	4.38	0.91	5.18	0.69	5.89	0.55
3	5.48	0.82	4.47	0.91	4.88	0.83	5.92	0.67
4	5.64	0.89	4.26	1.01	4.96	1.00	5.92	0.79
5	5.67	0.83	4.79	0.91	5.46	0.78	5.87	0.69
6	5.77	0.95	4.25	0.89	5.14	0.90	5.82	0.99
7	5.19	0.97	4.72	0.97	5.20	0.80	5.86	0.70