Student success in tertiary mathematics:

the multiple dimensions of institutional responsiveness

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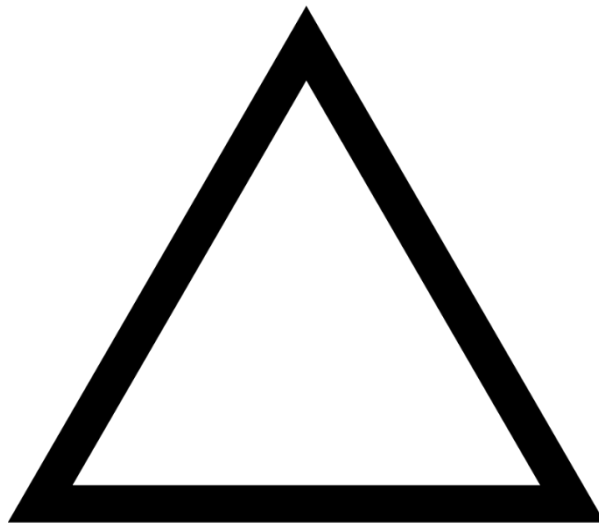
The context

- Annually only *ca.* 22 000 students achieve 60% or above for both NSC mathematics and physical sciences and this number is declining

- Only 4 600 learners achieved 80% for both NSC mathematics and physical sciences in 2018

- 25 Tertiary institutions in South Africa compete to recruit them for programmes in economics, engineering, science, medicine and veterinary sciences

- STEM professions are recognised as Scarce skills

- Academic development programmes provide access for students not meeting admissions requirements for direct access

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Waves of change

**Undergraduate mathematics:
Average module pass rate (2006 – 2018)**

2015: CAPS

#FeesMustFall

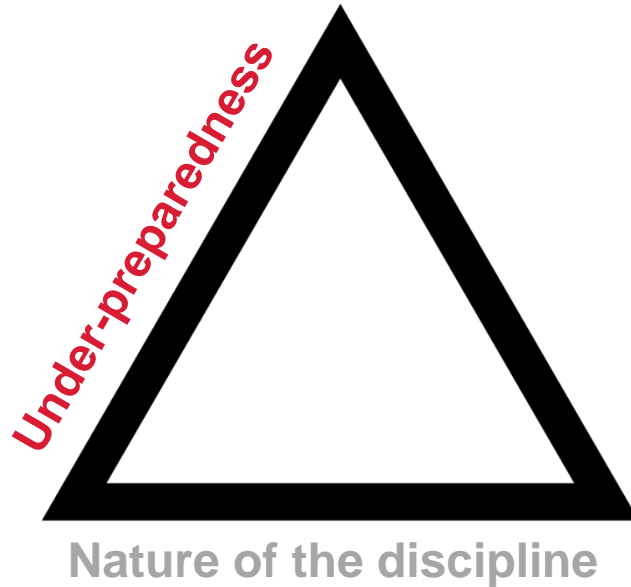2009: NCS
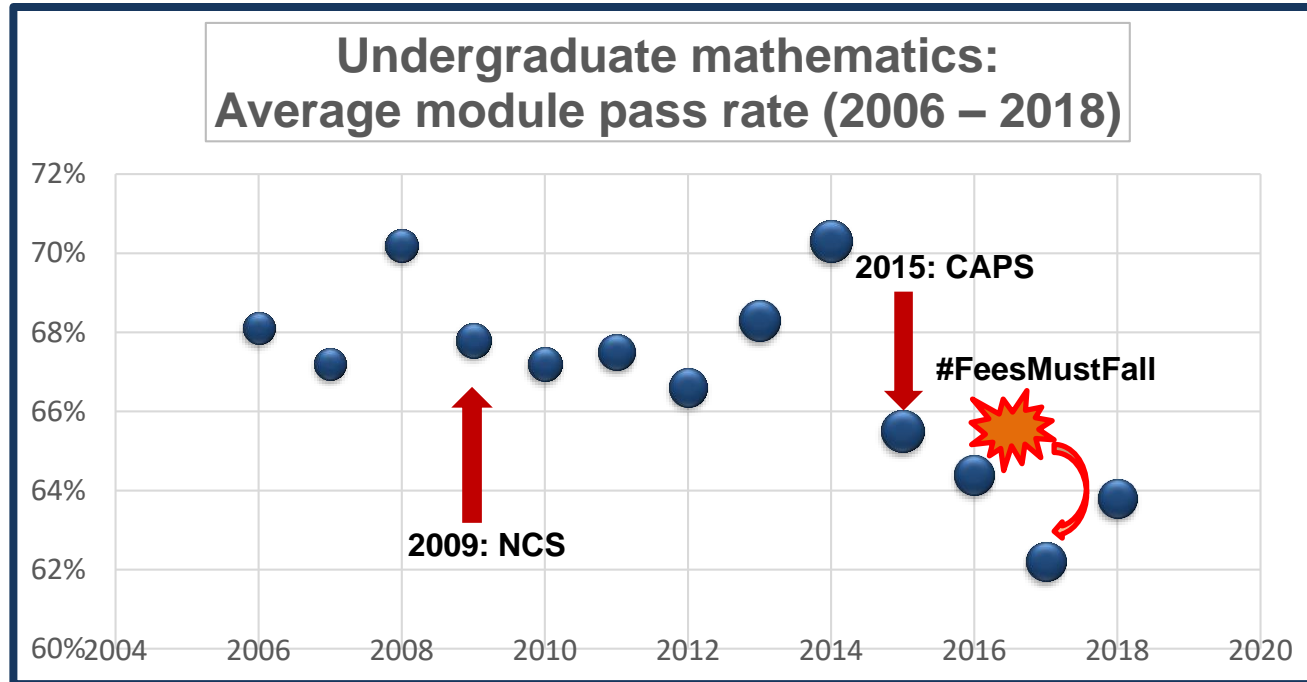
Analysis of the "problem"
(Undergraduate performance in mathematics)

