

Angela Ittel, Anja Meyer N. Pereira (Hg.)

Internationalisierung der Curricula in den MINT-Fächern

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Vorwort

Tagungsband Internationalisierung der Curricula in den MINT-Fächern

Neue Technologien, Globalisierung und die fortschreitende Digitalisierung verändern unsere Welt, wodurch die Bedeutung der sogenannten MINT-Fächer – Mathematik, Informatik, Naturwissenschaften und Technik – an den Universitäten in den nächsten Jahren noch stärker in den Fokus rückt.

Die Universitäten stehen vor der Herausforderung den MINT-Nachwuchs auf die Chancen, Risiken und Unsicherheiten einer globalisierten Welt bestmöglich vorzubereiten und sie gleichzeitig zu verantwortungsbewussten Weltbürger*innen (*global citizenship*) auszubilden.

Einher mit der Entwicklung geht die dringend notwendig gewordene Internationalisierung der Curricula, deren Relevanz durch die zunehmenden Anforderungen an Internationalisierung deutlich an Dynamik hinzugewonnen hat. Dies wird u. a. durch das Empfehlungsschreiben¹ der Mitgliederversammlung der Hochschulrektorenkonferenz (HRK) vom Mai 2017 verdeutlicht, das Internationalisierung als Querschnittsaufgabe begreift und somit eine Verankerung internationaler Dimensionen in allen Curricula empfiehlt. Der damit verbundene Kulturwandel zu einer internationaleren Einrichtung von der Hochschulleitung über die Lehrenden und Studierenden bis hin zur Verwaltung ist notwendig, um die Grundlage für eine zeitgemäße, qualitativ hochwertige Lehre zu schaffen.

Für die Konferenz zur Internationalisierung der Curricula in den MINT-Fächern an der Technischen Universität Berlin (ICM 2018) wurden fünf Dimensionen für ein internationalisiertes MINT-Curriculum identifiziert, die sich an der Definition von Betty Leask orientieren.² Betty Leask definiert den Prozess der Internationalisierung der Curricula durch die „Integration einer internationalen und interkulturellen Dimension sowie einer globalen Perspektive in die Inhalte der Curricula, die Lernziele, Lehr- und Lernprozesse und die Betreuungsstrukturen“. Die daraus abgeleiteten Dimensionen „Sprache, Kultur, Struktur, Fach und Methode“ werden in ausgewählten Beiträgen dieses Tagungsbandes beleuchtet.

In den MINT-Disziplinen und Ingenieurwissenschaften sind die Curricula häufig besonders eng gestaltet, sodass die Dimensionen nicht alle gleichermaßen berücksichtigt werden können. Die Möglichkeiten, internationale und interkulturelle Erfahrungen im Ausland zu sammeln, sind in den MINT-Fächern häufig gering, und die Mobilitätsrate Studierender fällt vergleichsweise niedrig aus. Alternativen, wie sie hier in diesem Band beschrieben werden, bieten sich durch gemeinsame Studiengänge, verpflichtende Auslandsaufenthalte oder Maßnahmen zur Internationalisie-

1 HRK Hochschulrektorenkonferenz (2017). *Zur Internationalisierung der Curricula*. Empfehlung der 22. Mitgliederversammlung der HRK am 9. Mai 2017 in Bielefeld.

2 Betty Leask. *Internationalizing the Curriculum. Internationalization in Higher Education*. London and New York: Routledge, 2015: 9.

rung@home, wie die Erweiterung von englischsprachigen Lehrangeboten, die Lehre von ausländischen Gastdozenten oder der Einsatz von digitalen Lernformaten, um globale Perspektiven zu erfahren ohne die Heimatuniversität verlassen zu müssen.

Auf den ersten Blick mögen die Lerninhalte der MINT-Fächer und Ingenieurwissenschaften universell und nicht internationalisierungsbedürftig scheinen, auf den zweiten Blick jedoch wird durch die Beiträge dieses Bandes deutlich, dass die Internationalisierung der Curricula keineswegs nur in sozial- oder geisteswissenschaftlichen Fächern relevant ist, sondern sich ebenso viele Forschungsfragen auch in den Ingenieurwissenschaften nur über internationale Perspektiven beantworten lassen. Besonders vor dem Hintergrund, dass die Mehrheit der internationalen Studierenden in Deutschland MINT-Fächer studiert, wie die Studie des Stifterverbandes für die Deutsche Wissenschaft ³(2018) belegt, verbirgt sich hinter einer international ausgelegten Ausbildung eine bedeutende Ressource, aus der hohe kulturelle Diversität und gleichzeitig großes Potenzial dem MINT-Fachkräftemangel entgegenwirken.

Der hier vorliegende Band gliedert sich thematisch in drei Teile. Der erste Teil beginnt mit einer Einführung zum Thema „Internationalisierung von Curricula“ und erörtert, welche Kompetenzen zukünftig bei MINT-Absolvierenden gefragt sind und inwiefern Lehrende bei der daraufhin notwendigerweise abgestimmten Konzeption und Umsetzung ihrer internationalen Curricula unterstützt werden können.

