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Mathematics in colleges: purposes, policies and practices

Presentation to the NANAMIC conference

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…because we can never know well enough the combination and salience of factors that are causing the school's or the system's failure, or exactly what it is that will turn things around, our best chance of success lies in addressing the problem from as many angles, levels and perspectives as possible (Mason, 2014, p. 7)

Purposes, policies and practices…

Purposes, e.g.

- Who needs what mathematics - and who decides?
- The problem with terms: numeracy, mathematical literacy, etc.
- Mathematics pathways…an unresolved problem

Policies, e.g.

- Adding (GCSE resit, Core) and embedding (A & T levels)
- Condition of Funding; implementation (MiFEC project)

Practices (leadership/change management)

- CfEM; 'mastery' for FE; Whole College Approach
- Cross college leadership

…but not necessarily in that order!

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On consensus, vision and change…

- There is compelling evidence on the value of mathematics skills to individuals and society, both in terms of economic participation and wage 'return' and in a variety of civic and personal contexts;
- There is considerable agreement on the need to improve mathematical competence and therefore to continue with the study of maths to 18;
- There is less agreement on a) who needs what mathematical knowledge/skills and b) how to achieve a maths-for-all-to-18 agenda;
- There is little evidence on whether or not making more young people do more of the currently available maths qualifications will actually improve the skills base and improve social mobility.

The economics of maths education…

Industrial Strategy (2017)

"Improving the take up of maths qualifications and the quality of maths teaching across the education system is one of the most significant interventions that government can make to tackle STEM skills shortages and secure wider benefits **for the economy**"…

"Adults with basic numeracy skills **earn higher wages** and are more likely to be employed than those who fail to master basic quantitative skills."

"We will …invest £40m to establish Further Education Centres of Excellence across the country to build teaching capacity and spread best practice."

The economics of maths education…

Skills for Jobs (Jan 2021)

"49% of adults have numeracy skills no better than the level expected of an 11-year-old"

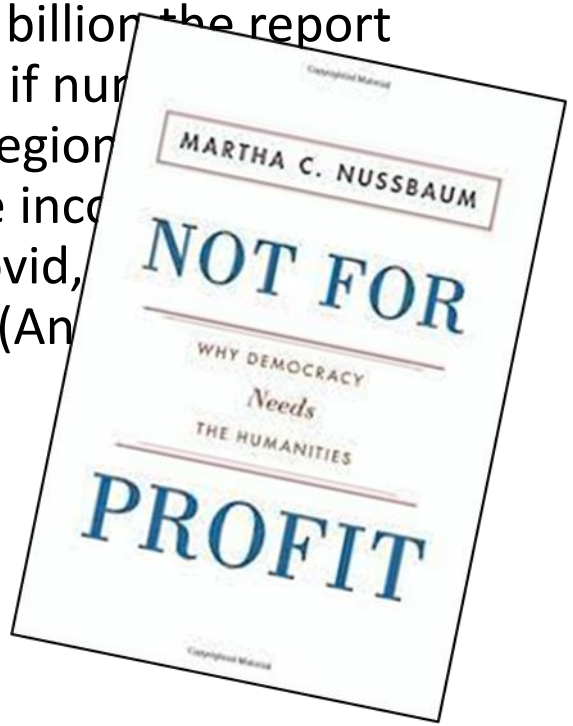
"through the Centres for Excellence in Maths programme we are improving the quality of teaching by embedding maths mastery nationally to support students aged 16-18 studying GCSEs, no matter which pathway they are on." [I will return to CfEM later…]

The economics of maths education…

National Numeracy's ***Counting on the Recovery***

"The UK faces a numeracy crisis, plain and simple. As this report makes clear, this crisis is having significant economic costs, especially for those least-advantaged in society.

This cost can be counted in lost earnings – the £25 billion the report finds would be added to our collective pay packets if nu could be levelled-up. The cost comes in widening regio since numeracy skills are weakest in regions whose inc lowest. And these costs have been increased by Covid, hardest those whose numeracy skills are fewest. " (An



The maths we need now…

What is “The maths we need now” (Wolf and Tikly, 2000)?

- Numeracy?
- Mathematical literacy? (PISA)
- Quantitative literacy?
- Data literacy?
- Techno-mathematical literacies? (Hoyles et al.)
- Computational thinking?
- Pure mathematics?
- Applied/embedded/contextualised?
  - And who is the ‘we’ anyway?
  - And should all of this be embedded across the curriculum or bundled in new qualifications?