Nature of the discipline

Analysis of the "problem"
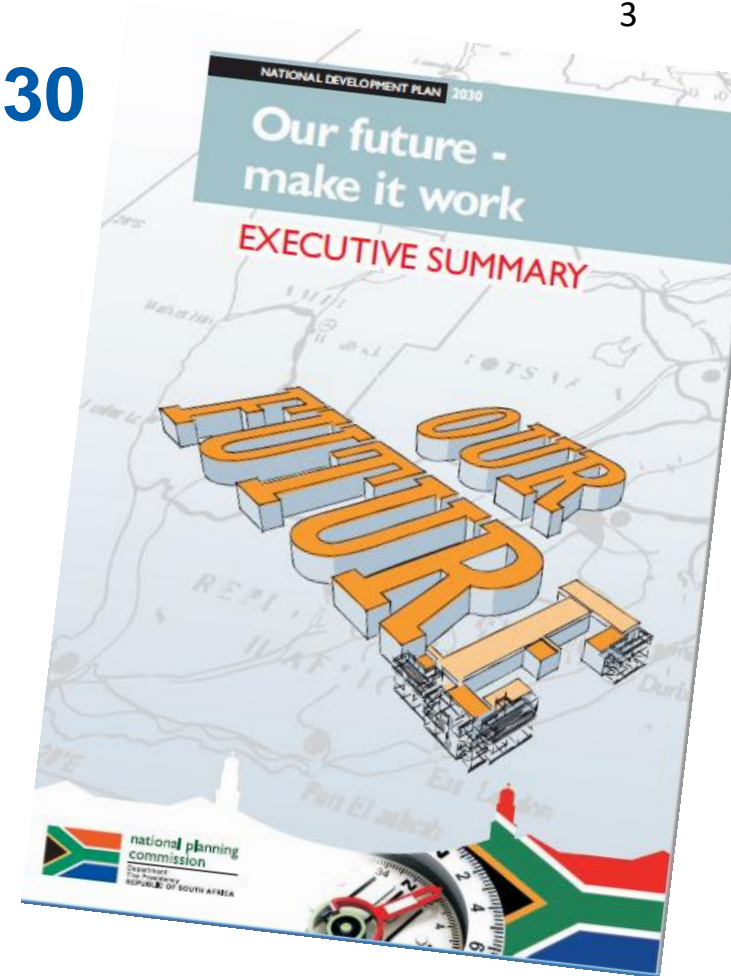## (Undergraduate performance in mathematics)

