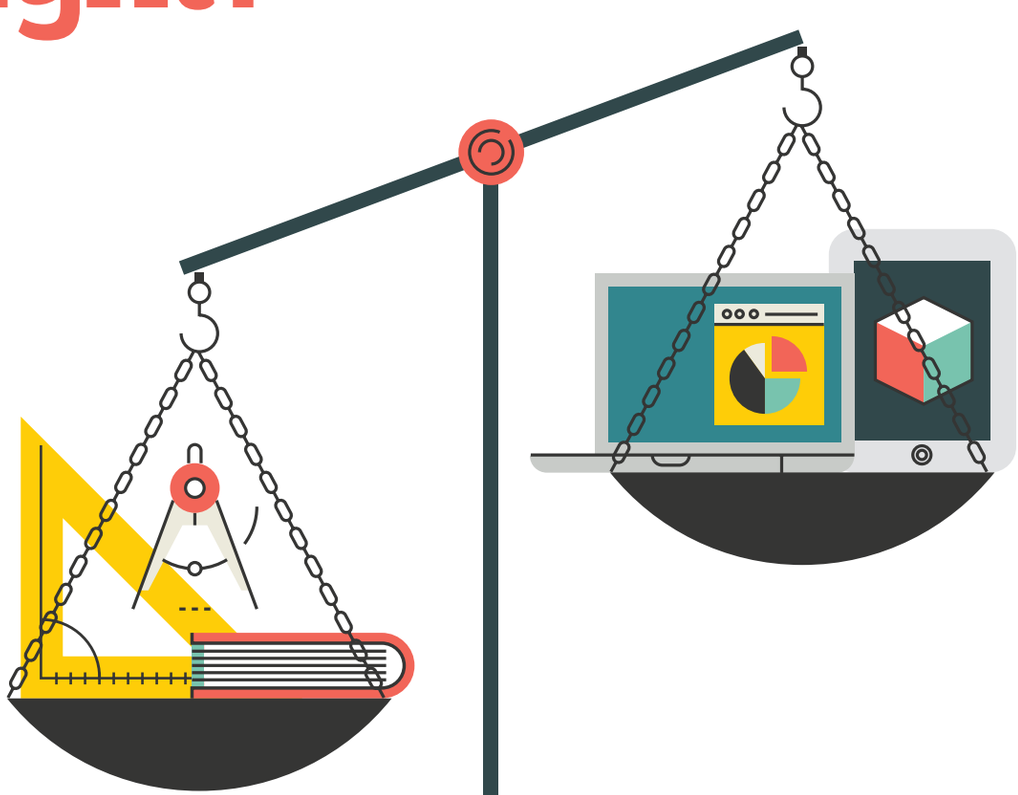
Mc Graw Hill Education

We need to talk about Maths...

Position Paper from McGraw-Hill Education

Mc Graw Hill Education

Maths doesn't change. Right?



Maths – in terms of what we need to be able to do with it – is changing.

The digital revolution has brought unprecedented, previously inconceivable changes to the way we do business; indeed the very way we live our lives.

There is growing recognition that '**pure maths**' as it is currently taught in Higher Technical Education globally is no longer fit for purpose, with current maths courses seen by students as too abstract and lacking in relevance, leaving them unprepared for the world of work. "School mathematics is complex but used in simple problems, whereas workplace mathematics is simple but used in complex problems," said Steen in 2003.[1] There is a large degree of latency between the maths skills and competencies needed by employers and those currently being taught in the vast majority of Higher Education curricula.

With computers more able and more efficient when it comes to complex calculations and modelling, there's far less need these days for human beings capable of doing the same thing. Advanced maths skills are no longer something that employers are searching for in their new recruits. What they are looking for instead is someone who can bridge the gap between computer and decision maker. Someone who can interface with a machine to give it the right inputs and get the right outputs, someone who can analyse, interpret and verify these outputs and communicate them onwards.

