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Editorial: Traditions and Trends in Mathematics, Science and Technology Education in Germany

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In these days mathematics, science and technology education in Germany is in a phase of intense reform. Initiated by the results of PISA 2000 and some further national and international studies, many initiatives started in Germany for making learning in the STEM subjects more efficient and motivating. In 2004, for the first time ever, Germany got nation-wide standards in mathematics and science education for the lower secondary schooling level. A lot of projects were launched to accompany and support the implementation of the new standards.

However, national standards for mathematics and science education in Germany are still operated differently by all 16 German federal states ('Länder'), as all 16 federal states have varying educational systems. Thus, a great variety exists and achievements in the German federal states differ much from one to another. However, there are also some common trends. Many of the German federal states started moving away from a traditional system of having had quite independent basic, middle and grammar schools for the lower secondary schooling level. More and more comprehensive schools are established and many of them offer full-day programs instead of half-day schooling which was the prevalent approach in the past. Also many innovations in primary and pre-primary science and mathematics education were started to get a better ground for secondary schooling and further education.

Many of these reforms touch teaching in the STEM subjects. After traditionally having had independent subjects in secondary science education all over the country, namely Biology, Chemistry, and Physics, today we see a trend towards more integrated science education at least for the first years of the lower secondary level (especially grades 5-8; age range 10-14). In science as well as in mathematics education, standards and governmental syllabi suggest a greater orientation towards everyday life contexts and socio-scientific issues as the starters for science learning. They also give a plea for a more skill-oriented paradigm of teaching as well as a more student-centered pedagogy. Foci of innovation projects were context-based and societal-oriented mathematics and science curricula, autonomous and cooperative learning, integrating formal and non-formal education, or a different culture of assessment and evaluation. Additionally, general changes in the educational systems also contributed to the challenges for mathematics and science education and initiated domain-specific projects of research and development, namely challenges by a growing diversity of students concerning achievement, linguistic skills, and socio-cultural backgrounds in science and mathematics classes, as well as issues that arose from a more thorough way towards inclusive education (e.g. Abels, 2014; Markic, 2014).

However, traditions in German mathematics, science and technology education, both in the fields of practice and academic research, have a much longer tradition. Since the 1970s many professorships and chairs were established for doing research and educational development in one of the STEM subjects. The German term for domain-specific educational research is Fachdidaktik. Fachdidaktik founds itself in a tradition of Bildung- and Didaktik-based education (Westbury, Hopman & Riquarts, 2000). This is a framework that found its way more and more into the international literature in recent years (e.g. Elmose & Roth, 2005; Hofstein, Eilks & Bybee, 2011; Sjöström, 2013). Fachdidaktik in this means stands for both, a domain of knowledge and an academic field of research and training. The knowledge domain can be understood as the corresponding Pedagogical Content Knowledge (PCK) in the subject in question. However, Kansanen (2009) suggested that the concept of Fachdidaktik is broader. Kansanen justified his claim by the connection of Fachdidaktik to the concept of Bildung and thus he sees Fachdidaktik as being more value-driven and originally less based in empirical research. Nevertheless, there is a big overlap between Fachdidaktik-knowledge

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and PCK. Both concepts represent the wide range of knowledge about the curriculum, pedagogies, experiments, models, or students' learning difficulties. The traditions in Fachdidaktik in Germany as academic fields are thus also very broad in focus and in methods. Fachdidaktik in the STEM subjects in Germany is made up by more than 300 research groups at German universities and universities of education with their courses, MEd and PhD programs, and research activities. The research domains cover the fields of formal, via non-formal and informal education, towards public understanding of science. Objectives range from pure research on learning processes and students' understanding, via curriculum design, towards the development of new school-type experiments and media. And the methods applied have a spectrum from explorative and descriptive quantitative and qualitative educational research, via educational design research, towards evidence-based curriculum development or action research (Eilks, 2014).

As it is the case for the field of STEM teaching also the academic fields of mathematics, science and technology education in Germany are in transition. Until the end of the last century only very few German scholars from the field were present on international conferences, even less published regularly in international journals or book series. At least the first observation changed in the last decade and there are indications for change also in the second. Many of the German STEM educators participate now in international networks, e.g. the many international cooperation programs funded by the European Union; participation in international conferences raised significantly. Nevertheless, there are still areas and achievements of German mathematics, science and technology education research and development that are not available in the international literature although there are clear connections of developments in Germany with those in other countries and on the international level. Searches in Google Scholar and in the Web of Science document that only around a quarter of the Germany mathematics, science and technology educators on the level of senior academic staff or professorships is publishing their research in international quality journals or handbook literature, there are even less doing this frequently. However, change is to come. This special issue intends to contribute closing this gap. The issue intends to show the richness of German STEM education research and educational development. It is also thought to offer starting points for future exchange and even more intense international cooperation.

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