National Development Plan 2030

About secondary education:
"The FET system is not effective. It is too small and the output quality is poor." (p 43)

About Higher Education:
"A major challenge is that poor school education increases the cost of producing graduates, and a relatively small number of black students graduate from universities."
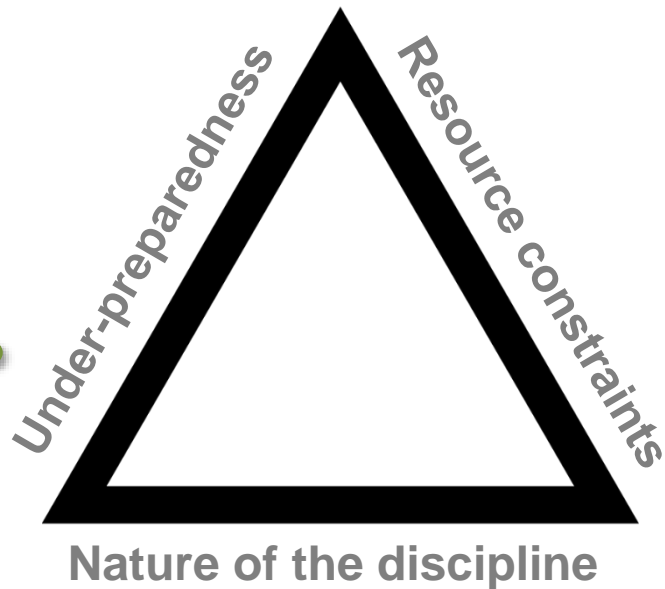(p 43).

Analysis of the "problem"
(Undergraduate performance in mathematics)

Under-preparedness

Resource constraints

Nature of the discipline
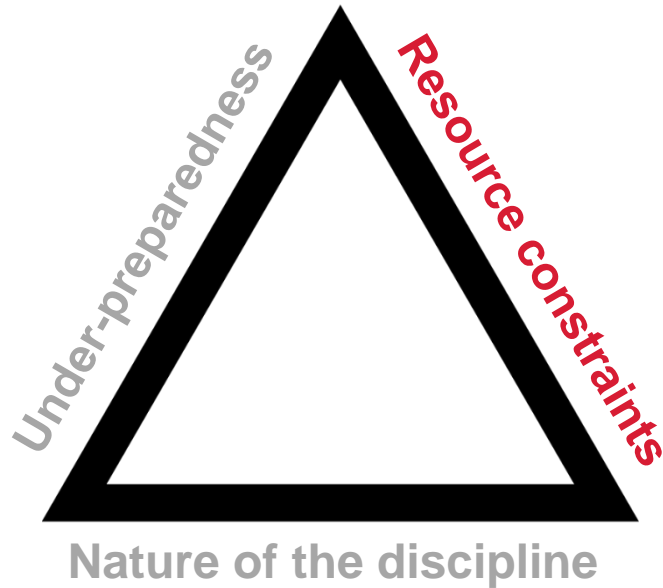
Fix the problem!

CHE report (2013): A proposal for undergraduate curriculum reform in South Africa

"It is widely accepted that student underpreparedness is the dominant learning-related cause of the poor performance patterns in higher education. It follows that it is the school sector that is most commonly held responsible.

….. the Task Team believes that [while] the level of dysfunction in schooling must continue to be a primary focus of corrective effort, …..there is effectively no prospect that it will be able, in the foreseeable future, to produce the numbers of well-prepared matriculants that higher education requires.

In these circumstances, a choice has to be made by the higher education sector: between, on one hand, allowing the status quo to persist, and, on the other, undertaking to act on factors that are within its control to address the systemic conditions impeding student success."

