Research in University Mathematics Education: The khdm

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The khdm[1] (German Centre for Higher Mathematics Education) was founded in 2010. In 2010, there had been a call *Bologna – Zukunft der Lehre* (future of teaching) by the German foundations VolkswagenStiftung and Stiftung Mercator that intended to provide financial support for projects aiming to optimise teaching and learning at traditional universities and universities for applied sciences. The proposal of the khdm was among the few successful ones. It was submitted by the Universities of Paderborn and Kassel with Rolf Biehler and Reinhard Hochmuth responsible. Together with Hans-Georg Rück from the University of Kassel, they form the current board of managing directors. After an intermediate period, where the University of Lüneburg joined the khdm, the khdm is now about to get the University of Hanover as a third partner university. The financial support by the foundations ended in 2015 but the centre will continue to operate with financial support from the three universities and further third party grants.

The main objective of the khdm is the realisation of research and development projects in cooperation with mathematicians and mathematics educators. Altogether, 15 professors from Kassel, Paderborn and Hanover work together with about 15 research assistants, most of whom are PhD students.

The starting point was a network of projects that were strongly focused on specific needs in various courses of study: the education of primary and lower secondary school mathematics teachers, mathematics majors and future high school teachers (Gymnasium), economists and engineers. Further projects focused on e-learning issues, in particular in the context of the secondary-tertiary transition. These five domains correspond to five working groups established within the khdm.

In order to give an insight into the research carried out by the khdm, we will describe two projects in more detail.

A first example is a cooperation project between mathematicians and mathematics educators. At the University of Kassel, this cooperation has led to a modification of the first year curriculum of mathematics majors, including a newly established course that focuses on mathematical thinking and working styles. In addition, the project f-f-u[2] (integration of mathematics and mathematics education at university), led by Andreas Eichler, Maria Specovius-Neugebauer and Hans-Georg Rück, develops teacher oriented exercises for these courses that are appropriate to illustrate connections between mathematics at university

[1] Kompetenzzentrum Hochschuldidaktik Mathematik.

[2] Vernetzung fachwissenschaftlichen, fachdidaktischen und unterrichtspraktischen Wissens im Bereich Mathematik.

level and school mathematics. These exercises should encourage teacher students to learn university mathematics with more engagement and motivation because they will better see its benefits for their future teaching. It is part of a larger project named PRONET[3] (professionalisation through interconnection) at the University of Kassel, funded by the BMBF (the German Federal Ministry of Education and Research).

A second example is a project carried out in cooperation with 14 other universities, the WiGeMath[4] project, which is a BMBF-financed joint project of the Universities of Hanover and Paderborn, led by Rolf Biehler, Reinhard Hochmuth and Niclas Schaper and running from 2015 to 2018 (Colberg et al., 2016). It evaluates different types of projects for supporting students in university mathematics, including bridging courses, mathematics support centres, redesigned lectures and support measures accompanying regular courses (e.g. special tutorials or the provision of online learning material) in programmes for secondary school mathematics teachers as well as regular mathematics and engineering programmes. One part of the evaluation uses a programme evaluation approach (Chen, 1994) that aims at reconstructing and evaluating goals, measures and their boundary conditions from the point of view of the involved protagonists. Moreover, some of the intended effects of the projects are investigated by control group designs that follow a quantitative empirical research paradigm.

Whereas these projects concentrate on innovations in whole courses and effects on the participants of courses, a considerable number of PhD students carry out their research within the khdm. Many of them study student learning processes related to specific topics such as convergence of sequences, derivatives, the vector concept and vector spaces, as well as mathematical activities such as proving and problem solving. Moreover, research on fostering student motivation, interest and learning strategies are the focus of other PhD projects.

Besides doing research and developing teaching, one major task of the khdm is to provide specific benefits and services for its home universities. Firstly, the khdm provides a natural context for interdisciplinary and collaborative research studies within and across our universities. Secondly, for the PhD students, it provides professional development on research methods and design, as well as regular forums for the exchange of practical experience and results of their research. Beyond that, there are also more personal exchanges on individual development processes, such as starting as a mathematician with some interest in teaching and becoming a researcher in higher mathematics education. In addition, the khdm provides some service and advisory competence for teaching mathematics at our home universities. Rather important is that the khdm builds a critical mass for applying and getting external funding through grants.

Last but not least, the khdm is an actor in the European research community that has recently developed. The khdm organised a workshop at the Oberwolfach Research Institute for Mathematics (MFO Mathematisches Forschungsinstitut Oberwolfach) in December 2014 under the title "Mathematics in Undergraduate Study Programs: Challenges for Research and for the Dialogue between Mathematics and Didactics of Mathematics" (Biehler et al., 2014). Another conference organised by the khdm was the international conference on "Didactics of Mathematics in Higher Education as a Scientific Discipline" in Schloss Herrenhausen, Hanover, in November 2015 (Göller et al., in press). Moreover, we are planning common activities with our colleagues from England, France, Norway, Denmark, Spain and other countries in the context of INDRUM, the International Network for Didactic Research in University Mathematics (indrum2016.sciencesconf.org).

Since its beginning, the khdm has been critically and constructively accompanied by an international scientific board, consisting of Tommy Dreyfus, Willibald Dörfler, Daniel Grieser, Lisa Hefendehl-Hebeker (chair), Holger Horz, Jürg Kramer and Johannes Wildt.

More information can also be found at the website http://www.khdm.de/en/.

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Rolf Biehler, Reinhard Hochmuth and Hans-Georg Rück are the current managing directors of the khdm. All three studied mathematics. Rolf Biehler is a professor of didactics of mathematics at the University of Paderborn, previously in Kassel. Reinhard Hochmuth has been a professor of didactics of mathematics at the University of Hanover since 2014 and was a professor of mathematics at the Universities of Lüneburg and Kassel before. Hans-Georg Rück is a professor of mathematics at the University of Kassel. Robin Göller, Axel Hoppenbrock, Michael Liebendörfer and Juliane Püschl are researchers at the khdm doing their PhDs but working at the same time on the management team of the kdhm. Robin, Michael and Juliane joined the khdm after having finished their diplomas or state examinations in mathematics. Axel had been teaching mathematics at school level for several years before he joined the khdm.

[3] Professionalisierung durch Vernetzung.

[4] Wirkung und Gelingensbedingungen von Unterstützungsmaßnahmen für mathematikbezogenes Lernen in der Studieneingangsphase.