Effects of Motivation on the Belief Systems of Future Mathematics Teachers from a Comparative Perspective

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Abstract The paper examines the relationship between future teachers' professional motivation and their beliefs on the dynamic nature of mathematics as an academic discipline as well as on their transmission-oriented beliefs on the teaching and learning of mathematics. As motives, intrinsic-pedagogical, intrinsic-academic and extrinsic motives were examined. Based on IEA's "Teacher Education and Development Study in Mathematics" (TEDS-M), carried out in 2008, we analyzed data from two Western (Germany, Norway) and two East Asian countries (Singapore, Taiwan) which represent different educational cultures. Our results revealed that the level of the motivational facets and the beliefs facets differed between the four countries. The pattern of relationships between professional motivation and teacher beliefs was largely similar across countries though. This result indicates a generic effect of motivation but culturally shaped strength of the different characteristics.

Keywords Epistemological beliefs • Nature of mathematics • Transmission beliefs • Professional motivation • Intrinsic motives • Extrinsic motives

Introduction

Motivation is often positively related to cognitive learning outcomes (Benware and Deci 1984; Grolnick and Ryan 1987), especially if *intrinsic motivation* – as one specific facet of motivation – is used as a predictor (Singh et al. 2002). This positive relationship applies not only to the K-12 student level but also to university

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students. Evidence exists that the level of their intrinsic motivation significantly predicts study success (Schiefele and Urhahne 2000). Also with respect to future teachers, studies revealed that intrinsic motivation is positively correlated with their professional knowledge (Blömeke et al. 2011; Brouwer and ten Brinke 1995; Keller-Schneider 2011; Watt et al. 2007). Longitudinal studies revealed correspondingly that future teachers' motivation influence their cognitive development during teacher education (König and Herzmann 2011; König and Rothland 2012; Mayr 2009).

However, how future teachers' motives to become teachers are related to their *beliefs,* is still an open question. The present paper intends to close this research gap with respect to future teachers from four countries. We selected these countries so that they represent different educational cultures, because we assume that the level of teacher motives and the relationship between motivation and beliefs differ across countries.

From a study on the relationship of future lower-secondary mathematics teachers' professional knowledge and their beliefs in Germany, Norway, Singapore and Taiwan based on data from the "Teacher Education and Development Study: Learning to Teach Mathematics" (TEDS-M, Blömeke 2012), we learned that these facets were correlated with each other in specific ways. The relationships pointed to belief *systems* which were largely the same across countries that belonged to different educational traditions – the two East Asian countries, Taiwan and Singapore, influenced by Confucian heritage, and the two Western European countries, Germany and Norway having a classical Greek-Roman background: Mathematics content knowledge (MCK) and mathematics pedagogical content knowledge (MPCK) were always positively or not related to a belief that the nature of mathematics is dynamic. In none of the countries, the relationship was negative. In turn, dynamic beliefs and transmission beliefs on the teaching of mathematics were always either negatively or not correlated with each other. In none of the countries, the relationship was positive. This pattern was thus more universal than we had expected, because teacher training programs had been described as being influenced by the context in which they are implemented (Leung et al. 2006; Even and Ball 2009).

In this paper, we intend to go beyond this relationship by including the motivational characteristics of the future teachers from Germany, Norway, Singapore and Taiwan and by examining how these influence their beliefs. The future teachers of these countries had different motives to enter mathematics teacher education: either intrinsic-pedagogical or intrinsic-academic motives or extrinsic motives. As it was with respect to knowledge and beliefs, the database of our study comes from the TEDS-M-study (see e.g. Blömeke et al. 2011; Blömeke et al. 2012).

These data point to varying levels of motivation why teacher education was entered across countries. So, the question arises, whether already at such an early point of the academic career the foundation of the future teachers' beliefs systems was developed. We assume that this in fact may be true and that the pattern of the relationships may once again be more universal than usually discussed in the literature. Furthermore, we assume that future teachers with an intrinsic pedagogical motive to enter the teaching profession may be more strongly convinced that mathematics is a dynamic discipline and that the teaching of mathematics should happen with strong participation of students and not in a teacher-directed way. In contrast, we assume that students with extrinsic motives to go into the teaching profession are more strongly convinced that a teacher-directed style may be the better way to go.