And what do we need it for?

The RS/ACME Mathematical Future Programme is aiming to tease out some answers to this question.

On mathematics pathways…

"We wish to see a highly flexible set of interlinking pathways that provide motivation, challenge and worthwhile attainment across the whole spectrum of abilities and motivations, but avoid the danger of returning to the O-level/CSE "sheep and goats" divide." (Smith, 2004, 0.32)

- Are we closer to achieving this than in 2004?
  - *Highly flexible*?
  - *Interlinking*?
  - *Motivation, challenge and worthwhile attainment*?
- Pathways vs pipeline vs participation (metaphors matter!)
- ACME contact group (Post-16 maths pathways)
- What pathways for which futures?

Two policy drivers: 'the sheep and the goats'?

1. Advanced maths participation (for those with GCSE Grade 4)
   - Nuffield Outliers report - comparative
   - Dolton & Vignoles (1999)/Adkins & Noyes (2016) – economic return
2. Basic skills (for those without GCSE Grade 4)
   - Moser (1999); Bynner & Parsons, etc
   - National Numeracy (2019; £388million per week)
   - PIACC (2011; 2nd cycle underway)
   - 'Policy waves' (Dalby & Noyes 2021)

- Are these the same agendas or do they represent different mathematical/motivational/economic/social concerns? Does it matter?
- What is the impact on curriculum/learners/teachers/institutions?
- Can we move past the historical academic/vocational divide and avoid 'academic drift'?

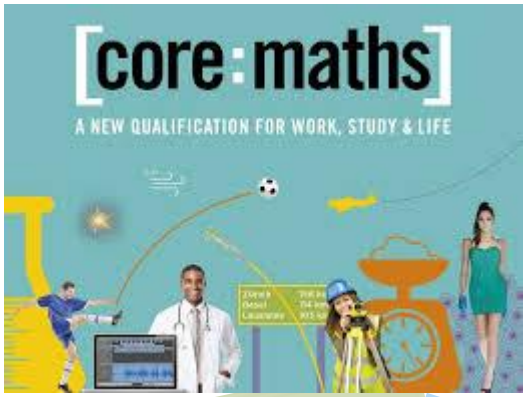
Embedding maths in A levels

- Nuffield 2012 – maths in A level assessments
- A level reforms in recent years have included varying assessment volumes of 'maths in…' (e.g. physics 40%, chemistry 20%). This was not without problems.
- So who is teaching maths post-16 now?

- McAlinden & Noyes (2019)
  - Assessing mathematics within advanced schools science qualifications
  - Mathematics in the disciplines at the transition to university
- Adkins & Noyes (2018)
  - Do advanced mathematics skills predict success in biology and chemistry degrees?

Adding Core maths

- Origins (ACME advice 2012)
- Development (expert panel)
- Challenges (AS equivalence? Different specs? Exchange value? Teaching? Step change)



Year	Total number of entries
2016	2931
2017	5376
2018	6849
2019	9027
2020	11,792

https://mei.org.uk/files/pdf/Summary-of-Core-Maths-entries-and-results-2020-2.pdf

Level 2 mathematics post-16

- Chequered history (core skills, key skills, functional skills…)
  - ‘The waxing and waning of functional skills mathematics’ (Dalby & Noyes, 2020)
  - ‘Mathematics curriculum waves within vocational education’ (Dalby & Noyes, 2021)
- Influential Wolf Review (2011)
- 2014 Condition of Funding (updated 2015; tweaked more recently)
- 2017 Smith report (March 2016 budget – maths for all to 18)
- MiFEC project 2017-2020

