

Mathematics in Initial Teacher Education Programs in Sweden, Germany, and Australia

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International comparisons of student achievement in mathematics and their attitudes towards, confidence with and anxiety to mathematics have a long history. Likewise, detailed international comparisons of teacher education programs have also been conducted. However, the relationship between the teacher education programs and teacher anxiety for teaching mathematics have not been investigated. This paper is part of a larger research project investigating the relationship between teacher education programs and mathematical anxiety of its pre-service teachers. It reports on the initial comparison of the teacher education programs for primary teachers from a university in Sweden, Germany, and Australia, specifically the mathematics education addressed in the programs. The paper concludes with an outline of the future research.

There is an emphasis on mathematics achievement in many nations, as evidenced by the discussions generated when results from international assessments such as the Programme for International Student Assessment (PISA) (see <http://www.oecd.org/pisa/>) and Trends in International Mathematics and Science Study (TIMSS) (see <https://timssandpirls.bc.edu/index.html>) are published. Both of these international assessments provide information on mathematics achievement of students at specific points in time within their education. Participating countries eagerly pour over their results and compare their position with past performances and with other countries. The focus for mathematics is often on performance. However, mathematics anxiety should also be a notable factor regarding mathematics achievement (Ramirez, Shaw, & Maloney, 2018). *Mathematics anxiety* can be defined as a conglomerate of negative emotions (e.g., fear, helplessness and shame) that occurs in maths-related situations and also has negative consequences for individuals, such as low achievement in mathematics.

In later iterations, PISA and TIMSS have expanded their focus to consider more than mathematics achievement at an international level. Foley, Herts, Borgonovi, Guerriero, Levine, and Beilock (2017) compared the 2012 results of mathematics anxiety and achievement for the PISA countries. They found that Sweden and Germany were similar in terms of mathematics anxiety but differed in achievement, whereas Australia and Germany were similar in terms of achievement but differed in terms of mathematics anxiety. Specifically, Australia had higher mathematics anxiety than Germany, and Sweden had the lowest anxiety of the three countries. For mathematics achievement, Germany had the highest achievement, followed by Australia then Sweden.

Lee (2009) used 2003 PISA data to compare mathematics self-concept, mathematics self-efficacy, mathematics anxiety, and mathematics achievement. The results showed that German students had a higher self-concept than Australian students and Swedish students; Swedish students had higher mathematics self-efficacy than German and Australian students; Australian students had higher mathematics anxiety than German and Swedish students (with Swedish students having the lowest mathematics anxiety of all participating countries); and Australian students had higher mathematics achievement than German and Swedish students.

TIMSS 2015 also considered students' views on mathematics, specifically whether they liked mathematics and their confidence in doing mathematics (Mullis, Martin, Foy, & 2019. In G. Hine, S. Blackley, & A. Cooke (Eds.). *Mathematics Education Research: Impacting Practice (Proceedings of the 42nd annual conference of the Mathematics Education Research Group of Australasia)* pp. 188-195. Perth: MERGA.

Hooper, 2016). For primary school students (Year 4) and whether they liked learning mathematics (very much like, like, do not like), Mullis et al. (2016) found similar results across the three countries, with between 35% to 38% of students identified in the category *very much like learning mathematics* (38% German, 37% Australian, 35% Swedish) and 25% to 27% of students identified in the category *do not like learning mathematics*. (27% German and Australian and 25% Swedish). In terms of confidence (with the options of very confident, confident, and not confident), Mullis et al. (2016) found greater variability, with 36% of Swedish and German students *very confident* in mathematics compared to 27% of Australian students; likewise, students who were not confident in mathematics, with Sweden having the lowest percent (15%), followed by Germany (22%), then Australia (27%).

Generally, mathematics anxiety usually is not the focus of the results of these international studies when countries examine and report on their results – the focus remains on mathematics achievement, even though mathematics anxiety can impact mathematics achievement (Ramirez et al., 2018). Mathematics anxiety also seems to be highly prevalent for pre-service primary school teachers. Empirical findings indicate that the level of mathematics anxiety changes only slightly from pre-service to in-service teachers (Gresham, 2018) and that teachers' mathematics anxiety can have negative effects on students' achievement (Ramirez et al., 2018).