Im zweiten Teil geht es um die Frage, wie international derzeit die Curricula an deutschen Hochschulen tatsächlich gestaltet sind. Es werden Konzepte und Best-Practice-Beispiele über bereits erfolgreich integrierte internationalisierte Curricula in den MINT-Fächern und Ingenieurwissenschaften sowie Methoden und Initiativen, wie das gewünschte Level der Internationalisierung in der Lehre gelingen kann, vorgestellt.

Im dritten Abschnitt wird die strategische Gestaltung der internationalen Curricula der Zukunft diskutiert und erörtert, wie digitale Lehr- und Lernformate die Internationalisierung der Curricula weiter voranbringen und welche Standards bei der Evaluation und Qualitätssicherung unterstützen können.

Wir wünschen eine spannende Lektüre und bedanken uns bei wbv Media für die Herausgabe dieser Publikation und bei allen Teilnehmerinnen und Teilnehmern sowie vor allem bei unseren Kooperationspartnern: Deutscher Akademischer Austauschdienst (DAAD), Hochschulrektorenkonferenz (HRK), 4ING, TU9, Zentraleinrichtung Wissenschaftliche Weiterbildung und Kooperation (ZEWK) und Berliner Zentrum für Hochschullehre (BZHL), ebenso wie bei den finanziellen Förderern, DAAD, Santander Universitäten, dem Stifterverband für die Deutsche Wissenschaft und der Gesellschaft von Freunden der TU Berlin e. V. für eine erfolgreiche erste Konferenz zur Internationalisierung der Curricula in den MINT-Fächern an der Technischen Universität Berlin.

Angela Ittel und Anja Meyer N. Pereira

Berlin, August 2018

3 Elena Mostova, Pascal Hetze. *Wie international ist MINT?* Essen: Edition Stifterverband, 2018.

- 1. Grundsätzliche Fragestellungen zur Internationalisierung von Curricula in MINT-Fächern, Kompetenzaufbau für MINT-Lehrende und -Studierende**

Internationalising curricula in STEM disciplines: Why, what and how?

ELSPETH JONES

Abstract

This chapter begins by considering why we need to internationalise the curriculum in STEM disciplines. In order to do this, it outlines what is understood by internationalisation of the curriculum and internationalisation at home. The key role of disciplines in the internationalisation initiative is emphasised and examples given for some of these. Finally, it discusses some resources and guidance on further reading which may be helpful in implementing curriculum internationalisation within STEM disciplines.

Dieses Kapitel beginnt mit der Fragestellung, warum es notwendig ist, Curricula in den MINT-Fächern zu internationalisieren. Es werden zunächst die Begrifflichkeiten „Internationalisierung der Curricula“ und „Internationalisation at home“ erläutert. Zudem wird auf die entscheidenden Schlüsselfunktionen bei der Internationalisierung von Curricula eingegangen. Abschließend werden weitere Quellen und Literatur diskutiert, die in der Implementierung der Internationalisierung der Curricula in den MINT-Fächern nützlich sein können.

1 Introduction

Why focus on internationalising the curriculum in Science, Technology, Engineering and Maths in particular? It could be easy to characterise this as merely opportunistic, given the current educational emphasis on STEM disciplines in many countries. While it is true that there are basic principles of curriculum internationalisation which apply to all subjects, there are several distinctive aspects of STEM disciplines which require further consideration.

Firstly, in the experience of this author, it can be in some of the disciplines covered by this grouping that there is the greatest challenge, in two senses of the word. Challenge by academics to the importance of curriculum internationalisation, ‘surely my discipline is universal and so does not need to be internationalised’. And challenge for academics who have always considered their work in this way to now reflect on the nature of the discipline in a changing global and societal dynamic. Internationalisation is not merely international and global but also intercultural, and highly relevant to the diverse societies we experience today as professionals and citizens.

“Responding to the diversity of international students and responding to the diversity of home students are in fact not two agendas but one”, argue Jones & Killick (2007 p. 110). Incorporating global perspectives and the development of intercultural competence into curricula is thus no longer optional in today’s continually changing world and it involves much more than merely content in the subject of study.

Secondly, it is precisely because academics within STEM disciplines may feel that their chosen field is different and based on norms, theories or concepts which are shared across the world, that it is perhaps timely to focus on these fields in particular. What does internationalisation of the curriculum actually mean for STEM subjects? Academics, trainers, authors on curriculum internationalisation, who may have backgrounds in arts, humanities or social sciences (this author included), also need to reflect on whether STEM disciplines present a different challenge to more standard approaches.

Thirdly, the study of STEM disciplines in some countries has been in decline, resulting in a particular focus on student recruitment into these subjects by governments and national agencies. Ensuring that curricula remain contemporary and reflect our changing society above and beyond programme content, should therefore be a prime concern.