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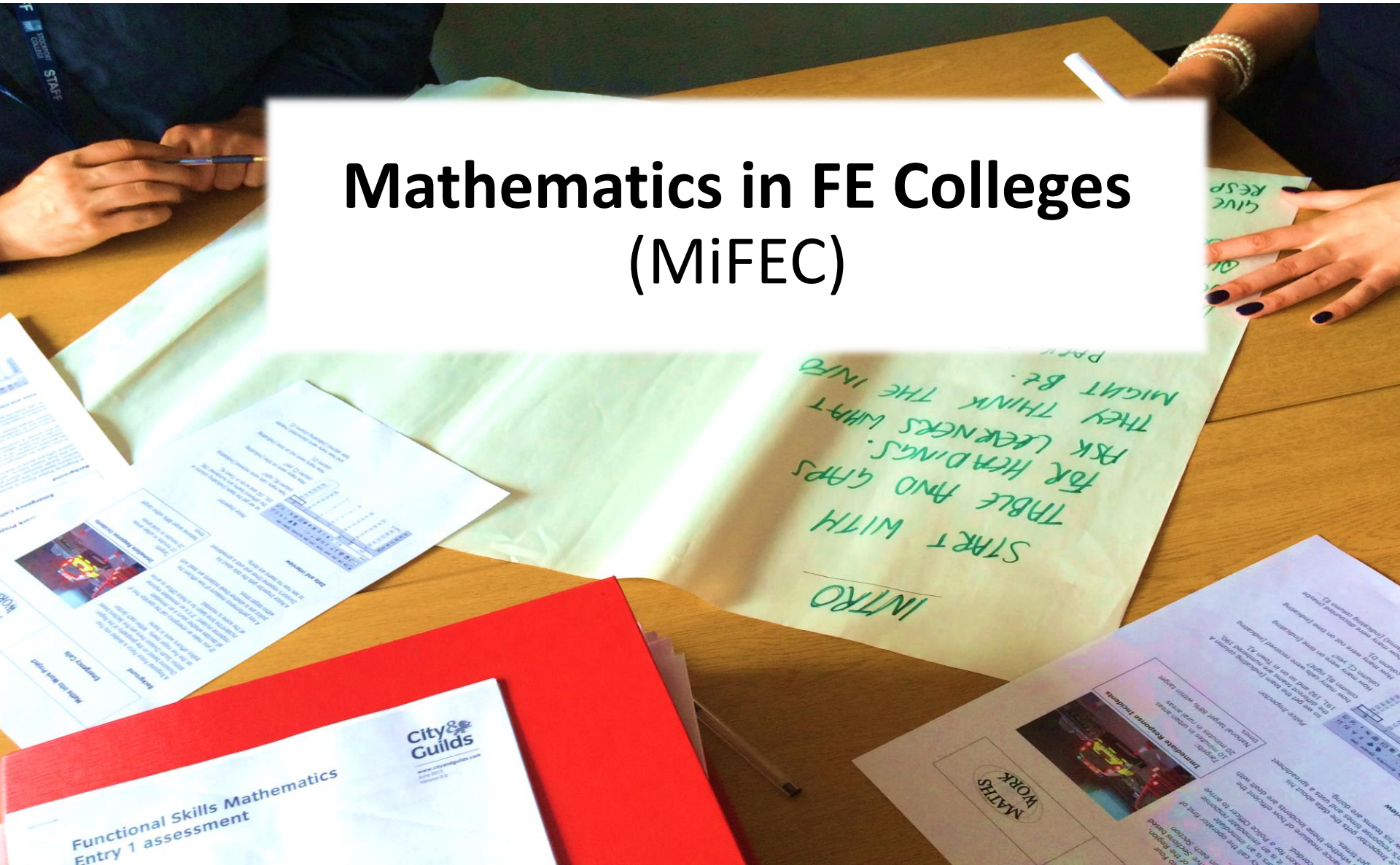

Mathematics in FE Colleges
(MiFEC)

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Research questions

1. How has FE mathematics policy and practice been shaped since 2000 and what lessons can be learnt to improve the design of policy in the future?
2. Who attains what mathematics qualifications in FE and how has this changed over time?
3. How do FE colleges mediate government policy on post-16 mathematics education?
   - What different strategies have been employed?
   - How has/is funding shaping college policy and classroom experience?
   - What are the workforce strengths and limitations?
   - How is curriculum and assessment changing?
   - What are the possible unintended consequences of policy upon classrooms?
4. Who is teaching post-16 maths in FE? What are the current and future training and development needs?

Work packages

1. Review of literatures and twenty year policy analysis
2. Analysis of national administrative datasets
3. Case studies of general further education colleges
4. National survey of the FE mathematics teacher workforce

The MiFEC project aimed to take a holistic, multi-scale perspective, drawing on ideas from systems and complexity thinking.

Appreciating context

A college's local context and its general curriculum offer influence both the size and the motivations of the mathematics student cohort. Mathematics performance models would be fairer if such contextual factors were taken into account.

Colleges' prioritisation of learner needs and/or different progress measures influence strategic decisions about students' mathematics pathways. Similar students in different colleges do not therefore get the same opportunities.