Conceptual Framework and Research Questions

With respect to teachers, intrinsic motives to enter the profession can be distinguished into altruistic-pedagogical and subject-related motives (Brookhart and Freeman 1992; Watt and Richardson 2007). Altruistic-pedagogical motives include the motivation to work with children and to support their development whereas subject-related motives express the enjoyment of the content to be taught. Extrinsic motives represent another motivational facet. If this perspective is taken, somebody wants to become a teacher mainly because of the salary paid or other working conditions.

Comparative studies revealed different levels of these specific motives across countries (Watt et al. 2012). Whereas future teachers from Western countries typically stress altruistic-pedagogical motives only, those from some East Asian countries endorse extrinsic motives, too (Schmidt et al. 2011).

In TEDS-M, beliefs were defined as "understandings, premises or propositions about the world that are felt to be true" (Richardson 1996, p. 103). If beliefs are looked at alongside both the subject being taught and a professional task which needs to be mastered, evidence suggests that there is a link between teacher beliefs and pupil achievement (Bromme 2005). Beliefs are a crucial aspect of a teacher's perception of teaching situations and in their choice of teaching methods in the classroom (Leinhardt and Greeno 1986; Leder et al. 2002). Thus, they are also an indicator of the type of teaching methods future teachers will use in the classroom in the future (Nespor 1987).

Beliefs are, however, not a well-defined construct (Pajares 1992). Clear distinctions between beliefs and other conceptions such as attitudes, perceptions or conceptions are rare. Rodd (1997) points out, that beliefs rely on evaluative and affective components. At the same time, the distinction towards knowledge – in particular towards pedagogical content knowledge and general pedagogical knowledge – is more heuristic than that it can strictly be kept up (Furinghetti and Pehkonen 2002). Several efforts have been made to categorize the belief systems of teachers (Thompson 1992). TEDS-M distinguishes between beliefs about the nature of mathematics and beliefs about the teaching and learning of mathematics. Self-related beliefs were not covered in TEDS-M.

With respect to the interaction of teacher beliefs, Wehling and Charters (1969) discussed beliefs in terms of discrete sets of inter-related concepts. Kagan (1992) argued along the same line that teachers dispose of a highly personalized belief system that constrains their perception, judgment, and behavior. This system grows more coherently as a teacher's experience in classrooms grows. Pajares (1992) stresses the role of experience as well: Individuals develop a belief system which has an adaptive function in helping individuals define and understand the world and themselves. The different belief dimensions are connected to each other. However, since beliefs are generally contextualized and associated with a particular situation or circumstance (Kagan 1992), systems of beliefs may contradict each other.

Specifically with respect to mathematics teachers, Op't Eynde et al. (2002) intended to clarify empirically with their mathematics-related beliefs questionnaire (MRBQ) the structure of teachers' belief system and how its different facets relate to each other. Subsequently, Schommer-Aikins (2004) introduced the idea of an "embedded systemic model" of epistemological beliefs after she had already in the early 1990s – inspired by the seminal work of Perry (1968) and Schoenfeld (1983) – argued that these beliefs may form a system of discrete beliefs which are connected to each other. Epistemological beliefs are defined as those beliefs that are related to the nature and scope of knowledge. In her embedded model, Schommer-Aikins (2004) pointed to the need of including other cognitive and affective characteristics besides beliefs, because "epistemological beliefs do not function in a vacuum" (p. 23). Concerning the components of the belief systems Schommer (1990) included already in the early 1990s beliefs about learning to the range of beliefs about knowledge, on which her predecessors had limited their models. Boekaerts (1995), in particular, requested to take motivation into account in order to "bridge the gap between metacognitive and metamotivation theories".

Schommer-Aikins (2004) points also to the cultural context as an influential factor. In line with Schoenfeld (1998), affective-motivational characteristics can, in fact, be understood as culturally shaped mental constructs acquired in educational settings with traditions that vary across countries. Culture can be defined as the "shared motives, values, beliefs, identities, and interpretations or meanings of significant events that result from common experiences of members of collectives that are transmitted across generations" (House et al. 2004, p. 15). It is hypothesized that through socialization processes a country's culture has an impact on the preferred modes of learning (Hofstede 1986). In anthropology as well as cross-cultural psychology, several conceptualizations exist with which different dimensions of cultural differences can be described.