Fix the problem!
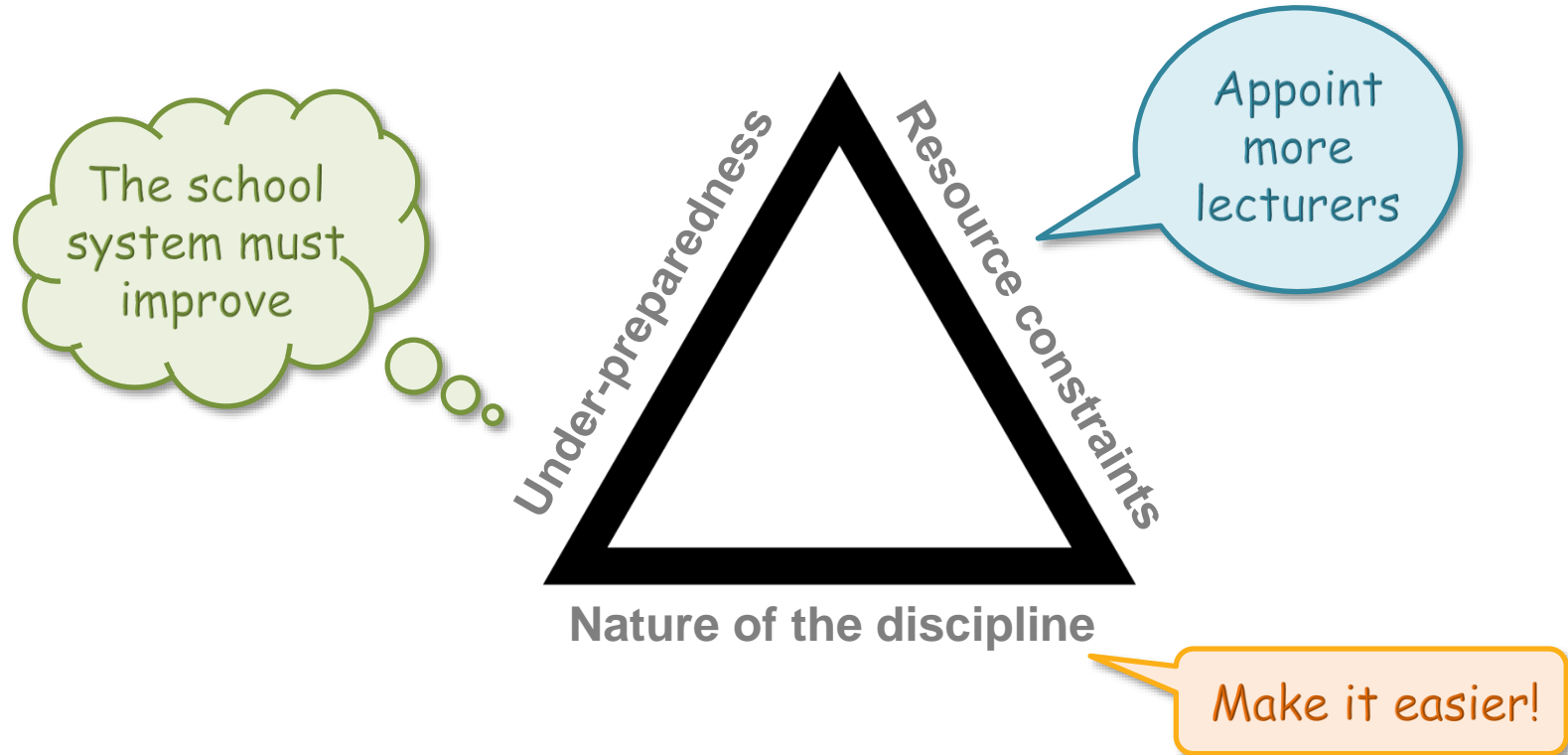
The UP approach:
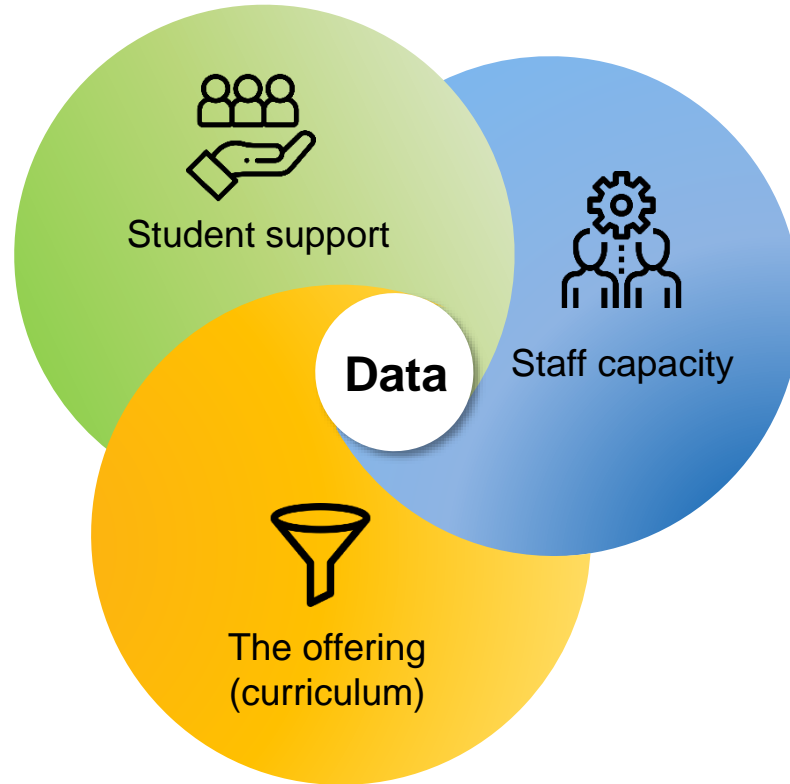
The UP approach: Institutional responsiveness