The teacher impacts on how students engage with mathematics. Teachers' competence (Blömeke, Gustafsson, & Shavelson, 2015), conceptualisation of mathematics (Ernest, 1989), and anxiety towards mathematics (Beilock, Gunderson, Ramirez, & Levine, 2010) can all contribute to the teacher's actions in teaching mathematics. Tella (2008) found that the teacher's affective-motivational facets of competence in teaching mathematics best predicted primary school students' mathematics achievement. Tella (2008) concluded that teacher education programs should consider these aspects in teaching mathematics and interest in teaching mathematics. In a similar vein, Callingham et al. (2017) found that students in schools that had either achieved high performance or had demonstrated high gains in performance in national assessments of numeracy in Australia perceived their teachers as liking mathematics and being enthusiastic about teaching it. In contrast, Ramirez, Hooper, Kersting, Ferguson, and Yeager (2018) found teachers with mathematics anxiety may use teaching strategies that negatively impact students' mathematics achievement, regardless of the teacher's usable mathematics teaching knowledge.

As part of the Teacher Education and Development Study: Learning to Teach Mathematics (TEDS-M), Blömeke, Suhl, and Kaiser (2011) noted that pre-service primary school teachers' professional knowledge in mathematics differs across countries. It is assumed that the main reason is the variability of primary school teacher education programs across the countries, respectively the variability of specific opportunities to learn for future primary school teachers (Blömeke & Delaney, 2014). TEDS-M highlighted the role of the structure of teacher education programs in the development of maths-related knowledge besides the context of teacher training (e.g., socio-economic, political), characteristics of prospective teachers (e.g., motivational aspects), and characteristics of teacher students' lecturers (e.g., professional background) (Blömeke & Kaiser, 2014). However, TEDS-M did not examine affective characteristics of prospective teachers (as beliefs could be conceptualised as rather motivational or cognitive constructs) as results of teacher education programs. On the other hand, a large number of studies exists regarding research of (pre-service) primary school teachers' mathematics anxiety, but none of these studies examine the effects of different teacher education programs. Thus, the current study combines the idea of TEDS-M (differently structured teacher education programs, consequently different curricula) with the idea of the role of primary school teachers' mathematics anxiety.

A consideration of the content in the mathematics education courses for pre-service

primary school teachers may provide insight into the differences in how pre-service teachers engage with mathematics and their mathematical achievement, as well as their amelioration of mathematics anxiety (Ramirez, Shaw, & Maloney, 2018). Three countries are the focus of this research – Sweden, Germany, and Australia. As discussed above, school students in these countries have similarities and differences in terms of mathematics anxiety (Foley et al., 2017) and whether they liked learning mathematics (Mullis et al., 2016). Of these three countries, however, Germany was the only participant in TEDS-M (Blömeke & Kaiser, 2014).

Mathematics in Initial Teacher Education in Sweden, Germany, and Australia

Teacher education programs in Sweden, Germany, and Australia are all conducted at tertiary levels. Each country has organisations or governmental departments outside of the university that impact on teacher education programs. However, the universities in each country have some flexibility in their teacher education programs. Academics at a university in each of these countries examined the content of the Primary Education program that pre-service teachers would undertake to become teachers in a primary classroom setting. Each academic had access to the format of their program and identified where mathematics was evident in their course. This included mentions of mathematics content, pedagogy, and affective factors.

Sweden

In Sweden, a new teacher education program was implemented in 2011. It is the government, through propositions in parliament, who decides on the overall construct, but the details can vary between universities. The teacher education program and the objectives of the education are the same all over Sweden and are stated in the Higher Education Ordinance (2015). The pre-school class and school Years 1 to 3 concerns children age 6 to 10 years. The program provides the teacher with a broad knowledge for teaching most of the school subjects. The knowledge of how to teach children to read and write and how to teach mathematics to young children is the core content, as well as English, science and social science for young children. The subjects are studied integrated with subject didactics. Mathematics and mathematics didactics are totally studied one full semester (30 ECTS), but there are three or four courses spread over the years. The courses are arithmetic, pre-algebra, geometry and problem solving. The same occurs for Swedish and English. The students have to take at least 15 ECTS of natural science and technology, and 15 ECTS social science and can add 15 ECTS more of one of those subjects. They study general teacher “skills” (pedagogy, social relations, school history, special needs, rhetoric, and curriculum theory) for three semesters (45 ECTS). Within the teacher program there is 30 ECTS (one semester) of practice in schools, and usually the time is divided into three or four occasions of practices of different lengths. The Higher Education Ordinance, (2015, ‘Förskollärarexamen’, para. 3) states “Courses in core education subjects (60 ECTS) shall be linked to future professional practice” and specifies seven areas that must be addressed. These areas focus more on pedagogy rather than specific content. The pre-service teacher must complete an independent project (degree project) for at least 30 ECTS or two such projects for at least 15 credits in one or two of the subjects studied as a requirement.

Germany

In general, the teacher education programs are regulated by each university itself in Germany. The universities have to meet some requirements, given by governmental laws and standards or recommendations, given by subject-specific societies and the

Kultusministerkonferenz KMK (=Standing Conference of the Ministers of Education and Cultural Affairs of the States in the Federal Republic of Germany, 2014).