Referring to studies by Hofstede (2001), Triandis (1995) and others, Schommer-Aikins (2004) argues that the degree of *individualism* and *collectivism* may have consequences for the shape of a belief system, because goals and emotional attachment are directed differently in individualistic and collectivistic countries. In countries such as Germany and Norway, typically classified as individualistic countries on Hofstede's individualism-collectivism scale, individuals are regarded as largely independent and the needs and goals of the self are regarded more important than the needs and goals of the society as a whole (Felbrich et al. 2012). In educational processes, autonomy and emotional detachment are supported whereas in collectivistic countries such as Singapore and Taiwan group identity and emotional attachment are stressed. In individualistic countries, learners are then perceived as autonomous subjects acquiring knowledge mainly independently on their own (Triandis 1995). Lack of success in learning is often attributed to a misfit between the conditions of learning and the individual learner, i.e. in terms of composition of groups of learners or too demanding tasks, rather than to individual characteristics of the learner. In contrast, learners from collectivist countries engage in learning processes because of an obligation towards their teachers, their families and other societal entities, which in turn are seen as obliged to grant the learner the necessary support (Felbrich et al. 2012). School failure in these countries is attributed to a lack of effort by the learner. Hofstede also assumed that specific differences exist in both teacher–student and student–student interactions between individualistic and collectivistic countries. In individualistically oriented societies students expect to learn how to learn and to think, whereas in collectivistic societies they expect to learn how to do something. Whereas in the latter diploma certificates are of utmost importance, they have lower symbolic value in individualistic countries (Hofstede 1986).

As part of her embedded systemic model of epistemological beliefs, Schommer-Aikins (2004) assumes that such cultural relational views are key antecedents of beliefs on teaching and learning. Based on her ideas, it can be assumed that student teachers in collectivistic societies more strongly endorse a transmission view on teaching and learning and less a dynamic view on the nature of mathematics, because teachers and final examinations expect pupils to be proficient in the application of rules and formulae and that it is the responsibility of the teacher as the master of the content to deliver these. In contrast, student teachers from individualistic societies should feel less comfortable with a transmission view and should stress a dynamic view of mathematics which stresses individual approaches to mathematics.

The MT21 Study (Mathematics Teaching in the 21st century; Blömeke et al. 2008a; Schmidt et al. 2011) was the first study to compare future primary teachers' beliefs in six countries, namely Bulgaria, Germany, USA, Mexico, Taiwan and South Korea (Blömeke et al. 2008b). The results revealed country-specific differences in beliefs on the nature of mathematics. German, Mexican and US future teachers agreed more strongly with dynamic statements than Taiwanese, South Korean and Bulgarian future teachers (Schmidt et al. 2011). The results of the TALIS Study (Teaching and Learning International Survey, OECD 2009) which refer to teachers' epistemological beliefs on teaching and learning of mathematics, point to the same direction. In collectivistic countries, such as Malaysia and South American states, transmission views have more strongly been articulated by teachers than in Western countries (Klieme and Vieluf 2009; Vieluf and Klieme 2011). With this study cultural *patterns* of beliefs were identified for the first time.

In contrast to these studies, Andrews et al. (2011) report on a comparative study of mathematics-related beliefs on teaching and learning of students in England, Slovakia and Spain. They addressed specifically the question of structural equivalence of these beliefs across countries by applying the above mentioned instrument developed by Op't Eynde et al. (2002) to 220 students from England, 405 students from Spain and 250 students from Slovakia. The students were at ages 11–15. Andrews et al. (2011) found convincing evidence that the beliefs structure was structurally equivalent across these three countries. For each factor identified in one country they found an equivalent factor in the other two countries.

Against this state of research, we examine the following two research questions:

1. To what extent are motivational characteristics of future lower-secondary mathematics teachers related to their beliefs on the nature of mathematics and the teaching and learning of mathematics? Can we, in fact, assume an embedded systemic model as Schommer-Aikins points out?
2. To what extent is the structure of this relationship structurally equivalent across countries? Do we have to distinguish between individualistic and collectivistic countries as Schommer-Aikins points out or not as Andrews et al. describe?