Recommendation 1: Consideration should be given to adding contextual factors into models of mathematics progress to more fairly reflect the achievements of students and colleges.

Recommendation 2: The learning goals and preferred qualifications pathways for students entering FE with GCSE grades 1 and 2 should be agreed, with performance measures being revised in support.

Understanding and developing leaders, systems and processes

Cross-college leadership and management is challenging due to the dispersion of students across sites and the shared responsibilities with vocational staff. Bespoke training is needed to equip cross-college managers to make well-informed decisions on strategic and operational approaches.

Colleges benefit from mathematics being an institutional priority, with well-defined sharing of responsibility and good collaboration between those with leadership responsibilities for mathematics at different levels. (whole college approach)

Operational challenges are complex in large colleges but student-focused approaches to timetabling, induction, staffing and attendance monitoring for mathematics help to produce classroom experiences that are more conducive to learning.

Recommendation 3: A new national programme of leadership training should be developed appropriate for those in cross-college mathematics leadership positions to include strands on 1) curriculum leadership, 2) organisational strategy, 3) systems management, and 4) reflective and evaluative change leadership.

Establishing the FE mathematics teacher workforce

Mathematics teachers in colleges come from a range of backgrounds with different subject and teaching qualifications. The workforce had to expand due to the Condition of Funding but amidst ongoing national teacher shortages. The deregulation in the sector has allowed colleges to make independent judgements about appropriate qualifications and training for their staff.

Entrepreneurial approaches to teacher recruitment have been developed by colleges but more support is needed nationally to boost recruitment and to provide appropriate training for those entering FE mathematics teaching through a variety of routes.

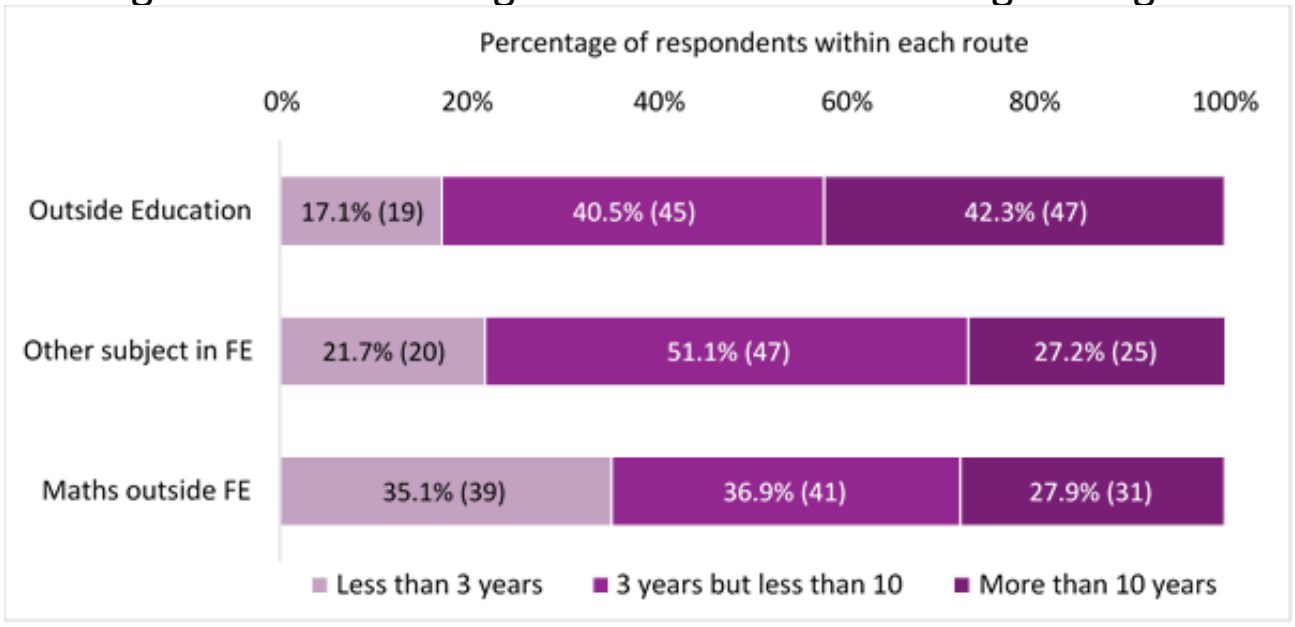

Figure 3: Time since entry into teaching maths in FE for each of the three routes in.