In other words, maths courses (whether pure maths or maths modules as part of a broader subject of study), aren't exempt from the slow but necessary slide towards '**21st century skills**', described succinctly by Voogt and Pareja Roblin (2010)[2] as encompassing problem-solving, creativity, technical skills, critical thinking and complex communication skills.

> **School mathematics is complex but used in simple problems, whereas workplace mathematics is simple but used in complex problems."**
>
> *Lynn Arthur Steen, 2003*

[1] Data, shapes, symbols: Achieving balance in school mathematics LA Steen

[2] 21st Century Skills Joke Voogt & Natalie Pareja Roblin http://development.todosmedia.com/klassetheater/wp-content/uploads/2015/04/discussie-nota-21_st_century_skills-.pdf

Mc Graw Hill Education

The pace of change in education is often perceived as slow, though there are often very good and understandable reasons for this.

Even aside from the scale of cultural change required among the vast legion of educators worldwide, we also need to bring with us those who ultimately benefit from the educational system – the consumer of our end-product (skilled and qualified graduates): namely business and industry. When the status quo has been in place for a long time, it is relatively easy for employers to understand what a particular level of qualification within a given subject means.

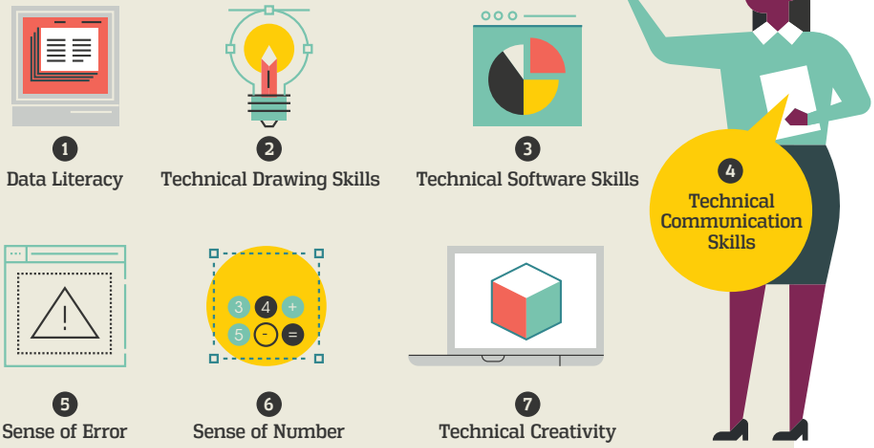
When we make too many changes all at once, it can cause damage.

Yet there is an increasingly loud global discourse on 21st century skills, with even the OECD's highly regarded Programme for International Student Assessment (PISA) changing to include a collaborative problem-solving element in 2016 – and where PISA leads, educational policymakers often follow. With Science, Technical, Engineering and Medical (STEM) skills shortages on the rise, and a large degree of acceptance that maths courses aren't adequately preparing students for their careers, there is a growing body of research into the precise maths-related skills typically needed in the STEM workplace.

One such study, conducted by Nathalie J. van der Wal and her team at the Freudenthal Institute at Utrecht University in 2014 attempted to define the types of 21st century maths skills specifically needed in the engineering industry.[3]

They were able to define seven '**Techno-mathematical Literacies**' – categories of the '**maths-in-context**' skills that are needed alongside an understanding of abstract maths.

They defined these as:



The skill sets they observed very much chimed with the findings of other studies into this topic (such as Bakker et al, 2006[4] and Hoyles et al, 2013[5]), which also highlighted the need for maths education to integrate pure maths with communication, ICT and other workplace skills.

[3] Which Techno-mathematical Literacies Are Essential for Future Engineers? Nathalie J. van der Wal, Arthur Bakker, Paul Drijvers https://link.springer.com/article/10.1007/s10763-017-9810-x

[4] Improving work processes by making the invisible visible A Bakker, C Hoyles, P Kent, R Noss

[5] Mathematics in the workplace: Issues and challenges C Hoyles, R Noss, P Kent, A Bakker

What is important is to understand the fundamentals of maths.