Study Design

Sampling

The target group of the present study was defined as future teachers in their final year of teacher education who would receive a license to teach mathematics in lower secondary schools (Tatto et al. 2008). A teacher education program was identified as focused on lower secondary school level, if the qualification included to teach grade 8 (basic education, cycle 2; UNESCO 1997). In a two-stage process, random samples were drawn in each participating country. The TEDS-M quality standards required minimum participation rates for all target populations of the survey to ensure that bias resulting from non-response was kept within acceptable limits. The samples were organized according to important teacher education features such as the type of program (consecutive vs. concurrent programs), the school level to be taught (grade range included in the qualification, e.g. grades 5–10 vs. grades 7–12), the attention paid to learning opportunities (e.g., a major or minor in mathematics) and the region where the training was based (for example, federal states) in order to reflect accurately the future teachers' characteristics at the end of their education.

In 2008, more than 8,000 future lower-secondary teachers from 15 countries were surveyed. All countries had to meet the strong IEA quality requirements. These included controlling translation, monitoring test situations and meeting participation rates. If a country missed the participation benchmark only slightly, its results are reported with an annotation. The present study uses the samples from Germany, Norway, Singapore and Taiwan.

In Germany, the 771 future lower-secondary teachers (response rate: 81 %) came from the following three programs:

- "Primary and Lower Secondary Teachers", a 5.5 year consecutive model that trained teachers for grades 1 through 10 in two subjects (mathematics had to be one of these subjects to be included in TEDS-M); a 3.5 year university training was followed by a 2-year practical training with mathematics as one of two subjects
- "Lower-Secondary Teachers", a 5.5 year consecutive model that trained teachers for grades 5 through 10 in two subjects (mathematics had to be one of these sub-

jects to be included in TEDS-M); a 3.5 year university training was followed by a 2-year practical training with mathematics as one of two subjects
- "Lower and Upper Secondary Teachers", a 6.5 year consecutive model that trained teachers for grades 5 through 13 in two subjects (mathematics had to be one of these subjects to be included in TEDS-M); a 4.5 year university training was followed by a 2-year practical training with mathematics as one of two subjects

The 555 teachers in Norway (response rate below 60 %) came from the following three programs:

- "Allmennlærerutdanning", a 4-year concurrent model that trained generalist teachers in a broad range of subjects including mathematics for grades 1 through 10
- "Allmennlærerutdanning with extra mathematics", a 4-year concurrent model that trained generalist teachers in a broad range of subjects including mathematics for grades 1 through 10
- "Praktisk-Pedagogisk Utdanning", a 4-year consecutive model that trained teachers for grades 8 through 13 in two subjects; a 3 year university training was followed by a 1-year professional training with mathematics as one of two subjects

The sampling process for Norway was difficult, and the final country sample consisted of two subsamples that were likely to partly overlap. While information about the seriousness of this problem is not available, we realized that using only one subsample would lead to strongly biased country estimates. Combining both subsamples would lead to imprecise standard errors (for more details, see Tatto et al. 2012). After an extensive research of the Norwegian literature about teacher education, combining TEDS-M data with publicly availably evaluation data from Norway (NOKUT 2006), and recourse to expert reviews, we decided to combine the two subsamples in order to represent the future teachers' knowledge as appropriately as possible. However, the results should be regarded as a rough approximation only. The country's participation rate was below 60 % with respect to lower secondary teachers. In addition, the sample met only partly the TEDS-M definition of the target population (Tatto et al. 2008). Therefore, caution is necessary with respect to these results.

In Singapore, the 393 future lower-secondary mathematics teachers (response rate 91 %) came from the following two programs:

- "PGDE 7–10", a 5-year consecutive model that trained teachers for grades 7 through 10 in two subjects; a 4-year Bachelor program was followed by a 1-year Master program with mathematics as one of two subjects
- "PGDE 7–12", a 5-year consecutive model that trained teachers for grades 7 through 12 in two subjects; a 4-year Bachelor program was followed by a 1-year Master program with mathematics as one of two subjects

In Taiwan, the 365 future lower-secondary teachers (97 %) came from a concurrent model that trained mathematics specialists for grades 7 through 9 in one subject only.