This chapter aims to explore some of these issues and offers ideas for future work in the field.

2 Why internationalise the curriculum in STEM disciplines?

For too long the tendency has been to associate internationalisation with student mobility. This is particularly true in a European context which has seen significant benefits from the Erasmus programme (European Commission, 2014), to such an extent that other regions, such as south-east Asia, are seeking to emulate the scheme. In fact around the world, student mobility, study abroad, education abroad, whatever we call it, is seen as the gold standard for developing the kind of intercultural competencies and global perspectives we hope to engender in our students. Governments, their agencies and universities alike see increasing the number of students having an international experience during their studies as one of the key objectives in today’s globalising world. As an example, for Europe, this statement appears on the website of the European Commission:

“EU Ministers have agreed to double the proportion of higher education students completing a study or training period abroad to 20 % by 2020 and support for mobility is a core focus of the EU programme for education and training.” (European Commission Education and Training, n. d.)

Other regions, governments and institutions have similar objectives, although the target varies. It is true that international experiences can yield substantial benefits for students, including the development of employability skills and intercultural compe-

tence (see Jones, 2013, for examples). Yet even if the EU target of 20 % is met, that would leave 80 % of students without the benefit of an international and intercultural experience. This kind of inequity alone is one of the key arguments for internationalising the curriculum at home for all students.

The central implications of a global context for the professional lives of graduates from all disciplines is highlighted by Casper-Hehne & Reiffenrath (2017). They note that many aspects of contemporary working life transcend national boundaries,

„In unserer von Globalisierung und Migration stark geprägten Gesellschaft gewinnen internationale und interkulturelle Kompetenzen für alle universitären Disziplinen immer mehr an Bedeutung: Handelsabkommen, Rechtsfragen und Prozesse der Produktentwicklung überschreiten häufig nationale Grenzen; Texte, Daten, Forschungsmethoden und Wissen zirkulieren international; und in allen Tätigkeitsbereichen arbeiten interkulturelle Teams, in denen Kommunikationsprozesse sowie kulturelle Unterschiede und Gemeinsamkeiten im Alltag ausgehandelt werden.“ (Casper-Hehne & Reiffenrath, 2017b p. 5).

For STEM disciplines the imperative may be even greater than in others, given the vital role many of these fields have to play in helping to resolve some of the major supra-national issues facing the world today – climate change, pollution, poverty alleviation, disease, sustainable energy, water access and conflict, health epidemics etc. It is often argued that for some STEM disciplines, the curriculum is the same everywhere in the world because, at least at the ‘harder’ end of sciences and maths, the subject is universal. Yet this suggests both a limited view of curriculum content and its method of delivery in different countries.

Furthermore, solving problems requires collaborative and innovative solutions, with different views on how those problems are framed and interpreted. Page’s (2007) ‘Diversity Conjecture’ finds that groups displaying a range of perspectives outperform groups of like-minded experts, and that different methods of approaching problems, or ‘cognitive diversity’ most often leads to better outcomes when a team shares the same goal (Page, 2007). He argues that this is because teams which have a variety of cultural perspectives, language and experience, can also mean they have different ways of thinking, defining and solving problems, resulting in more creative and effective solutions. Therefore, just as teaching in these disciplines often takes a problem-solving approach, we also need to offer an internationalised and ‘interculturalised’ (Jones, 2016) curriculum, not least in preparation for future work in international and intercultural teams.

The need for such collaboration is recognised in the internationally agreed Sustainable Development Goals (SDGs) (United Nations, 2018) with their 17 dimensions for action by 2030. Many of the goals will require international and intercultural teams to approach the challenges with different mindsets, ways of thinking and alternative approaches to problem solving. Higher Education thus has a significant role to play in providing opportunities for students in the STEM disciplines with a framework and launch pad for their future roles as graduates. In her article discussing how Higher Education can contribute to delivering the SDGs, Eva Egron-Polak argues that, “no SDG can be achieved without involvement – through research, educa-

tion, and outreach – of higher education institutions”, “building a sustainable future depends on both knowledge creation and collaboration “ and that “International education and research can serve to raise awareness, be at the forefront of a search for alternatives, demonstrate centrality of both knowledge and collaboration and gain new impetus by building on other broad agendas”. (Egron-Polak, 2018, p. 1). She goes on to outline three important priorities for higher education:

1. **Ensure more equitable access** to higher education for students from all backgrounds
2. **Develop and adhere to a broader approach to internationalization:** (beyond global student mobility).
3. **Value and promote international education in all disciplines,** beyond business and management. *More attention must be given to a broader array of disciplines – engineering and medicine for example – to lift the quality of life around the globe.*
(Egron-Polak 2018, p. 1)

However, the problem continues to be that, as described in guidelines on internationalisation of the curriculum published by the Hochschulrektorenkonferenz (HRK, 2017):

‘Even though there is a long-held conviction in the academic community that the major and cross-border challenges of our century – such as climate change, poverty, malnutrition, migration, energy security – demand not only interdisciplinary, but also international approaches to a solution, individual disciplines all too frequently favour an understanding of university education which gives preference to national standpoints over international perspectives’. (HRK, 2017 p. 4)

It is therefore incumbent upon academics to address this issue within their subject areas if programmes are to be relevant for graduates in the globalised, intercultural world they will join as professionals and citizens.