Developing the FE mathematics teaching profession

Few mathematics teachers in FE undertake full-time training prior to entering the workforce so professional development is particularly important. There are wide variations in the amount, type and quality of mathematics-specific CPD accessed by teachers.

Colleges would benefit from clearer guidance on what 'professionalism' in FE mathematics teaching means and a framework of professional standards to guide teacher development.

Diverse entry routes and teacher backgrounds add to the complexity of providing appropriate professional development for all.

Training needs analysis tools, longer-term professional development planning and better understanding of CPD models are needed so colleges can make good use of effective models, including college-based opportunities to develop professional learning communities and practitioner research.

Understanding and developing pedagogy in context

Teachers' choices of classroom approaches are contingent upon a range of contextual, organisational and educational factors . Teachers and students are largely in agreement about the teaching and learning approaches that work best in the FE context.

Most students view their learning experiences more positively than those in school, although they would like more use of student-centred approaches. Teachers identified the need to counter low levels of student motivation and engagement and to adapt teaching in multiple ways to meet students' needs. This contingent teaching requires a rich toolkit of strategies and resources.

There are variations in the provision and uptake of out-of-class learning opportunities, and in the embedding of mathematics into vocational learning which require further research to ensure colleges can supplement and support classroom teaching in the most effective ways.

Understanding and developing pedagogy in context

Recommendation 14: Teaching and learning approaches that address the specific contexts, constraints and affective issues in FE need to be researched, developed and widely disseminated across the sector.

Recommendation 15: Mathematics teachers in FE need to be supported to develop a rich pedagogical toolkit that enables them to adapt teaching and learning to meet diverse students' needs.

Recommendation 17: Research on approaches to the 'embedding' of mathematics into vocational learning and the impact of different practices needs to be commissioned.

Objectives, pathways and sustainable improvement

Analysis of FE mathematics policy over the last 20 years shows how repeated attempts to develop alternatives to GCSE mathematics (i.e. core, key and functional skills) have failed to produce a sustainable and trusted qualification that addresses the skills needs of vocational learners.

[N.B. RS/ACME Qualifications Assessment Framework]

Recommendation 18: The long-term policy objectives for post-16 mathematics education need clear articulation. This might include:

- Renewed effort to establish a pathways model for 14-18 mathematics that complements different academic, vocational and technical routes;
- Identification of recommended qualification pathways for students with particular prior attainment and mathematical learning needs.
- A mapping of post-16 mathematics learning opportunities both in stand-alone qualifications and embedded within programmes.