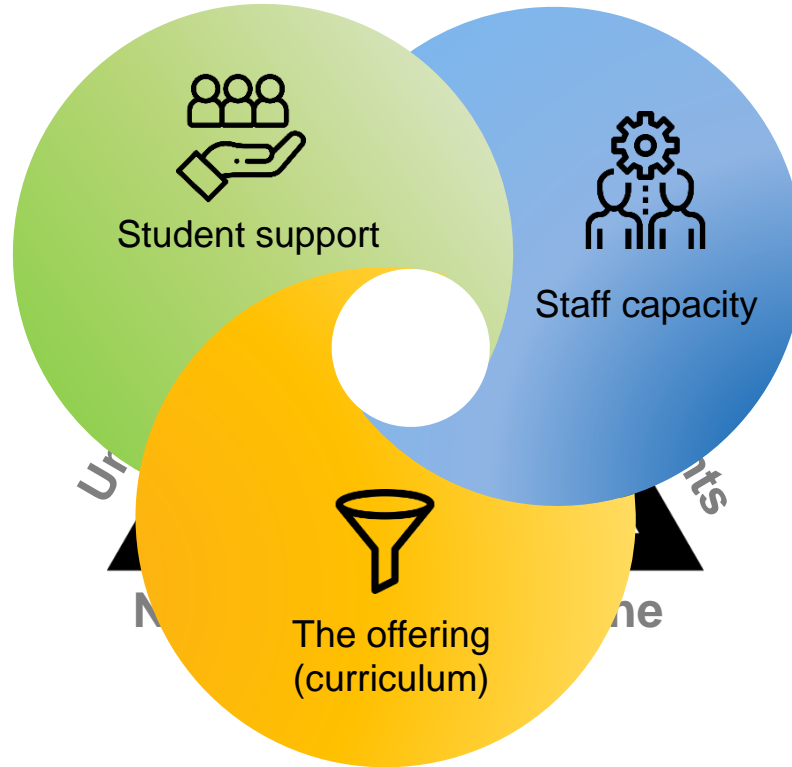
The centre piece – data
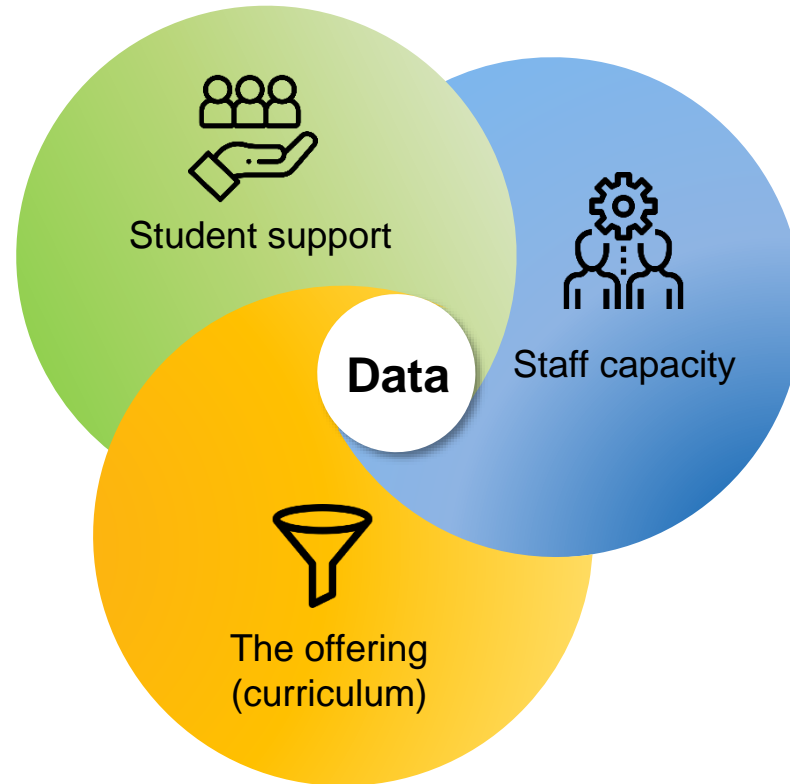
Evidence-based decision-making