3 What is internationalisation of the curriculum in STEM disciplines?

To some extent the challenge for STEM is similar to that for all disciplines. Leask’s (2015) definition of curriculum internationalisation notes that this is much broader than simply content:

“Internationalization of the curriculum is the incorporation of international, intercultural and/or global dimensions into the content of the curriculum as well as the learning outcomes, assessment tasks, teaching methods and support services of a program of study.” (Leask, 2015 p. 9).

She exemplifies this further in seeing,

“the curriculum in practice as inseparable from teaching and pedagogy ... [and] the processes by which we, as educators, select and order content, decide on and describe intended learning outcomes, organise learning activities and assess learner achievement as being part of the curriculum.” (Leask, 2015 p. 7–8)

What this means for STEM disciplines, just as for others, is to identify the kind of demonstrable attributes expected of graduates, not only within the disciplinary context, internationally and nationally, but also within that specific programme in that individual university, even though in these disciplines there may be aspects of content and theory which are universal. How that content is prioritised, structured, delivered and assessed will not be the same in all countries of the world. Indeed it is likely that another university, even within the same country, may have a very different approach to curriculum content and delivery.

Understanding these alternative approaches is one of the key challenges for academics and this may be informed by international collaborations on projects or research, visits to partner institutions or even identifying differences through reading of the research literature in the field. Working with colleagues on interpreting curriculum internationalisation for the individual discipline area through a process of reflection is a vital stage, and is a point at which collective understanding can be of great value. Leask (2015) draws on the idea of a reflective learning cycle (eg Kolb, 1984), but adds the important 'Imagine' phase (see figure 1). She argues that this

"stimulates *creative uncertainty* through challenging the traditional and the taken-for-granted and inviting a broadening and deepening of engagement with difference in the process of constructing the curriculum." (Leask, 2015 p.42)

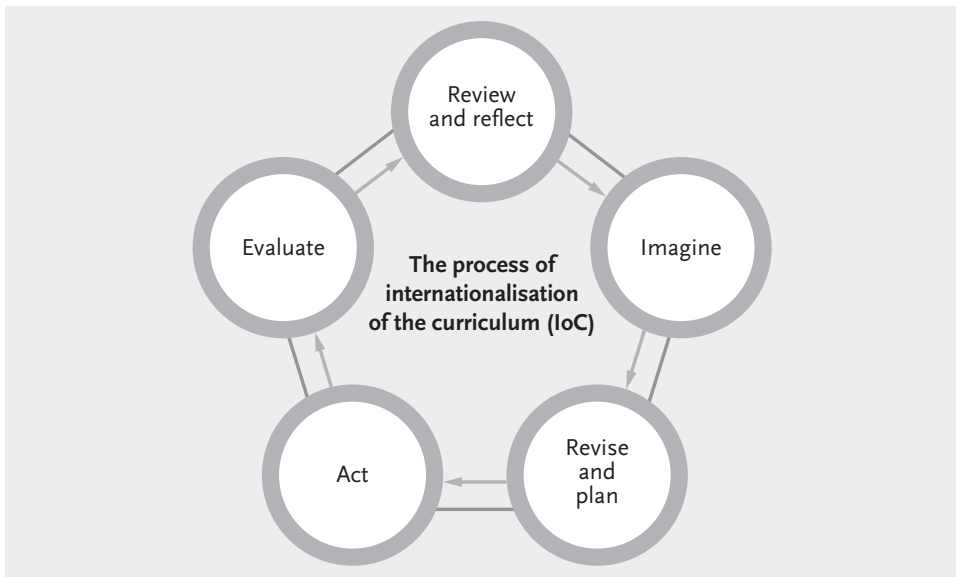


Figure 1: Leask's process of internationalisation of the curriculum (Source: Leask (2015) p. 42).

A useful set of questions to stimulate these discussions is offered by Killick (2005), with suggestions and ideas which may assist colleagues with less experience of internationalisation. A similar approach is taken by the Questionnaire available on the Internationalisation of the Curriculum in Action website (Leask, n. d.).