Data Sources

Regarding motives to go into the teaching profession, TEDS-M distinguished between intrinsic-pedagogical, intrinsic-academic and extrinsic motives. The scales were developed based on the study "Mathematics Teaching in the twenty-first century (MT21)" (Schmidt et al. 2011). Four items covered pedagogical motives, e.g. "I like working with young people." Academic motives were captured with two items, e.g. "I love mathematics". Three items covered extrinsic motives. "I seek the long-term security associated with being a teacher" is an example for this scale. All items had to be rated on 4-point Likert scales from "not a reason" to "a major reason". The means reported below represent the equally weighted means of each scale's items.

The future teachers' beliefs about the nature of mathematics were measured using an instrument developed by Grigutsch et al. (1998). This instrument originally consisted of 75 items, but due to time constraints it was reduced to 12 in TEDS-M based on the highest factor loadings in the original study and high-scale reliability in the TEDS-M pilot studies. The items' two-dimensional structure represented a static and a dynamic view on the nature of mathematics.

For the present paper we used the scale that represents a dynamic view which means that mathematics is seen as a process of enquiry. The scale's structure was confirmed through explorative and confirmatory factor analysis. The scale consists of six items which emphasize the process- and application-related character of mathematics, for example, "in mathematics you can discover and try out new things by yourself" or "many aspects of mathematics are of practical use". The future teachers had to express their agreement on a six-point Likert scale (1 = strongly disagree, 6 = strongly agree). The raw data were scaled using a partial credit IRT model (Tatto et al. 2012). For the sake of clarity, individual scores were transformed to a scale with a mean value of 10 based on the test characteristic curve. Conceptually, this mean represents the mean of the scale (corresponding to 3.5 on the initial scale) and thus a neutral view.

The future teachers' beliefs about the teaching and learning of mathematics were measured with another well-established scale from instructional research (Peterson et al. 1989). One scale represented a transmission view. Teachers who agreed strongly with its four items tended to see mathematics learning as teacher-centered with the pupil's role being to follow instructions given. Two examples of its items are: "The best way to do well in mathematics is to memorize all the formulae"; and "Pupils need to be taught exact procedures for solving mathematical problems".

Since our intention is to get pure regression parameters for professional motivation predicting teachers' epistemological beliefs on the nature of mathematics, we control for the future teachers' professional knowledge. Mathematics content knowledge (MCK) and mathematics pedagogical content knowledge (MPCK) were assessed in a 60-min paper-and-pencil test that had to be completed during a standardized and monitored session. The items were supposed to depict classroom performance as closely as possible. Many of them therefore represent problems and situations constitutive for mathematics teaching (NCTM 2000). In order to capture the desired breadth and depth of teacher knowledge, a matrix design was applied. Three test booklets were developed that had rotated blocks of items ("Balanced Incomplete Block Design"). The items of the mathematics test covered number, algebra, geometry and to a small extent data. The items of the mathematics pedagogy test covered pre-active curricular and planning knowledge which is necessary before a teacher enters the classroom and interactive knowledge about how to enact mathematics for teaching and learning. Three item formats were used: multiple-choice, complex multiple-choice, and constructed-response items.

All parameter estimations for this paper (in particular means and regression parameters) were carried out using the International Database Analyzer provided by IEA. As a consequence all results are based on weighted data (taking unequal selection probabilities into account as well as non-response adjustments) and using appropriate estimations of standard errors (taking the complex sample design into account by applying the balanced repeated replication technique).

Whether systematic mean differences between countries exist was estimated by taking the confidence intervals into account. As a rough "thumb of rule", the approach can be explained as follows: If intervals around the means of two countries which have a size of 1.96*Standard Error do not overlap, a 95 % probability exists that the differences are significant. We provide the standard error of the means in each table.

