Country Reports

Germany

Germany has been found to have a particularly successful approach to maths in the post-16 vocational sector and may be of particular use and/or relevance to the UK context. Maths, for example, remains an important component of general education alongside technical and vocational training and approximately 80% of VET programmes in Germany have some maths component. Maths education is also specifically aimed at consolidating learners' numeracy skills that have been previously acquired in general education.

1.1 Relevant Policy

Responsibility for vocational education and training in Germany is shared between the federal Government, which oversees in-company training, and 16 *Länder (*or states), which are responsible for publicly provided schools.[1] Germany has a dual training system, through which training is delivered both in companies and through vocational schools; young people may move to the dual training scheme after completing compulsory full-time education.[2]

There are ongoing policy and structural reforms that aim to address the need for greater flexibility within the early academic/vocational divide, for example, by creating more mixed institutions.[3] There have also been more pathways created that allow learners to move from upper secondary VET to tertiary education, as well as attempts to create a transition system, although current transition arrangements are reported to be fragmented.[4]

The German Centre for Continuous Professional Development (DZLM) has recently been established to address the skills shortages in maths teaching; the status of maths in VET; and the level of maths skills acquired by VET students. It accomplishes this by supporting the professional development of maths teachers and to engaging learners, teachers and parents in maths and science.[5] The development of this centre has drawn on the UK experience of establishing the state-funded National Centre of Excellence in Teaching Mathematics (NCETM) in 2006.[6]

There appear to specific issues related to equity and equality of access with respect to engagement with maths education and training in Germany. There is a clear gender gap, for example, in terms of motivation to study maths; this gap in motivation is wider in Germany than the OECD average.[7] The impact of socio-economic disadvantage on maths learning is also greater in Germany than the OECD average.[8]

Some initiatives have attempted to address this imbalance, in particular, the action day for girls initiative (described below). There does appear to have been some progress; the 2012 PISA results show that the influence of socio-economic status on maths performance has weakened and that there have been significant improvements in the performance of low-achieving learners.[9] The additional disadvantage faced by immigrant learners with respect to maths proficiency has also reduced between 2003 and 2012.[10] Nonetheless, the disadvantages faced by immigrant students, low achievers, those of low socio-economic status and female students remain substantial.[11]

1.2 Institutions and Courses

General System

In Germany, schooling is compulsory from six to 18 years of age. The (primary) education phase typically lasts four years, or six years in Berlin and Brandenburg. Secondary education varies across the different *Länder*. All states offer the academic *Gymnasium* route up to Grade 12. Technical, vocational and general routes include *Realschule* (up to Grade 10), *Mittelschule, Regionale Schule*, and *Hauptschule* (up to Grades 9-11 depending on specific state) and a number of comprehensive *Gesamtschule* (up to Grade 12). Learners may attend *Fachoberschule*, or technical school, from Grade 10 onwards. The route that learners follow is determined differently according to state and local guidelines.[12]

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[1] http://www.cedefop.europa.eu/en/Files/5173_EN.PDF
[2] http://www.cedefop.europa.eu/en/Files/5173_EN.PDF
[3] http://www.oecd.org/germany/PISA-2012-results-germany.pdf
[4] http://www.oecd.org/education/skills-beyond-school/47955326.pdf
[5] http://www.euro-math-soc.eu/ems_education/Country_Reports_Education_Committe.pdf
[6] http://www.euro-math-soc.eu/ems_education/Country_Reports_Education_Committe.pdf
[7] http://www.oecd.org/germany/PISA-2012-results-germany.pdf
[8] http://www.oecd.org/germany/PISA-2012-results-germany.pdf
[9] http://www.oecd.org/germany/PISA-2012-results-germany.pdf
[10] http://www.oecd.org/germany/PISA-2012-results-germany.pdf
[11] http://www.oecd.org/germany/PISA-2012-results-germany.pdf
[12] https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Germany:Overview

The focus at primary level for children in Germany is on reading, writing and arithmetic[13]. Legislation regarding secondary education varies across the states. Lower secondary education is provided at *Gymnasium*, *Realschule*, *Hauptschule* or *Gesamtschule* up to Grades 9 or 10; upper secondary up to Grades 12 or 13[14] (in general or vocational education schools in the dual system and comprises *Gymnasium*, *Gesamtschule*, *Abendgymnasium* and *Berufsbildende Schule* (vocational schools)[15].