Being clear on why internationalisation of curriculum is important for graduates in the discipline is a crucial starting point, and it may be helpful to see how this has been interpreted in other disciplines, using some examples. As part of HRK's work in developing guidelines on internationalisation of the curriculum (HRK, 2017) a number of academics were asked to identify what this meant for their disciplines in order to inform the overall guidelines. In **Medicine**, Michael Knipper and Reinhard Putz identified the following:

In view of the growing ethnic and socio-cultural diversity and the increasing mobility of future patients, the socio-cultural, economic, structural, ethical and legal prerequisites and conditions of medicine and medical practice in Germany must be taken into account; [also] cross-border demographic, social and societal developments in Europe and globally.....

Examples of content:

- link between global health and cultural competence
- global epidemiology
- socioeconomic determinants of health
- health systems and funding
- international health policies and institutions (global health governance)
- human rights and ethics

(Knipper & Putz, 2016. Translated by this author)

In a different discipline, **Engineering**, some interesting work was done at the Institute of Education (now part of University College London) to identify what the global environment of the discipline meant for graduates and includes the following:

"Higher education needs to prepare engineers of the future with the skills and knowhow they will need to manage rapid change, uncertainty and complexity. Key here is the ability to tailor engineering solutions to the local social, economic, political, cultural and environmental context and to understand the impact of local action on the wider world. Although there is a global dimension within all subject areas, engineering and technology has unique importance in addressing global challenges, delivering environmental sustainability, international poverty reduction and economic growth." (Bourn & Neal, 2008)

The document (Bourn & Neal, 2008) offers a range of linkages which Engineering academics can draw upon in internationalising curricula in their discipline. See for example Figure 2.

A final example of a disciplinary approach is in **Computer Science**. André Schappo, an academic at Loughborough University in the UK, posts regular blogs on what internationalisation means in his discipline and often describes how he uses these ideas with students. Some of the topics include:

- Internationalisation and Localisation of software
- Character sets
- Unicode and Unicode encodings
- Internationalising websites and building Adaptive Internationalised websites
- Usage of language tags

- Fonts – glyph variants and relationship to Unicode
- Keyboard Mappings and Input Methods
- Internationalised Domain Names
- Unicode Regular Expressions
- Characteristics of English, Chinese, Japanese, Korean, Russian and Arabic languages/scripts

(Selected from Schappo, n. d.)

Simple map of the global context showing the linkages and impacts of climate change, poverty, globalisation and engineering upon each other

Climate change linkages and impacts	Impact of climate change on poverty • Poor hit earliest and hardest with the least capacity to adapt. Climate change may lead to: • Loss of habitats & biodiversity, • Loss of livelihoods / new opportunities, increased frequency / severity of natural disasters, flooding and extreme weather, • Water scarcity & desertification, • Conflict, civil unrest and migration, • Health impacts & food insecurity, • Complex trade-offs: e.g. biofuels could boost or undermine livelihoods of poor, carbon markets could reduce or entrench poverty.	Impact of climate change on globalisation • The impacts of carbon trading and the shift towards a low carbon economy especially in energy, transport, foodstuffs, manufacturing, construction & tourism markets, • Localisation of supply chains & markets due to higher transport costs, • Increased risk, uncertainty & market volatility, Disruption to agriculture & infrastructure, • Failure to address climate change undermines global economy and support for globalisation processes.	Impact of climate change on engineering • New markets and opportunities in renewable energy, alternative fuels, energy conservation & waste reduction, • New research / innovation opportunities, • Disaster preparedness and relief and post-disaster reconstruction, • Low carbon economy especially in energy, infrastructure & construction markets.
Impact of poverty on climate change • Farming, energy, transport, urbanisation and development choices of developing nations are critical if global CO₂ reduction targets are to be met especially in rapidly industrialising economies (Brazil, Russia, India & China). • Global carbon trading and emissions targets must recognise the needs and rights of the poor and the obligations of industrialised nations.	Poverty linkages and impacts	Impact of poverty on globalisation • The responsibility to act ethically, contribute to poverty reduction and involve poor in decision making is becoming recognised by global corporations, • Failure to act responsibly or to address poverty undermines support for (current models of) globalisation. • Globalisation criticised by international development & trade reformers.	Impact of poverty on engineering • Requires low cost solutions that are appropriate to cultural, political, social and economic environment, • Requires participation of the poor and local knowledge, • Developing countries are often high risk / high return markets.
Impact of globalisation on climate change • International supply chains increase energy and transport impacts, • Reduced production costs increase waste and consumerism fuelling carbon emissions • Environmental impacts displaced to less developed country (LDC) production centres.	Impact of globalisation on poverty • Social, legal & environmental safeguards often lower in less developed countries (LDCs), • Offers economic opportunities esp. in natural resources & agriculture, tourism, manufacturing and fair-trade goods, • LDC economies vulnerable to capital flight and brain drain, trade rules disadvantage LDCs and undermine national sovereignty.	Globalisation linkages and impact	Impact of globalisation on engineering • Growth in LDC markets esp. in utilities, infrastructure & the extractive industries, • International supply chains promote technology transfer & standardised systems, • Growth in labour mobility, access to knowledge.
Impact of engineering on climate change • Transport, energy, agriculture, infrastructure and manufacturing choices determine impacts, • Engineering and innovation key to mitigation and adaptation, • Engineering key to disaster preparedness and reconstruction.	Impact of engineering on poverty • Engineering key to providing pro-poor energy, transport, shelter, health and water products and services, • Platform infrastructure and technologies provide an enabling environment for growth, • Engineering supply chains and technology transfer offer poverty reduction opportunities.	Impact of engineering on globalisation • Engineering knowledge and innovation especially in transport, energy, manufacturing and ICT are the drivers behind economic integration and globalisation, • Sustainability and climate change will force a revised model of engineering and globalisation.	Engineering linkages and impacts