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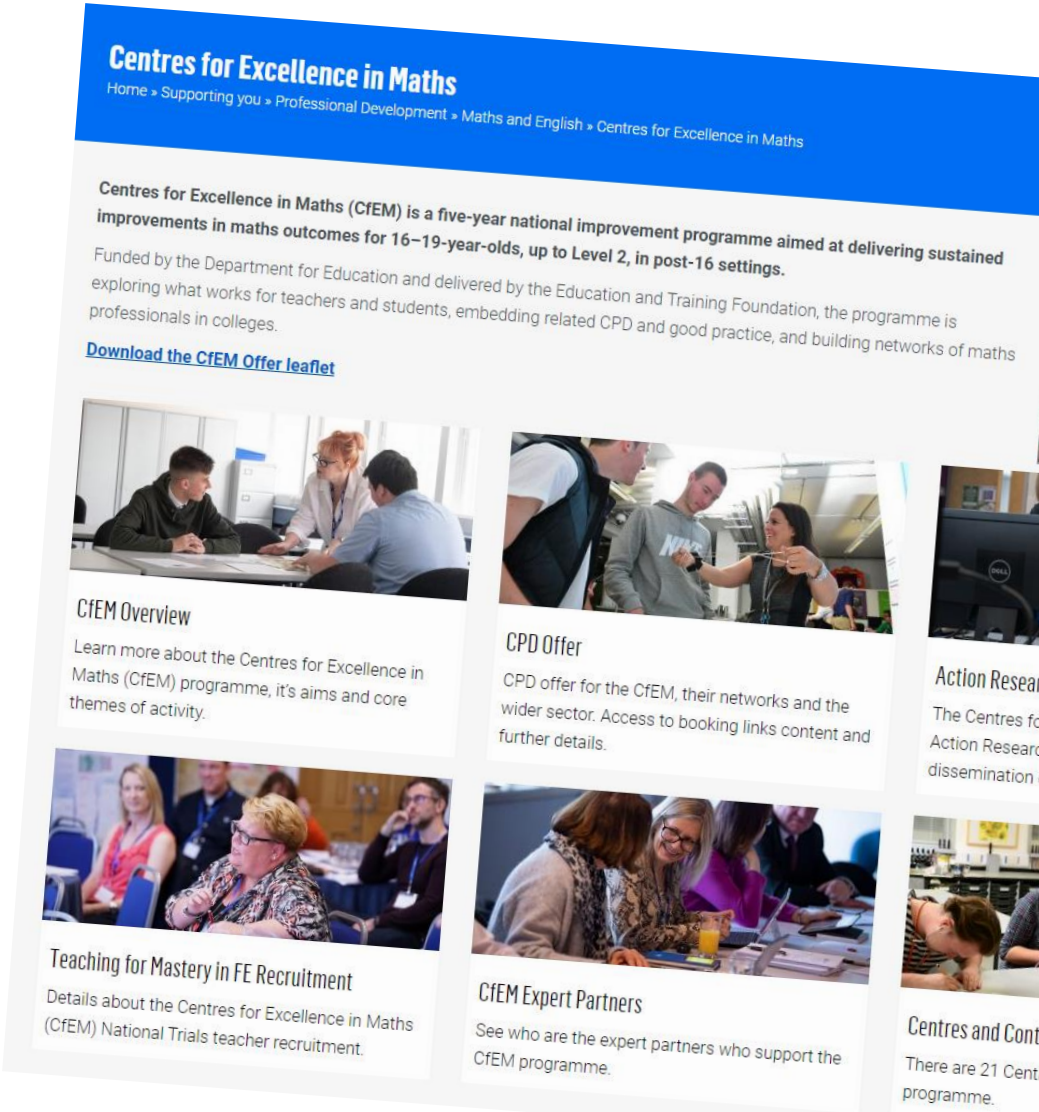
A couple of other *little* things…

Centres for Excellence in Maths

£40M, 2018-2023

originally a 9-partner consortium led by ETF

- 21 Centres
- Linked networks of FE and sixth form colleges
- Mastery for FE trials (collapsed from 4 themes)
- Action research
- Whole College Approach (new, from MiFEC)



Other post-16 mathematics developments

General Mathematical Competences in the T-levels

1. Measuring with precision
2. Estimating, calculating and error spotting
3. Working with proportion
4. Using rules and formulae
5. Processing data
6. Understanding data and risk
7. Interpreting and representing with mathematical diagrams
8. Communicating using mathematics
9. Costing a project
10. Optimising work processes

RS/ACME post-16 Contact Group rationale

Post-16 maths – does joining the dots reveal anything?

Strategic, tactical and technical design (Burkhardt 2009)

- Can we discern a **strategic design** for mathematics education nationally, at the interface between school, FE, HE, work?
- What about **strategic design** of mathematics education at the institutional level?

And would such 'design' processes work anyway – in terms of systems and complexity thinking? Or do they represent outdated notions of change planning?

The Whole College Approach (part of the CfEM programme) is one attempt to explore this question…

A whole college approach

Fragmentation → Coordination → Collaboration → Active participation

In a Whole College Approach, improving students' mathematics skills becomes a shared responsibility, supported by all staff through their active engagement in a collaborative effort.