The study looked at a number of graduates from different technical domains where maths was part of the curriculum, now working in a wide variety of roles – from Technical Consultants and Quality Assurance Engineers to Technical Writers and Marketing & Communications Officers – within the engineering sector.

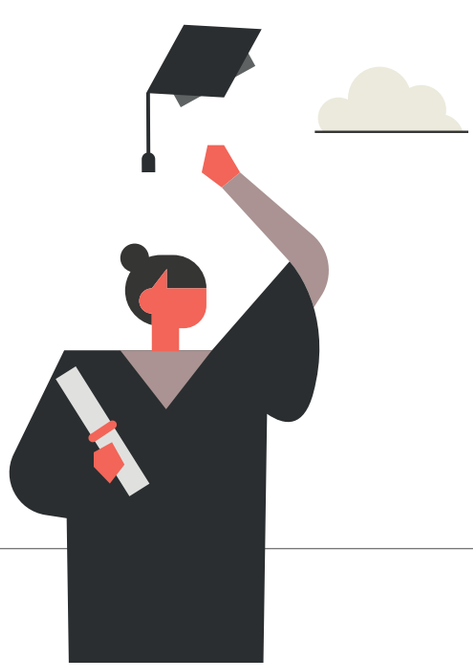
While the '**frequency**' of skills needed varies from role to role, there was a distinctive common thread of Techno-mathematical Literacy skills woven among them. Data Literacy, for example - the ability to handle textual, numerical and graphical data sensibly – is a crucial skill for almost any role today. Equally, technical software skills – the ability to use software packages such as Excel, or proprietary company software – is a must for any white-collar job in existence today. Meanwhile, the ability to communicate confidently and appropriately can make careers – or a *lack* of them hold back potential.

We assume that many of these skills will be learned '**on the job**' as if by osmosis, but in reality, many employees will never receive adequate or advanced training and support in these areas unless they undertake additional self-funded study.

As with any skill, they are usually only mastered when they have been taught explicitly.

By contrast, many of the advanced maths skills students learn during their degrees are never used after academic study. Whilst many learners acknowledge the link between their thinking styles and their training, they also felt that the ability to make complex, sophisticated calculations manually and/or mentally is less essential in an age when machines can make such calculations more quickly and with pinpoint accuracy.

What is important is to understand the fundamentals of maths – to have a conceptual understanding of how a particular calculation needs to be made, rather than necessarily having intensive procedural training in how to perform the calculation. Some went even further with this, stating that they would find it useful to have an understanding of what goes on '**behind the scenes**' with computer-driven equipment and calculations.



Following on from this research...

Following on from this research, van der Wal has been experimenting with a different type of maths course for first-year students across all technical domains.

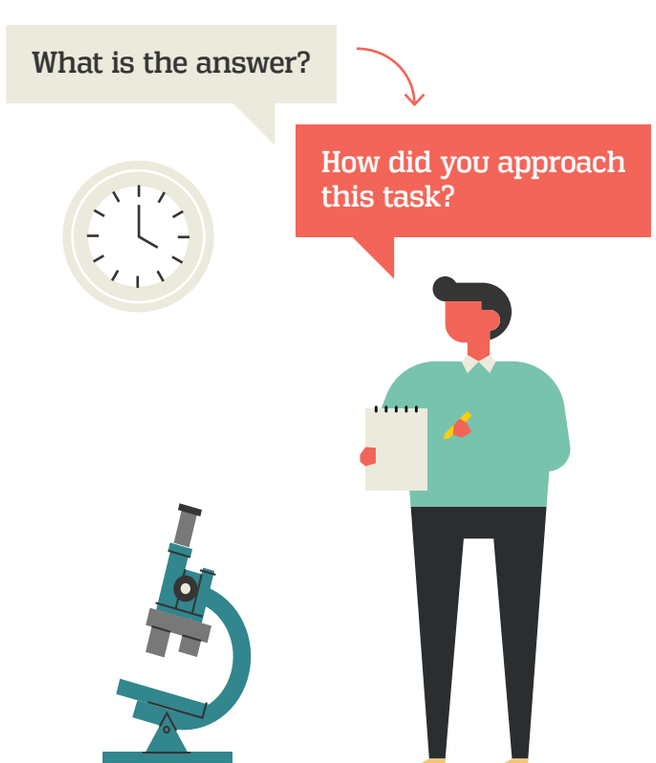
The course she has designed with her team combines a firm base of pure maths with an equal focus on developing Techno-mathematical Literacies. It's a difficult balance to achieve, and one which has been enormously facilitated by educational technology.[6] The approach is highly innovative and marks a radical departure from the traditional approach of '**transmission lecturing**'.