Figure 2: Linkages and impacts of climate change, poverty, globalisation and engineering upon each other (Source: Bourn and Neal [2008]. Reproduced with permission).

These examples indicate the breadth of disciplines we loosely term STEM, and may also suggest ideas of what curriculum internationalisation means for students, graduates and the curriculum in other STEM subject areas.

4 How can curricula in STEM disciplines be internationalised?

It may be helpful to begin by challenging some assumptions. In section 2 above, it was noted that student mobility does not, in itself, represent internationalisation of the curriculum. It may be valuable for students who have the means to take part but this will only ever be a small minority. To be of greatest benefit, curriculum internationalisation ‘at home’ needs to reach all students, and not be an elective or optional element of a programme of study.

Secondly, internationalisation of the curriculum does not simply mean translating an existing curriculum into English. As argued by Beelen & Jones (2015),

“Simply providing a program in English is insufficient for it to be considered an internationalised curriculum. If the program content and learning outcomes are not internationalised, and remain the same as in the original language, merely changing the language of instruction will not make them so.” (Beelen & Jones, 2015 p.64)

This is reinforced in the HRK Guidelines which state,

“[internationalisation of the curriculum should not] be equated with a general departure from German as the language of instruction. Teaching in a foreign language alone is no guarantee of the successful transmission of international and intercultural competences.” (HRK, 2017 p.7)

The final important assumption which needs to be challenged is that the mere presence of international students will internationalise the curriculum. Although students can offer alternative cultural perspectives for classroom discussions and group work, effective and authentic interaction will not necessarily happen without appropriate intervention by the tutor. Many researchers and commentators have argued that institutions and academics do not take advantage of the international and intercultural diversity which international students bring to the campus and classroom (Harrison & Peacock, 2009, 2010, Leask, 2009, 2010; Montgomery, 2010; Thom, 2010; Volet & Ang, 1998). We need to build on the opportunities brought to the curriculum by students from diverse backgrounds.

Regardless of the discipline, it is clear that academics have the most important role to play in internationalising the curriculum, firstly by identifying the purpose for this and the value for graduates within their own discipline in their own university, as outlined in section (2) above. This is the first step, but it is up to academics to take forward the initiative in their programmes and it is a job that only they can do:

“Internationalisation of the curriculum is more than simply engaging in a series of tactics or student activities, or hoping that it will happen by bringing together people from different backgrounds. Instead, it requires us to use student learning outcomes and their assessment purposefully and in a consistent way across the programme as a whole.” (Jones, 2017, p. 24)

It should also be integrated into the broader internationalisation strategy of the university rather than in isolation from other measures, and needs to be seen as an on-going process rather than a one-off activity (HRK, 2017). Beelen & Jones (2015) offer this definition of internationalisation at home, which is a term used largely across Europe to denote internationalisation of the curriculum, and which emphasises the need for intentional intervention:

The purposeful integration of international and intercultural dimensions into the formal and informal curriculum for all students within domestic learning environments. (Beelen & Jones, 2015 p. 76)

In turn the Internationalisation at Home Expert Community of the European Association for International Education has outlined ten features, pointing out that internationalisation at home:

- “1. Offers all students global perspectives within their programme of study, whether or not they spend time abroad.
 2. Moves beyond electives or specialised programmes.
 3. Involves developing international and intercultural perspectives through internationalised learning outcomes in the formal curriculum.
 4. Is supported by informal (co-)curriculum activities across the institution.
 5. Makes purposeful use of cultural diversity in the classroom for inclusive learning, teaching and assessment practice.
 6. Creates opportunities for student engagement with ‘cultural others’ in local society.
 7. Involves all staff, not only academics and international officers.
 8. May or may not include teaching in English or another *lingua franca*.
 9. Can include virtual mobility through online working with partner universities.
 10. Fosters purposeful engagement with international students.”
- (Jones & Reiffenrath, 2018)

Academics in STEM disciplines wishing to incorporate internationalisation into their curriculum are advised to consider the following as the basis for taking forward this initiative, ideally in discussion with other colleagues in the same or related discipline areas:

- Incorporate international, global and intercultural dimensions into content.
- Use internationalised/interculturalised learning outcomes, tied to assessment.
- Make the most of clinical or work placements to focus on the international and intercultural.
- Enable/encourage meaningful dialogue across intercultural teams and consider alternative approaches to problem-solving.
- Bear in mind graduate employment in the field.

