PREDICTORS OF FUTURE MATHEMATICS TEACHERS' READINESS TO TEACH: A COMPARISON OF TAIWAN, GERMANY, AND THE UNITED STATES

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This study uses data from TEDS-M to explore and compare possible individual-based and institutional-based predictors of future secondary mathematics teachers' readiness to teach in Taiwan, Germany, and the United States. Across the three countries, future teachers' intrinsic motivation to become teachers and the consistency of courses arrangement in the institutions where they studied were significant predictors of teaching readiness. Future teachers' highest grade level of mathematics studied at secondary school was a predictor of teaching readiness only in Taiwan, whereas the motivation derived from the empathy of prior learning experience was a predictor of teaching readiness in Germany and the United States, but not in Taiwan.

INTRODUCTION

The purpose of teaching is to help students learn (Hiebert, Morris, Berk, & Jansen, 2007), and the purpose of teacher education is to cultivate teachers' ability to help students learn. NCTM (1991), NBPTS(2001), and CCSSO (2010) have set standards to articulate the teaching competencies that mathematics teachers should acquire. These standards delineate not only the knowledge mathematics teachers should possess, but also the actions they should undertake during teaching (for example, performance-based standards of the CCSSO account for actions).

Teacher Education and Development Study in Mathematics (TEDS-M), an international comparison study conducted by the IEA, investigated the readiness of future secondary mathematics teachers to execute tasks central to mathematics teaching in 15 countries (Tatto et al., 2012; hereafter, referred to as "teaching readiness"). TEDS-M measured various facets of teaching readiness, for example, items related to instructional planning (e.g., set up mathematics learning activities to help pupils achieve learning goals), items related to instructional strategies (e.g., use questions to promote higher order thinking in mathematics), and items related to assessment (e.g., develop assessment tasks that promote learning in mathematics). The TEDS-M question was self-reported. Although self-reported data may be skewed because participants' self-impressions may deviate from reality, self-reporting is simple and economical, and allows a large number of respondents, who may belong to various cultures and speak various languages, to be surveyed and compared. Moreover, future teachers' self-evaluation constitutes a pragmatic benefit that is similar to customer evaluation of whether teacher education institutions prepared them well.

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Self-evaluation is an effective indicator of readiness since it incorporates components of individual reflection and practical field experience into the survey process.

Tang and Hsieh (2012) indicated that future secondary mathematics teachers in various TEDS-M participating countries reported different levels of teaching readiness. The characteristics that affect future teachers' teaching readiness remain unclear; it also remains unclear whether the characteristics that affect the readiness are the same in various countries. Determining the characteristics that affect the readiness is crucial to enable teacher education institutions to develop their training programs according to reliable references. These characteristics can be considered by such institutions when recruiting or screening future teachers. In this study, TEDS-M data was used to explore and compare possible individual-based and institutional-based predictors of future teachers' teaching readiness in three higher-achieving countries (achieved MCK and MPCK means beyond the international mean of 500) in Asia, Europe, and North America—Taiwan, Germany, and the United States.

RESEARCH METHOD

Conceptual framework

Future teachers' teaching readiness is considered an indicator of the effectiveness of teacher education (Tatto et al., 2012). After a review of studies related to effectiveness of schools and teacher education, individual- and institutional-based characteristics that possibly influenced this readiness were selected for further investigation. Several backgrounds of respondents have been identified to be influential.

Demographics: *Gender*, *home language*, and *socioeconomic status* (SES) are typically considered powerful predictors of future teachers' competence to teach mathematics. Blömeke et al. (2012) revealed that gender was the most critical individual characteristic that affected MCK across TEDS-M participating countries. Language background was known to affect students' achievements in mathematics and was determined to affect knowledge levels among future teachers (Laschke, 2013). SES reflects access to learning resources, such as wealth or education (Stevenson & Baker, 1992). Blömeke et al. demonstrated the relationship between future teachers' MCK and their parents' education levels.

Entrance quality: Two indicators in TEDS-M were designed to measure future teachers' entrance quality: *secondary mathematics level* and *overall grades received in secondary school*. Researches revealed that these two cognitive characteristics affected future teachers' knowledge levels across TEDS-M countries (e.g., Hsieh et al., 2010).

Motivation: Motivation is widely considered as a critical affective characteristic to impact student mathematics achievement (Eklöf, 2010). TEDS-M investigated the factors that motivated future teachers to pursue teaching. Studies found that *intrinsic motivation* and *empathy from prior learning experience* were positively correlated with knowledge achievements; and *extrinsic motivation* was negatively correlated with knowledge achievements (Blömeke et al., 2012; Hsieh et al., 2010; Laschke, 2013).