Results

Descriptive Results: Job Motivation and Professional Beliefs of Teachers

Regarding their motivation to become a teacher, the future teachers from all four countries agree the most with intrinsic-pedagogical motives (see Table 1). However, we can distinguish between Germany and Norway on the one hand and Singapore and Taiwan on the other hand. Whereas intrinsic-pedagogical motives are an important reason to go into the teaching profession in Germany and Norway, in particular teachers from Taiwan are more neutral in this respect. Taking the confidence

Table 1 Intrinsic-pedagogical motives in Germany, Norway, Singapore and Taiwan

Country	Mean	Standard error	Standard deviation	min–max
Germany	3.23	0.03	0.48	1.25–4.00
Norway	3.26	0.02	0.44	1.75–4.00
Singapore	2.99	0.03	0.61	1.00–4.00
Taiwan	2.76	0.04	0.73	1.00–4.00

Table 2 Intrinsic-academic motives in Germany, Norway, Singapore and Taiwan

Country	Mean	Standard error	Standard deviation	min–max
Germany	2.73	0.04	0.65	1.00–4.00
Norway	2.22	0.03	0.72	1.00–4.00
Singapore	2.51	0.03	0.75	1.00–4.00
Taiwan	2.27	0.03	0.61	1.00–4.00

Table 3 Extrinsic motives in Germany, Norway, Singapore and Taiwan

Country	Mean	Standard error	Standard deviation	min–max
Germany	2.43	0.04	0.68	1.00–4.00
Norway	1.99	0.02	0.56	1.00–3.33
Singapore	2.01	0.03	0.68	1.00–3.67
Taiwan	2.26	0.03	0.66	1.00–4.00

Table 4 Dynamic beliefs of future teachers in Germany, Norway, Singapore and Taiwan

Country	Mean	Standard error	Standard deviation	min–max
Germany	11.98	0.08	1.4	7.95–15.48
Norway	11.67	0.08	1.4	8.54–15.48
Singapore	11.75	0.06	1.3	9.10–15.48
Taiwan	12.08	0.07	1.4	9.10–15.48

intervals into account, the pedagogical motivation is significantly higher in the first two countries than in the latter two. The variation is much smaller in the first two countries, too, compared to the latter countries.

In all four countries, the view on intrinsic-academic motives is more neutral. In this case, the difference is the largest between Germany and Norway. Whereas German future teachers take a slightly positive view, Norwegian teachers reject this view to some extent. The difference between these countries is significant, if one takes the confidence intervals into account (Table 2).

The future mathematics teachers from Norway and Singapore reject in addition extrinsic motives whereas future teachers from Taiwan and particularly those from Germany have a more neutral view. The differences between Norway and Singapore on the one hand and Taiwan on the other hand and again between Taiwan and Germany are significant. In addition, the variation in Norway is lower than in the other countries, meaning that future teachers are more homogenous in their rejection of extrinsic motives than those from the other countries (Table 3).

When it comes to professional beliefs, there is also variation between the four countries examined. Future teachers from all four countries react positively to statements stressing that mathematics is creative and useful. However, the support of such a view is significantly stronger in Taiwan than in Norway if one takes the confidence intervals into account (see Table 4).

Table 5 Transmission beliefs on the teaching and learning of mathematics

Country	Mean	Standard error	Standard deviation	min–max
Germany	8.90	0.06	0.8	4.98–14.80
Norway	8.96	0.03	0.7	6.21–10.72
Singapore	9.50	0.04	0.8	4.98–14.80
Taiwan	9.02	0.04	0.8	4.98–11.08

When considering transmission beliefs on the teaching and learning of mathematics, the variation between the four countries is even larger (see Table 5). Lower-secondary teachers in Germany, Norway and Taiwan reject teacher-led learning significantly more strongly than those in Singapore. The mean of the future teachers from Singapore is still below a neutral position though.

Effects of Motivation on Teacher Beliefs

We examined the relationship between the different beliefs with two regression models. In these models served the future mathematics teachers' dynamic beliefs on the nature of mathematics or their transmission-oriented beliefs on the teaching and learning of mathematics as dependent variables and the motivational characteristics as predictors while we controlled for the future teachers' knowledge (not displayed in Tables 6 and 7). The variance explained by the predictors was generally higher in the first case than in the latter. If we use the adjusted R^2 as a measure of the effect size in order to take the sample size and the number of predictors into account, we can point out that – according to Cohen's (1988) classification of effect sizes – the practical relevance of job motivation as a predictor was between medium and large with respect to dynamic beliefs whereas it was between small and medium with respect to transmission-oriented beliefs.