- Consider these approaches to assessment suggested in the HRK guidelines (HRK, 2017) self-reflective discussions; scientific papers jointly compiled in international teams; presentations of results in intercultural teams, for example of experiments or project tasks.
- Remember the contribution of STEM disciplines to the final element of this definition of internationalisation:

“The intentional process of integrating an international, intercultural or global dimension into the purpose, functions and delivery of postsecondary education, in order to enhance the quality of education and research for all students and staff, and to make a meaningful contribution to society.” (De Wit, Hunter, Howard, & Egron-Polak, 2015)

5 Useful resources

Internationalising the curriculum is not an easy or short-term task and many academics feel that they lack the skills and/or experience to deliver an internationalised curriculum. But some research and sharing of knowledge within and across disciplines means that the wheel does not have to be reinvented yet again.

For some, the notion of global citizenship may be a helpful starting point (for example, see Killick, 2015; Lilley, 2014; Lilley, Barker, & Harris, 2015). Or, for a different kind of overview as the basis for interpretation within individual STEM disciplines, the Council of Europe (2016) offers these Competences for Democratic Culture (figure 3).

Other, more detailed, resources may be of value including those which are generic in focus (Carroll, 2015; Leask, 2015; Leask & Carroll, 2013), or which offer disciplinary dimensions in fields such as Veterinary Science (Maud, Blum, Short, & Goode, 2012), Pharmacy (Murdan et al., 2014), or Medicine (Willott, Blum, Burch, Page, & Rowson, 2012). Other notable works on internationalising the curriculum in different disciplines include those by Clifford (2009) and by Green & Whitsed (2015). Casper-Hehne & Reiffenrath (2017a) include chapters with a disciplinary focus in addition to more general chapters on curriculum internationalisation.

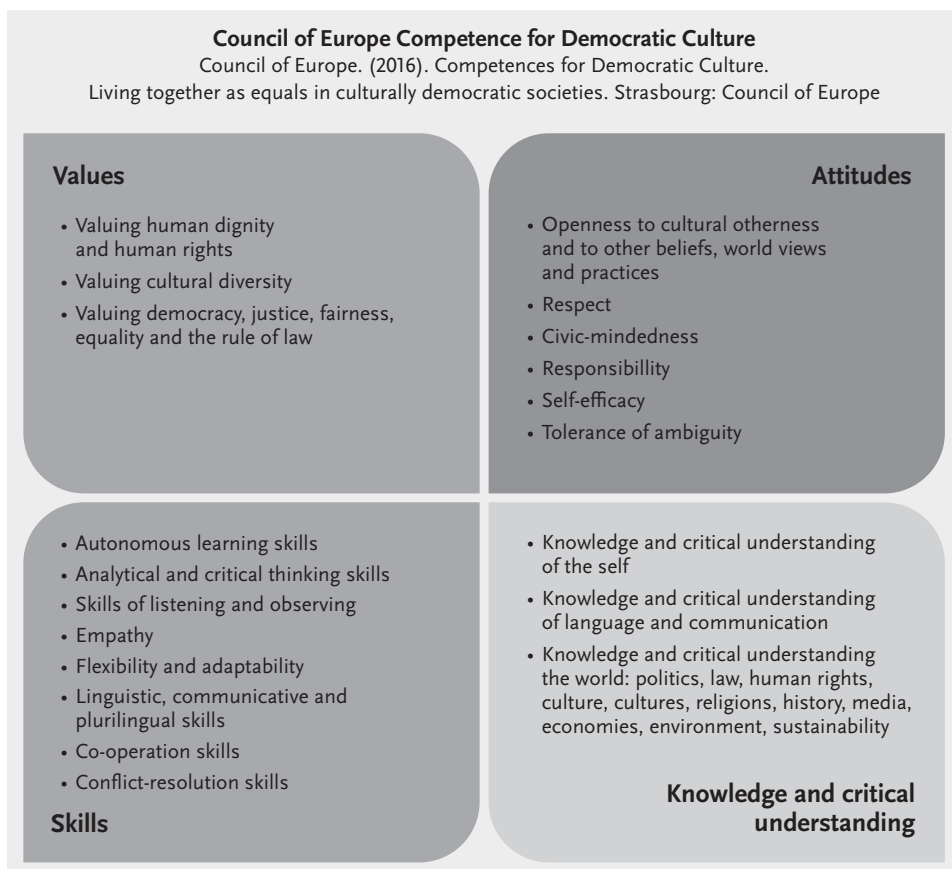


Figure 3: Living together as equals in culturally diverse democratic societies (Source: Council of Europe [2016, p. 11]).