Predictors of student achievement are often studied by examining the characteristics reflecting the school education quality, like teacher quality and school features (Akyüz & Berberoğlu, 2010). Thus, this study took several indicators of teacher education quality as the institution characteristics to examine.

Teacher education quality: Hsieh et al. (2011) proposed a framework for teacher education quality of programs in institutions, and designed two indicators to measure course quality, *courses arrangement* and *teaching coherence*, measuring the consistency of courses and content within a university, and the continuity between university instruction and practicum instruction respectively. Three indicators were designed to measure person quality: *MR-instructor* and *SB-supervisor* measured the effectiveness of educators responsible for teaching **m**athematics-**r**elated courses and supervising future teachers' school-**b**ased experiences, respectively. The third person quality indicator was future teacher achievement, including *MCK* and *MPCK*.

The framework and the potential predictors of teaching readiness are shown in Figure 1. MCK and MPCK were also analysed as individual characteristics, because teachers' MCK and MPCK are often related to whether they can carry out mathematics teaching or not (Leinhart & Smith, 1985).

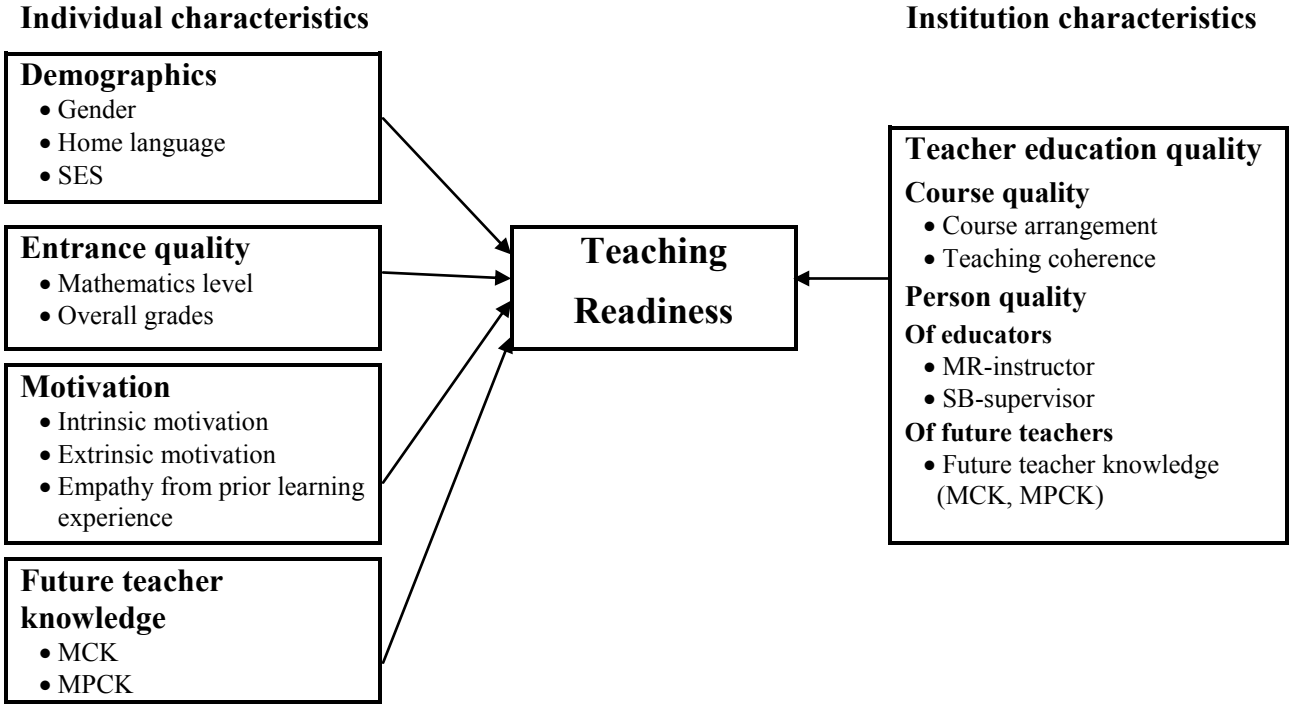

Figure 1: Framework of this study.