Instead, van der Wal's course runs two separate tracks in parallel. With the first track, which focuses on the pure maths skills, students are expected to take responsibility for their own learning and work autonomously, outside of class, using ALEKS from McGraw-Hill Education to master precalculus topics. The individual learning paths that the software is able to provide supports students to master topics more quickly, thus freeing up class time for students to work collaboratively to develop a deeper understanding of these topics and how they relate to real-life scenarios through what van der Wal terms '**cases**'.

For example:

Students doing a Chemistry major will look at linear and quadratic functions and equations through the lens of Solutions. They will look at exponential and logarithmic functions in relation to Bacterial growth.

Classes are intense, lasting for four hours. The first and last hour are with the lecturer, while for the middle two hours students work together on the case they have been set. This work will pull in all of the Techno-mathematical Literacy skills: students will learn to use Excel for calculations, how to evaluate data, identify error and so on. Classes are run on the basis of 'Inquiry based learning' with students encouraged to discover knowledge for themselves, supported by process-focused questions by the lecturer. Instead of asking students 'what is the answer?' the lecturer asks 'how did you approach this task?' Care is taken to establish a warm and cooperative atmosphere to reduce maths anxiety.



[6] Bookchapter Monograph 'Designing a course for future engineers to acquire Techno-mathematical Literacies Nathalie J. van der Wal, Arthur Bakker, and Paul Drijvers (in preparation)

The Results

The results, after the first cycle, are cautiously optimistic.

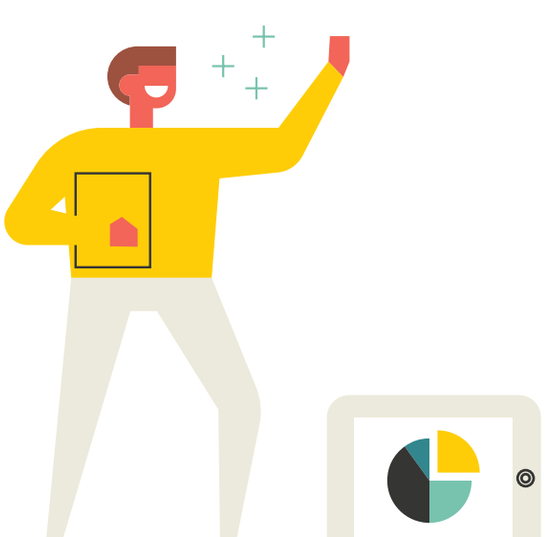
There has been a significant rise in the number of students passing the course first time (from 73% to 92%) and all of the lecturers involved report an increase in student motivation. As with any new initiative there are a few teething problems to iron out and tweaks have been made to the '**Hypothetical Learning Trajectory**' for future courses. However, students are no longer asking 'why do we need to study this?' Instead they find the cases challenging and fun.

First time pass rate from 73% to

92%

An increase in student motivation

It's a course that employs 21st century technology to deliver 21st century skills to 21st century students.



Mc Graw Hill Education

ALEKS®

Problem Solved

Enable students to learn at their own level and own pace, to improve academic math performance.

To find out more, read the full study **'Which Techno-mathematical Literacies Are Essential for Future Engineers?'** (Van der Wal et al 2017) Open Access via SpringerLink.

Or to find out more about the ALEKS software that has helped to facilitate this new and innovative approach, visit:

mheducation.co.uk/aleks