Each secondary education route has an exit point with a corresponding assessment and qualification. For progression to university, an *Abitur* qualification is required, although some equivalents and alternative access routes are becoming more commonly accepted. The majority of students attending *Gymnasium*, and some students attending the *Gesamtschule,* will gain an *Abitur*.[16]

For learners pursuing an academic route at secondary level, there is a formal syllabus that allows for a degree of local flexibility.[17] The syllabus has traditionally focused more on academic approaches to maths education and there remains some tension between the priority given to 'pure' and 'applied' maths.[18] Maths performance is above OECD average.[19]

Vocational Courses

Following compulsory education, a vocational route is provided through apprenticeship programmes. These programmes typically comprise a combination of two days a week at a *Berufsschule* (vocational school) and the remaining weekday working as a salaried, employed apprentice in a company. Apprentices are registered at the chamber of industry and commerce (IHK). There is also a professional vocational route that registers participants with relevant professional associations. This route allows for a career in a wide range of professions up to all levels unless a higher degree is required.[20]

For students pursuing a vocational route at secondary and post-secondary levels, general school education continues alongside technical and vocational training. Maths remains an important component of this general education.[21] Detailed data for levels of participation by VET learners in maths are not available for Germany, but it is estimated that about 80% of VET programmes have some maths component.[22]

1.3 Practice and Pedagogy

In the classroom strand of VET programmes in the *Berufsscule*, two to three hours per week are typically allocated to vocational maths.[23] Maths education is specifically aimed at consolidating learners' numeracy skills, previously acquired in general education.[24] There is also a broader aspiration that all maths teaching, vocational as well as academic, should develop logical thinking, philosophical understanding and self-reflection.[25]

In practice, however, maths is not always seen as a priority for learners and apprentices, partly because the final assessment at the end of apprenticeships (the Chamber exam) does not take account of school performance.[26] This can lead to apprentices focusing more on the vocational learning and less on developing and consolidating maths learning.[27] In a multi-country study that includes Germany, vocational instructors expressed concern that while mathematical knowledge does not affect the ability to graduate successfully from VET programmes, it may limit the ability to function effectively in the workplace.[28]

The early choice made by students between vocational and academic education routes determines the nature of young people's engagement with maths learning.[29] For those taking the academic route, there is a formal syllabus through to Grade 12 and learners must achieve the required level in maths in order to pass the *Abitur* examinations.[30] For students taking one of the vocational routes available, the vocational component of the course is typically seen as key

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[13] http://ec.europa.eu/ploteus/sites/eac-eqf/files/German_EQF_Referencing_Report.pdf
[14] http://www.nuffieldfoundation.org/sites/default/files/files/GERMANY%20(R-P)%20country%20profilev_FINAL.pdf
[15] http://ec.europa.eu/ploteus/sites/eac-eqf/files/German_EQF_Referencing_Report.pdf
[16] http://www.oecd.org/education/skills-beyond-school/ASkillsbeyondSchoolReviewofGermany.pdf
[17] http://www.history.didaktik.mathematik.uni-wuerzburg.de/meg/weidiga2.html
[18] http://www.euro-math-soc.eu/ems_education/Country_Reports_Education_Committe.pdf
[19] http://www.oecd.org/germany/PISA-2012-results-germany.pdf
[20] http://www.oecd.org/education/skills-beyond-school/ASkillsbeyondSchoolReviewofGermany.pdf
[21] http://www.oecd.org/education/skills-beyond-school/47955326.pdf
[22] http://www.nuffieldfoundation.org/sites/default/files/files/Towards_universal_participation_in_post_16_maths_v_FINAL.pdf
[23] Rudolf Straesser, R., (2002), Mathematical Means and Models from Vocational Contexts, Education for Mathematics in the Workplace, Mathematics Education Library Volume 24, 2002, pp 65-80
[24] Rudolf Straesser, R., (2002), Mathematical Means and Models from Vocational Contexts, Education for Mathematics in the Workplace, Mathematics Education Library Volume 24, 2002, pp 65-80
[25] Rudolf Straesser, R., (2002), Mathematical Means and Models from Vocational Contexts, Education for Mathematics in the Workplace, Mathematics Education Library Volume 24, 2002, pp 65-80
[26] http://www.oecd.org/education/skills-beyond-school/47955326.pdf
[27] http://www.oecd.org/education/skills-beyond-school/47955326.pdf
[28] Hodgen, J., et. al. (2013), 'Towards universal participation in post-16 mathematics: lessons from high performing countries', Nuffield Foundation.
[29] http://www.oecd.org/germany/PISA-2012-results-germany.pdf
[30] http://www.history.didaktik.mathematik.uni-wuerzburg.de/meg/weidiga2.html

to future employment, not least because it is directly examined to obtain final course qualification.[31] Assessing the level of core numeracy and maths skills of VET participants is not required for most programmes.[32] This applies to both compulsory and post-compulsory stages of VET.[33] Given that a high proportion of students follow the vocational route, participation rates in advanced mathematics is relatively low.[34]

ICO Textile Mill[35]

Target Group:

Apprentices needing maths support across a range of trades at ICO and other small and medium enterprises (SMEs) that do not currently have provision for maths training.