Participants

This study uses TEDS-M samples of future secondary mathematics teachers in Taiwan, Germany, and the US. TEDS-M used a stratified multistage probability sampling design, and drew the samples reflecting the distribution of future teachers at the end of their training in each country[1] (Tatto et al., 2012). The samples of this study

[1] The United States limited its participation to public institutions.

include 365 Taiwanese future teachers at 19 institutions, 771 German future teachers at 13 institutions, and 607 American future teachers at 46 institutions. In Taiwan, only one training program is offered: teachers are trained to teach a single subject from Grades 7 to 12. German teachers are trained to teach two subjects from Grades 1 to 9/10, 5/7 to 9/10, or 5/7 to 12/13. In the US, teachers are trained to teach one subject either to Grades 4/5 through 8/9, or 6/7 through 12 (Tatto et al., 2012).

Measures

Teaching readiness was measured by using 11 items graded on a 4-point Likert scale. In TEDS-M, a partial-credit model was used to estimate future teachers' logit scores on the scale; a score of 10 was associated with the neutral position (Tatto et al., 2012). Higher scores indicated greater self-evaluated teaching readiness.

Gender was a dichotomous item. *Home language* measured the frequency of speaking the official language used in teacher education at home on a 4-point Likert scale. A partial-credit model was used to estimate *SES* score for a composite of parental education and home resources. Four TEDS-M questions were included: paternal and maternal education levels (1 = primary to 7 = beyond ISCED 5A), a quantity of items available for education and leisure (e.g., DVD players; 0 to 7 items), and number of books at home (1 = none or few to 5 = enough to fill three or more bookcases).

Secondary mathematics level employed a 5-point Likert scale to measure the highest grade level of mathematics future teachers studied in secondary school (1 = below year 10 to 5 = advanced level of year 12). *Overall grades* were also graded according to a 5-point Likert scale that measured future teachers' secondary school achievements in comparison to their age cohort (1 = generally below average to 5 = always at the top).

TEDS-M measured the factors that motivated future teachers to pursue teaching based on nine items through a 4-point Likert scale (1 = not a reason to 4 = a major reason). In a factor analysis, Hsieh et al. (2010) extracted three aspects: *intrinsic motivation*, *salary and job security*, and *empathy from prior learning experience*, with 4, 3, and 2 items respectively. The average of rating points within an aspect was employed.

TEDS-M measured future teachers' *MCK* and *MPCK* based on 76 and 27 items, applying a balanced incomplete block design with three booklets. Scaled scores were created by using item response theory, and standardized to a mean of 500 and a standard deviation of 100 (Tatto et al., 2012).

Courses arrangement, *teaching coherence*, *MR-instructor*, and *SB-supervisor* were determined based on six, five, six, and four items, respectively, all of which were graded according to 4-point or 6-point Likert scales. In TEDS-M, data were managed by conducting the same statistical analyses as those used for teaching readiness.

Data analysis

This study employed a hierarchical linear model to analyze the data to account for the nested sample structure of TEDS-M (using HLM 6.08). The influence of individual characteristics (level-1) on teaching readiness was examined. These characteristics

were introduced using group centering (centered around the arithmetic mean of the institution) to separate level-1 effects from higher-level effects. The effects of institution characteristics were then examined by controlling level-1 predictors.

Institutions with fewer than 6 future teachers were excluded to ensure robust estimates. The adjusted data set contained data collected from 361 Taiwanese future teachers at 18 institutions, 771 German future teachers at 13 institutions, and 563 US future teachers at 32 institutions. Weights of future teachers and institutions provided by TEDS-M were used to reflect selection probabilities and response rates.

RESEARCH FINDINGS

To examine the predictive effects of characteristics on teaching readiness, this study introduced the predictors by block. First, for level 1, demographics were included in the model (M1). Entrance quality (M2), motivation (M3), and future teacher knowledge (M4) were then added in order. Controlling level-1 predictors, the following level-2 predictors were then added to the model: future teacher person quality (M5), educator person quality (M6), and course quality (M7) in order.

Individual characteristics

As shown in M7 for Taiwan (see Table 1), *SES*, *secondary mathematics level*, and *intrinsic motivation* are influential individual characteristics. The effect size of *SES* is much smaller than that of the other two predictors. The German and the US models exhibited predictors different from Taiwan' model, but were similar to each other.

Intrinsic motivation (e.g., I want to have an influence on the next generation) is a common predictor of teaching readiness in all three countries. This corresponds with the idea in the literature that intrinsic motivation is crucial in both East Asia and the West (Zhu & Leung, 2011). However, the connotations of intrinsic motivation differ in the two cultures. Intrinsic motivation among Asian people involves attempts at mastering practices and gaining assurance from others, reflecting "social orientation." People in the West derive intrinsic motivation from individual interest and fulfilment, reflecting "individual orientation" (Laschke, 2013; Markus & Kitayama, 1991).