With respect to our first research question, the data revealed that significant relationships between motivation to become a teacher and teacher beliefs exist if the knowledge is controlled for. The relationships vary by facets of the predictors and by the dependent variables. With respect to our second research question the data revealed that the patterns of these relationships were surprisingly homogenous across countries in the case of epistemological beliefs on the nature of mathematics but less so in the case of beliefs on the teaching and learning of mathematics.

The more strongly future teachers were intrinsically motivated to go into the teaching profession, the more strongly they believed in the dynamic nature of mathematics. This result applies to intrinsic-academic professional motives as well as to intrinsic-pedagogical motives and it applies to teachers from Taiwan and Singapore as well as from Germany and Norway. Although the practical relevance of the standardized beta coefficients was large in all cases (Roussos and Stout 1996), the strength in the relationships varied: If one controls for the professional knowledge of the future teachers, academic motives were particularly important in Norway and

Table 6 Regression parameters for professional motivation predicting teachers' dynamic beliefs on the nature of mathematics (while controlling for knowledge; not displayed)

	Taiwan		Singapore		Germany		Norway	
	b	β	b	β	b	β	b	β
MOT_ACA	.26	.12†	.33	.20***	.48	.23***	.56	.29***
MOT_PED	.53	.28***	.27	.13*	.49	.18***	.34	.11**
MOT_EXT	ns	ns	ns	ns	ns	ns	−.16	−.06†
R^2_{adj}	.10		.06		.12		.10	

MOT_ACA intrinsic-academic professional motive, *MOT_PED* intrinsic-pedagogical professional motive, *MOT_EXT* extrinsic professional motive, R^2_{adj} determination coefficient adjusted for sample size and number of predictors (MCK and MPCK were controlled for), *ns* not significant, † = $p<.10$, * = $p<.05$, ** = $p<.01$, *** $p<.001$

Table 7 Regression parameters for professional motivation predicting teachers' transmission beliefs on the teaching and learning of mathematics (while controlling for knowledge; not displayed)

	Taiwan		Singapore		Germany		Norway	
	b	β	b	β	b	β	b	β
MOT_ACA		.14**		ns		−.17**		−.07†
MOT_PED		ns		ns		ns		ns
MOT_EXT		.11†		.15**		.16*		.12**
R^2_{adj}	.07		.04		.06		.02	

MOT_ACA intrinsic-academic professional motive, *MOT_PED* intrinsic-pedagogical professional motive, *MOT_EXT* extrinsic professional motive, R^2_{adj} determination coefficient adjusted for sample size and number of predictors (MCK and MPCK were controlled for), *ns* not significant, † = $p<.10$, * = $p<.05$, ** = $p<.01$, *** $p<.001$

still more important in Germany than in Singapore and Taiwan. In contrast, pedagogical motives were particularly important in Taiwan but less important in the other three countries (although still significant). Extrinsic motives tended to have a negative relationship with dynamic beliefs on the nature of mathematics. However, only in Norway the correlation became marginally significant ($p<.10$).

The patterns were different with respect to beliefs on the teaching and learning of mathematics. The more strongly future teachers were extrinsically motivated to go into the teaching profession, the more strongly they believed in a transmission-oriented teaching style. This result applied to teachers from all four countries, although it was only marginally significant in Taiwan. The practical relevance of the beta coefficients was large in all cases (Roussos and Stout 1996). In contrast, pedagogical motives were not systematically related to these beliefs.

Interestingly, intrinsic-academic professional motives had differential effects on the future teachers' beliefs. In the two Western countries, the data revealed the following relationship: The more strongly future lower-secondary mathematics teachers from Germany and (marginally) Norway were intrinsic-academically motivated to go into the teaching profession, the less strongly they believed into a transmission-oriented teaching style. This result applied although we controlled for the mathematics-related knowledge level of the teachers. In contrast, future teachers from Taiwan (and the tendency was the same in Singapore) believed more strongly in a transmission-oriented teaching style, if they were more strongly intrinsic-academically motivated. Also in this case, the result applied although we controlled for mathematics-related knowledge and although the relationship between this knowledge and the transmission beliefs were negative. It has to be taken into account, that these differential effects were quite small and not always significant.