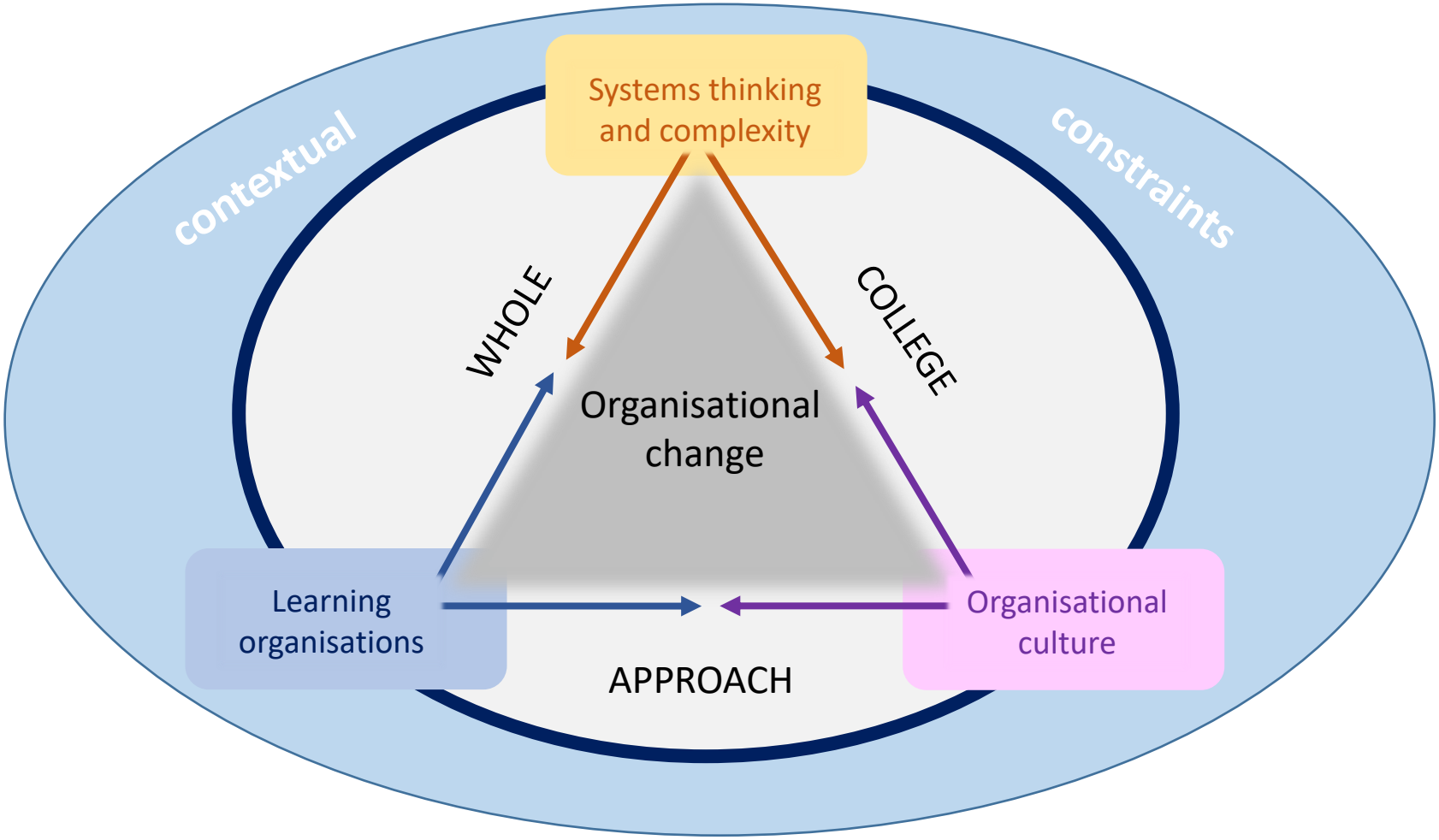
WCA project

Aims

- The WCA project aims to achieve an improvement in the understanding, planning and implementation of Whole College Approaches for mathematics in large FE colleges.

Objectives

- To translate the MiFEC and other related WOA research into practice;
- To build sector knowledge about WCAs;
- To develop, pilot and research the use of WCA self-assessment tools;
- To develop, pilot and research mechanisms to support practitioners in the development and use of a WCA;
- To produce stand-alone resources for improvement in WCA to mathematics;
- To produce case studies of the implementation of WCA in the FE college context.


contextual
constraints
Systems thinking and complexity
WHOLE
COLLEGE
Organisational change
Learning organisations
Organisational culture
APPROACH

CHIME framework

Contextual	Context matters. A WCA to mathematics must take into account the particular features of the college, in addition to external factors (national and local) that frame the implementation of mathematics policy and practice in FE.
Holistic	Colleges operate as complex systems of people and processes with the whole being both *more than the sum of the parts.* Understanding the big picture, and the relationships between the parts and the whole, is key to a WCA to mathematics.
Interconnected	There are many connections in a college system. Causes and effects are not always simple and change can be unpredictable. Planned WCA improvements can fail if the interactions between processes (and people) are not well understood.
Multidimensional	WCA problems have multiple dimensions, and these are perceived and understood from different points and angles of view. Valuing such diversity can aid understanding and the planning of improvement for mathematics.
Evaluative	Understanding and improving a WCA for mathematics requires effective data generation and information exchange. It is important to develop a culture of self-assessment, critical inquiry, iterative evidence-building and collective analysis.