6 Conclusion

This chapter has sought to offer perspectives on **why** we need to internationalise the curriculum in STEM disciplines and what it means for subjects in these fields. It has put forward interpretations of **what** curriculum internationalisation means in a number of disciplinary contexts and highlighted several definitions. It has discussed **how** the internationalisation challenge may be approached, and offered some resources and guidance on further reading which may be helpful in implementation of curriculum internationalisation. This quotation is offered as a final reminder of why such work represents an essential endeavour, particularly within STEM disciplines:

“when they graduate all students will live and work in an increasingly interconnected, globalised world, both as professionals and as citizens. Similarly, if we are to solve major global problems the crossing of boundaries using international and intercultural knowl-

edge, communication skills and critical thinking will be essential. It will also require a commitment to ethical practice, global responsibility and an understanding of and respect for cultural others, regardless of their origin. For these and many other reasons, we owe it to our students to offer an internationalised and 'interculturalised' curriculum in the relatively safe space for debate represented by higher education." (Jones, 2017)

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STEM goes global

Is internationalization of the curriculum adequate?

MARIJK VAN DER WENDE

Abstract

Internationalization in higher education depends on the extent to which the academic discipline or professional field is subject to globalization. STEM is a particular case, as its research is organised in a global science system and engineering is among the most globalized regulated professions. It strongly defines the standing of universities in global rankings and is central to West-East competition for economic growth and geo-strategic positioning. Star institutions seek innovative cross and interdisciplinary models. What does this imply for internationalization of the curriculum?

Die Internationalisierung an Hochschulen ist abhängig von dem Einfluss der Globalisierung auf die einzelnen akademischen Disziplinen. MINT-Fächer sind ein spezieller Fall, da die Forschung in globalen Netzwerken organisiert ist und die Berufsfelder zu den am meisten globalisierten gehören. Die Internationalisierung ist entscheidend für die Platzierung in globalen Rankings und wesentlich im West-Ost-Wettstreit um Wirtschaftswachstum und geostrategische Lagen. Global player streben nach innovativen und interdisziplinären Modellen. Was bedeutet dies für die Internationalisierung des Curriculums?

Defining internationalization of the curriculum

Defining internationalization of the curriculum takes us back to the early 1990s when the first international study on this theme was initiated by the Centre for Educational Research and Innovation (CERI) of the OECD. It defined it as: *“The process of curriculum development and curriculum change, aimed at integrating an international dimension into the content of the curriculum, and, if relevant, also into the method of instruction”*. Resulting in an internationalized curriculum, which was defined as *“Curricula with an international orientation in content, aimed at preparing students for performing (professionally / socially) in an international and multicultural context, and designed for domestic and/or foreign students.”* (Van der Wende, 1996a, 1996b). The study anticipated a broad variety of initiatives that were underway in a range of countries. As to better understand this variety, a typology of nine different types of internationalized curricula was developed (figure 1). The typology aimed to accommodate

the differences between disciplines and cultural-linguistic contexts (mostly between Anglo-Saxon and other countries), while clearly avoiding that internationalized curricula would simply be understood as programmes taught in English and (thus) accessible for international students. It aimed to be more comprehensive, including a focus on skills for international employment, with a view to the OECD's interest in employability, labour mobility and global human capital. (Later OECD work extended this into mobility of the highly skilled and trade in professional services).

1. Curricula with an international content
2. Curricula in which the traditional/original subject area is broadened by an internationally comparative approach
3. Curricula which prepare students for defined international professions
4. Curricula in foreign languages or linguistics which explicitly address cross-cultural communication issues and provide training in intercultural skills
5. Interdisciplinary programmes such as region and area studies, covering more than one country
6. Curricula leading to internationally recognized professional qualifications
7. Curricula leading to joint or double degrees
8. Curricula of which compulsory parts are offered abroad, staffed by local lecturers
9. Curricula in which the content is especially designed for foreign students

Figure 1: OECD Typology of internationalized curricula (Source: Van der Wende, 1996a p. 187; 1996b p. 48).

STEM as an early mover on internationalization

STEM fields were among the first movers in internationalization. It was argued that curricula, especially those in natural sciences, did not need to be internationalized because their content was already universal, that teaching methods did not need much adjustment, facilitated by the use of mathematics and/or by computer languages as universal languages. In a mostly pragmatic way, and facilitated by the already strong international research and publication cultures, STEM was among the first fields to switch to English and attracted indeed a lot of international students, mostly coming to OECD countries from the rest of the world. In Europe, organizations such as the European Physics Society (EPS) were important actors, and also chemistry and biology were among the first disciplines to join the European project, such as the development of the European Credit Transfer System (ECTS). Engineering, as a regulated profession, was also strongly represented in these developments, with a particular focus on the international recognition of engineering degrees. Driven by economic interests since it ensures access to markets (i. e. ability to participate in international competition / bidding for large construction projects). FEANI (the federation of professional engineers that unites national engineering associa-