Summary and Conclusions

In this paper, we extended the state of research on (future) teachers' beliefs system by including motivational characteristics as demanded by the discussion on teacher education and its development. Since our prior research had pointed to an interrelationship of knowledge and beliefs we carried out our study while controlling for mathematical content knowledge and mathematics pedagogical content knowledge. With respect to epistemological beliefs on the nature of mathematics a homogenous pattern across the four countries examined emerged: The more strongly future teachers were intrinsically motivated to go into the teaching profession, either from a pedagogical or an academic point of view, the more strongly they believed in the dynamic nature of mathematics in Taiwan and Singapore as well as in Germany and Norway. Regarding beliefs on the teaching and learning of mathematics, we found another homogenous pattern with respect to extrinsic motives to go into the teaching profession. The more strongly future teachers from these four countries were motivated this way, the more strongly they believed in a transmission-oriented teaching style.

In contrast, intrinsic-academic professional motives had differential effects on the future teachers' beliefs, although these effects have to be treated cautiously, because they were quite small and not in all countries significant. In the two Western countries, future lower-secondary mathematics teachers from Germany and (marginally) Norway more strongly motivated in an intrinsic-academic way believed less strongly in a transmission-oriented teaching style. In contrast, future teachers from Taiwan (and the tendency was the same in Singapore) believed more strongly in a transmission-oriented teaching style, if they were more strongly academically motivated.

Thus, our data support Schommer-Aikins' (2004) "embedded systemic model" of beliefs by including not only epistemological beliefs but also beliefs about the teaching and learning of mathematics. In addition, our data support Boekaerts' (1995) request to take motivation into account to "bridge the gap between metacognitive and metamotivation theories". In contrast, the study supports Schommer-Aikins' (2004) assumption of the cultural context as an influential factor only to a very limited extent and this is the small differential effect of one of the three motives (intrinsic-academic) on one of the two outcomes (transmission beliefs). Mainly, the relationships are the same across individualistic and collectivist countries. With this study we therefore confirm Andrews' et al. (2011) findings that belief systems are structurally equivalent across countries.

To close we see the following three conclusions, which can be drawn from this study:

At first place the results point out, that the differences between East Asian and Western countries concerning their beliefs on the teaching and learning of mathematics and the epistemological beliefs on the nature of mathematics are increasingly vanishing, the two cultures do apparently not exist as monolithic blocks anymore. However, in this respect it must be considered that Singapore and Taiwan are countries which are strongly influenced by Western culture. Taken together, these results indicate that a dynamic perspective onto mathematics, which traditionally had been identified with Western countries, nowadays is more and more accepted in East Asian countries too. Therefore, this trend might be summarized by the statement that internationalization leads to blurring of cultural differences in education within a globalized world.

Secondly, the data point to the fact – which might be valid worldwide or at least for East Asian and Western countries –, that those future teachers who are less interested in the subject mathematics, show more transmission oriented beliefs, which is a traditional model worldwide no longer accepted. It can be expected that internationally seen these groups of future teachers may become a problem for the future development of schools and educational systems, which expect openness for innovations and the willingness to accept change in contrast to these future teachers, who tend to stick to traditional beliefs on the organization of learning as transmission-oriented processes. As a consequence, it can be stated that self-assessments at study entry containing motivational elements will become increasingly important in the future and might be applied wide-spread in order to identify potential risk groups already at the beginning of their university studies.

Thirdly, we can note, that there are still enough culturally significant differences within the belief systems of future teachers. In East Asian countries teachers with a more learner-oriented motivation in their studies can be clearly distinguished from those teachers, who are more guided by subject-oriented beliefs regarding mathematics as science. For those more subject-oriented teachers transmission-oriented conceptions play a greater role even though we controlled for knowledge. According to this position, learners do not need such constructivistic-oriented learning environments, but want to be fostered rapidly and effectively. This indicates that the greater need of time for constructivist learning is regarded quite sceptically by East Asian teachers, and that these kinds of approaches are seen to be more adequate for low performing learners. On the contrary, in Western countries constructivist attempts are deeply rooted so that irrespective to learning groups and learning environments, transmission-oriented attempts are generally rejected.

Overall it is obvious how much the different education systems have come closer together, while some identifiable differences between East Asian and Western countries still exist.

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