Key elements of WCA project

WCA college teams of staff with different roles will work together on a self-identified problem or area for improvement in their mathematics provision. They will be supported by:

- Professional development events for all participants to develop understanding of a WCA;
- Self-assessment tools to examine the *college context* and *WCA climate*, and to *analyse the problem*;
- Meetings of college WCA teams with a 'critical friend';
- Meetings of college WCA teams with 'buddy' colleges;
- Regular monitoring meetings with WCA college leads.

Project phases

Discovery phase (May-July 2021)

- WCA college teams will engage in three Self-Assessment (SA) activities to explore the context of their problem, assess the current situation and identify possible affordances and constraints.

Planning phase (July-October 2021)

- WCA college teams will build on the outcomes of the self-assessments to better define the problem they intend to solve, the interlinked issues and the affordances and constraints.

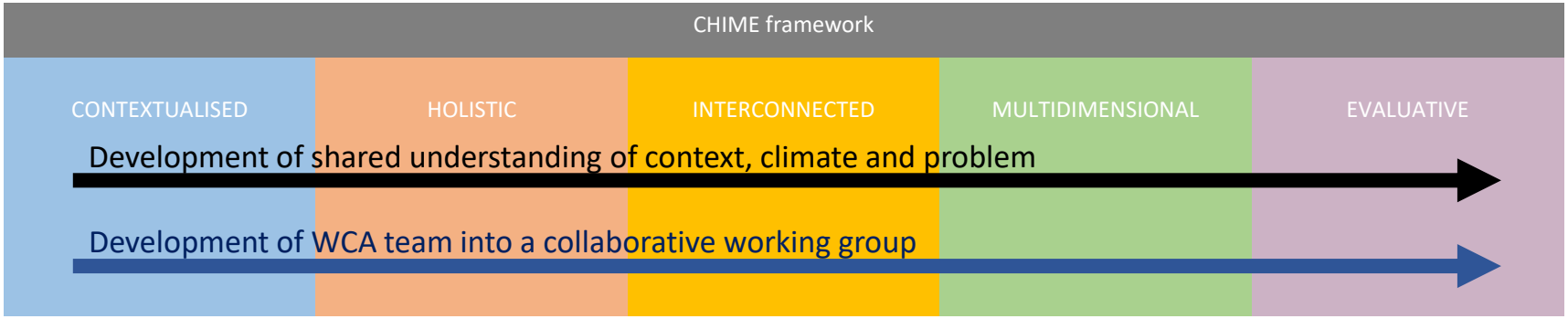
Intervention phase (October 2021-May 2022)

- WCA college teams will plan and implement their intervention with support from their critical friend (UoN). Colleges will also have two meetings with a 'buddy group' of colleges to discuss their plans and provide mutual support.

Review phase (June-July 2022)

- Each college will develop a short report of their work. These will inform the research and form part of the longer term plan for the project.

DISCOVERY PHASE		
SA1: context	SA2: climate	SA3: analysis
To develop: • a shared understanding of the college **context**; • collaborative ways of working together within an open-minded within an open-minded, inquiring and supportive culture.	To develop: • a shared multidimensional view of the college **climate**; • better understanding of different perspectives and their value in multidimensional analysis; • collaborative ways of working together.	To develop: • a shared understanding of the **problem** and related issues; • a detailed analysis of the problem (using CHIME and systems mapping); • Understanding of key elements, connections, affordances and constraints of systems and culture.



In summary…

A few general points, in no particular order…

- Multiple purposes, policies and practices in post-16 mathematics make intentional, sustainable change difficult
- There is a raised profile for mathematics post-16, but not yet the 'maths-for-all-to-18' envisioned by Michael Gove in 2011; such a *vision* is arguably *blurred* by two quite different agendas
- The renewed attempts to embed mathematics 'across the curriculum' presents both opportunities and challenges; better understanding of this is needed
- Flexible, meaningful, motivating mathematics pathways still do not exist for most learners
- The curriculum and assessment in established maths qualifications is hard to change, and dominant
- Post-16 institutions vary considerably and new change models are needed ('spreading best practice' needs rethinking)
- Etc.

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That’s all folks
Thanks for listening
Any questions?