Context:

The ICO Textile Mill currently comprises 32 companies and includes a Commercial and Technical Apprenticeship Department which oversees all apprenticeship training. Trainees work on a rotation basis across different trades within a large industrial organisation.

Nature of Intervention:

The apprenticeship scheme needs to be able to support a diverse group specialising in different areas. It has established a system of maths support in the workplace to complement this training.

Results/Impact:

Trainees have tailored support that complements their off-the-job training and that enables them to consolidate and apply maths skills. This allows apprentices to progress to appropriate levels and develops the potential for transition to higher education. One trainee, for example, described in an interview how he was studying Physics and Applied Mathematics and expected to be moving to study at a higher level.

Lessons Learned:

This is an example of how maths support can be provided in a range of complementary ways that increase the effectiveness of learning and that contribute to the possibility of progression beyond VET. It also demonstrates the potential of larger companies to maths skills for employees at SME's, and so contribute to building maths capacity in the VET system overall.

Berufsschule 1 Aschaffenburg (Vocational School)[36]

Target Group:

Vocational apprentices from a range of companies.

Context:

This is a vocational school with a variety of exit points.

Nature of Intervention:

The use of specialised mathematical techniques to solve a problem. Instruction is provided by dual qualified technical teachers.

Results/Impact:

This is an example of a programme which provides training at three levels:

- Technicians after four years
- Specialised/Advanced technicians after six years
- Engineers – those who completed the six years with high final results can make the transition to university and become engineers.

Lessons Learned:

This example illustrates the substantial nature of vocational training and the contextualised approach to maths with the potential for progression to higher level maths.

German Electron Synchrotron (DESY) Action Day for Girls[37]

Target Group:

Female students who may consider maths or science training in a vocational context.

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[31] http://www.oecd.org/education/skills-beyond-school/47955326.pdf
[32] http://www.oecd.org/education/skills-beyond-school/47955326.pdf
[33] http://www.oecd.org/education/skills-beyond-school/47955326.pdf
[34] http://www.oecd.org/education/skills-beyond-school/47955326.pdf
[35] https://www.det.nsw.edu.au/media/downloads/what-we-offer/awards-scholarships-and-grants/scholarships/premier-s-teacher-scholarships/volume9/tafe_ziems.doc
[36] https://www.det.nsw.edu.au/media/downloads/what-we-offer/awards-scholarships-and-grants/scholarships/premier-s-teacher-scholarships/volume9/tafe_ziems.doc
[37] http://www.spiegel.de/international/germany/germany-boosts-efforts-to-get-women-in-stem-fields-a-924023.html

Context:

This is one of a number of initiatives to attract female students into maths and science training and careers. It responds directly to demographic changes that have led to a shortage in the labour supply, and increasing competition for the engagement of young people in maths and science. It also addresses the fact that females are less likely to specialise in maths and science.

Nature of Intervention:

200 female students attended an action day for girls at this large company in Hamburg. Students were welcomed and given an information briefing by a business director and information to take away. There were then opportunities to talk to female employees in a range of roles and to discuss career opportunities which would use maths and science skills. This was followed by tours in small groups.

Results/Impact:

This initiative has the potential to:

- Develop greater understanding among the visiting female students about the nature of careers at DESY which use maths and science skills;
- Create a ripple effect which raises the awareness of peers and families of the possibilities of maths and science careers as realistic options for young females;
- Raise the awareness at DESY of the potential of female trainees and the value of an additional labour market supply pool.

Lessons Learned:

This initiative illustrates the recognition by German industry of the need to engage more young people in mathematics, and in particular the role of positive action initiatives to engage a wider pool of young people in maths and science.

1.4 Key Points of Learning

Vocational and academic routes are separated at an early stage. This affects student expectations and their engagement with mathematics. It has been recognised that limitations arise from the inflexibility of this early vocational/academic divide. In the context of rapid technological change and the need for a sound grasp of mathematics, there are a number of measures in place to develop more blended pathways and greater opportunity for transition between academic and vocational routes.

For students pursuing a vocational route at secondary and post-secondary levels, general school education continues alongside technical and vocational training. Maths remains an important component of this general education. It is estimated that about 80% of VET programmes have some maths component.

In the classroom strand of VET programmes in the *Berufsscule*, two to three hours per week are typically allocated to vocational maths. Maths education is specifically aimed at consolidating learners' numeracy skills, previously acquired in general education. There is also a broader aspiration that all maths teaching, vocational as well as academic, should develop logical thinking, philosophical understanding and self-reflection.