In Germany, two different types of teacher education concerning primary school exist. The first type describes teachers who are qualified for teaching only at primary level. The second type describes teachers who are qualified for teaching at primary level and additionally at the first secondary level (Years 5 and 6). As teacher education is governed by each federal state, teacher education programs differ throughout Germany, and in Berlin, only the second type of teacher education exists.

As Blömeke, Kaiser and Lehmann (2010) state, teacher education shows a huge variety regarding content and structure in Germany compared to other countries. Usually, primary school teachers have to teach all subjects at school in Germany (Porsch, Strietholt, Macharski, & Bromme, 2015). Usually there are no constraints for studying mathematics for primary school at university. It is assumed that future primary school teachers in Germany undertake the level of primary school mathematics taught at university (Porsch et al., 2015).

Two main guidelines determine the content to study in teacher education at universities: On the one hand, the “Lehrkräftebildungsgesetz” (teacher education law, specific for each federal state) regulates the formal outline of the teacher program. On the other hand, subject-specific standards for teacher education drawn up by subject-specific committees (e.g., the Society of Didactics of Mathematics) recommend mathematical content to be taught at universities (number and operations; geometry; patterns and structures; quantities and measurement; data and chance) and maths-related processes (modelling, representing, problem-solving, communicating, and reasoning).

The teacher education program consists of two stages: first, the Bachelor of Education stage (six semesters) and second, the Master of Education stage (four semesters). Both degrees are required for teaching at primary school. During both stages, courses concerning mathematical content as well as mathematics didactics are offered besides general pedagogy and other subjects. During the master stage, a six-month-practice phase is also part of the program. Usually, about 25% of all courses are related to mathematics (content and didactics). When mathematics is one of the chosen main subjects, the number of maths-related courses increases to 35% of all courses. During the first and the second semester, arithmetic and its didactics is the main topic of the program for future primary school teachers, followed by geometry and its didactics (third semester) and stochastic and a general introduction to mathematics didactics in the fourth semester. In the fifth semester, only mathematics didactics-related courses take place. During the sixth semester, only courses for students specialising in mathematics take place. These courses are about problem-solving and mathematical proofs at primary school and research on mathematics didactical issues. During the four-semester master stage, courses related to mathematics in Years 5 and 6 and mathematics didactics courses (e.g., diagnosing students’ competencies in mathematics in the light of heterogeneity) take place. After a practice phase for six months, the master thesis as the final exam of this stage has to be written by the future teachers.

After studying at university, future primary school teachers have to take a 2-year internship at primary school. After completing this so called “Referendariat” the teacher students are awarded their professional teaching certificate.

Australia

In their review of teacher education in Australia, Groundwater-Smith and Mockler (2017) stated that “more and more of the university curriculum has been appropriated to meet the various state and national standards and accreditation requirements ... audits and quality-assurance procedures” (p. 129) and “require tighter and more technical standards for initial teacher education” (p. 133). There are several organisations that either provide

accreditation processes or guidelines to ensure that the content of the programs is sufficient to enable graduating students to become teachers. The Tertiary and Education Quality and Standards Agency [TEQSA] (n.d.) is an Australian Government agency responsible for regulatory and quality assurance within the Australian tertiary education sector. The Australian Institute for Teaching and School Leadership (AITSL) is responsible for the national Accreditation Standards and Procedures used as the basis of the accreditation of initial teacher education programs (Australian Institute for Teaching and School Leadership [AITSL], 2018). Teacher regulatory boards and authorities (TRBs) for each state and territory are where graduates are required to register before they can apply or be appointed to teaching positions and are responsible for the accreditation of the initial teacher education programs that are provided in that state or territory (AITSL, n.d.).

At one metropolitan university campus that has both local and national cohorts, students are able to complete an initial teacher education qualification either as a four-year Bachelor degree or a two-year Master degree (if they already have an undergraduate degree not in initial teacher education) for local and Australia-wide students. The focus in this research is on the Bachelor of Education Primary program (for teaching children in Years 1 to 6) as taught to local students. Students completing the Bachelor of Education Primary program are generalists, qualified and expected to teach all subjects in the primary curriculum.

The structure of the degree will be outlined as provided in the course plan. In total, there are 29 units. All units, except the final Internship, are worth 25 credit points (the Internship is 100 points). A student working through the program with a full-time load would complete 100 credits points per semester (equivalent to four units, except the Internship, which is completed by itself). Four professional practice units are within the program, with the final one being the Internship completed in fourth year.