For the two Western countries, another motivating factor, *empathy from prior learning experience* (e.g., I love mathematics or I was always a good student in school), is predictive of future teachers' teaching readiness. Compared with Taiwan, teaching is a less desirable job and secondary school academic performance requirements for future teachers are less demanding in Germany and the US (Laschke, 2013; Schmidt et al., 2011). Thus, future teachers have various prior learning experiences. Positive experiences may serve as cognitive and affective supports for future teachers' teaching readiness. By contrast, teacher training and teacher jobs are competitive, because of benefits for teachers and social expectations. Typically, only secondary school students competent in mathematics are admitted. *Empathy from prior learning experience* was thus determined to be unimportant to teaching readiness in Taiwan.

In Taiwan, *secondary mathematics level* positively affects teaching readiness. The highest level of mathematics offered in Taiwanese schools is offered in three forms: 12th grade mathematics A (for students with science orientations), 12th grade mathematics B (for students with literature and arts orientations), and 11th grade vocational mathematics. The concepts and skills taught and the difficulty levels differ substantially among these courses (Hsieh et al., 2010). Future teachers who were more competent at secondary mathematics evaluated themselves to be more ready to teach.

	TW						DE	US
	M1	M2	M3	M4	M6	M7	M7	M7
Individual predictor								
Gender	ns							ns
Home language	ns						-0.28**	-0.40**
SES	0.24*	0.23*	0.15†	0.16†	0.16*	0.16*		
Sec. math level		0.61**	0.61**	0.58**	0.64**	0.64**		
Overall grades		ns					ns	
Intrinsic motivation			0.57**	0.59**	0.60**	0.60**	0.53**	1.11**
Salary and job security			ns					
Empathy			ns				0.21**	0.27*
MCK				0.001†				
MPCK				ns				
Institution predictor								
MCK								
MPCK								
MR-instructor,					0.57*	ns		
SB-supervisor					ns			ns
Courses arrangement						0.39†	0.65**	0.39**
Teaching coherence						ns	ns	ns
R^2 of level 1	3%	6.4%	17.4%	17.3%	21.4%	20.8%	10.7%	16/8%
R^2 of level 2					43.8%	42.1%	22.4%	64.7%

Note. ns = not significant. †$p < .1$. *$p < .05$. **$p < .01$.

Table 1: Hierarchical linear model for future teachers' teaching readiness.

SES predicts Taiwanese future teachers' teaching readiness. In Confucian culture, SES is often considered to be irrelevant to achievement. Whether SES affects future teachers' teaching readiness from a cognitive or an affective perspective warrants further study. It was unexpected that *home language* produces negative effects in Germany and the US for its representing immigrant status to some degree (Laschke, 2013). Further studies are needed.

Institution characteristics

Courses arrangement was determined to be predictive of future teachers' teaching readiness after controlling for individual predictors in all three countries. This indicated that *courses arrangement* is the most crucial factor to be modified by teacher education institutions in order to improve future teachers' teaching readiness.

In Taiwan, *teaching coherence* and *MR-instructor* were shown to have a significantly positive effect on the readiness when each of them is the single predictor at level 2, indicating that they were also crucial characteristics to modify to improve teaching readiness. When *courses arrangement* was singularly introduced in level 2, the proportions of variance explained by levels 1 and 2 were 20.8% and 39.3%; these percentages were close to those of M7. Most of the variance explained by *teaching coherence* and *MR-instructor* overlaps with that of *courses arrangement*, and *teaching coherence* and *MR-instructor* affect teaching readiness through *courses arrangement*. Germany and the US yielded similar results, but on different institution characteristics.

CONCLUSION

In Taiwan, Germany, and the US, future teachers' intrinsic motivation is a critical individual characteristic predictive of teaching readiness. In Taiwan, whether future teachers are science oriented is a predictor of the readiness, whereas whether future teachers had satisfactory prior learning experiences is predictive of the readiness in Germany and the US. Regarding institution characteristics, the consistency of courses and content arranged by institutions was determined to be most predictive of teaching readiness; thus, this factor is the most crucial factor to enhance in the institutions. Unexpectedly, MCK and MPCK were not observed to be predictive of teaching readiness. A gap exists between future teachers' knowledge and their evaluation of whether they are ready to teach mathematics. Further research is required.

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