There are four mathematics education units, one undertaken in each year of the program. The mathematics education units are taught in the second semester for first and second year of the program and in the first semester for the third and fourth year of the program. The outcomes of the four units focus on the mathematics identified within the Australian Curriculum: Mathematics (Australian Curriculum, Assessment and Reporting Authority [ACARA], n.d.), which addresses both proficiency and content. The content includes number, algebra, geometry, measurement, statistics, and probability and the proficiency strands are problem solving, reasoning, fluency, and understanding (ACARA, n.d.). The course also addresses personal numeracy; analysis of curriculum documents; best practice in mathematics education; interpreting children's demonstration of mathematical understandings; assessment; using technology and resources in teaching and learning; planning for teaching and learning that incorporates strategies, technologies and resources; creating lesson plans and series of lessons; appraising constructivist approaches to teaching; evaluating strategies and resources; and critiquing mathematics teaching. As well as completing the mathematics education units, students must also sit and achieve the standard in the Literacy and Numeracy Test for Initial Education students [LANTITE] to graduate and potentially to gain registration with their state or territory TRB (Australian Council for Educational Research, n.d.).

Comparison

The Initial Teacher Education programs from Sweden, Germany, Australia have similarities and differences in both the oversight and what is addressed in the program. Entry into the programs for each of the universities is via university selection processes based on university-set criteria. There are no specific requirements regarding prior mathematical achievement – a factor not to be ignored when it comes to prospective teachers' mathematics anxiety. For all three countries, it can be assumed that school students who want to become

primary school teachers do not necessarily reflect the “high-achiever portion” in their country. There are external requirements for the programs for Sweden, Germany, and Australia at the national level, and Germany also has state-level requirements. Germany also has subject-specific committees that recommend the mathematical content to be taught. The Bachelor program in Sweden and Australia is four years full-time equivalent, whereas it is five years full-time equivalent in Germany for the three-year Bachelor and two-year Masters. Germany’s approach is different to that of Sweden and Australia, reflecting the “hybrid system” noted by Blömeke and Kaiser (2014, p. 29). All programs develop generalist teachers who can teach all of the curriculum content in the primary school years. The practical experience in schools occurs over the course of the program in the Swedish and Australian universities. For the German University, there is a six-month practice in the Masters phase and a two-year Internship after the completion of the Masters coursework.

The Swedish and Australian universities have similar numbers of mathematics education courses, roughly one per year, whereas in the German university, there is one per semester for the first stage (three years) and a minimum of one per quarter for the Masters stage (not including the practice phase). All universities integrate pedagogy and didactics with the mathematics content. The mathematical content taught in the Swedish and German universities is similar when comparing the four-year Swedish Bachelor program to the three-year German Bachelor program. The content in the Australian program specifically mentions measurement, statistics, and probability, which are not listed in the Swedish and German programs, although the Swedish and German programs specify arithmetic (which is considered as *number* in Australia) and the German program mentions “stochastics”. All university programs include problem solving, with the Australian program mentioning proficiency strands (ACARA, n.d.) – reasoning, fluency, and understanding – with problem solving as the fourth. Although mathematical content is addressed by all of the programs, none of the programs specifically mentions addressing pre-service teacher mathematics anxiety. At the German University, a voluntary course regarding emotional experiences in mathematics classes exists. However, this course focuses on primary school students and not future teachers.

Conclusion and Future Research

It can be argued that the assessments completed during the courses within each of the programs determine whether students have developed sufficient understandings, particularly those of mathematical content and mathematical pedagogical content knowledge (Shulman, 1986; Ball & Bass, 2000). However, measures of other factors that can impact on mathematical content knowledge and engagement with mathematics (Blömeke et al., 2015) are not considered. That is, have students completing the program developed, maintained, or improved anxiety they might have regarding mathematics (Gresham, 2018), particularly as this has the capacity to impact on their perception of mathematics, their engagement with mathematics, and how they address mathematics when an educator (Ernest, 1989; Ramirez, Shaw, et al., 2018).

Initial teacher education qualifications need to develop teachers who have content and pedagogical knowledge (Shulman, 1986; Ball & Bass, 2000) but also the willingness and enthusiasm to engage with and teach mathematics (Callingham et al. 2017). As Tella (2008) noted, the teacher’s affective-motivational disposition in teaching mathematics and their interest in teaching mathematics should also be considered. Likewise, Gresham’s (2018) findings that improvements in mathematics anxiety can be greatest over the duration of the initial teacher education qualification than once it is completed. In addition, mathematics anxiety can interact with mathematical self-efficacy, mathematical engagement, and mathematical understandings (Luttenberger, Wimmer, & Paechter, 2018). An international

comparison of mathematics education programs and the pre-service teachers' mathematics anxiety could lead to suggestions for practice within teacher education. The future research will consider what it is within teacher education programs that can build content knowledge, enthusiasm, self-efficacy, and interest, whilst reducing mathematics anxiety.

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