a) Student readiness tests during Orientation week

b) Prediction modelling for WTW 200 (BSc mathematics)

c) Bayesian network analysis of Engineering mathematics

a) Calculus Readiness Test

Developed in-house

- Test implemented since 2017; administered during O-week

- Objective assessment: 30 MCQs

- The test was refined after 2017, prediction power is good

- Results inform lecturers of students' strengths & weaknesses

- Students receive detailed feedback

- Early warning for student at risk

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Email message to students at risk of failing WTW 114

"*Dear Student*
Your WTW 114 semester Test 1 is taking place on 7 March 2019.
That means you have exactly **9 days** *before the test. In 9 days, you could achieve the following:*

1. Consult with lecturers on aspects of the work you still do not understand

2. Consult with tutors for assistance

3. Make use of Maths room 1-14 to practice Maths problems. Remember practice makes perfect. And lastly

4. Visit the WTW 114 click-up page for Maths specific advice and access to previous test papers"

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b) Predictive modelling for WTW200 performance

Problem statement

- To what extent can achievement in 1st year Maths be used to explain students' performance in their 2nd year Math modules? Focus on *Success.*

1 ≡ Success	> 55
2 ≡ At risk	45 ≤ WTW2.. ≤ 55
1 ≡ Failure	< 45

Modelling tools

- CHAID   ⟶   Data segmentation   ⟶   Dendogram (tree)
- Logistic regression models

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WTW 211

1 ≡ Success	> 55
2 ≡ At risk	45 ≤ WTW2.. ≤ 55
1 ≡ Failure	< 45

WTW211_1st_rec

Node 0

Category	%	n
■ Success	43.8	383
■ At risk	36.6	320
■ Failure	19.7	172
Total	100.0	875

Legend:
- ■ Success
- ■ At risk
- ■ Failure

WTW114_first
Adj. P-value=0.000, Chi-square=431.608, df=10

Split: <= 55.0; <missing> | (55.0, 64.0] | (64.0, 69.0] | (69.0, 76.0] | (76.0, 80.0] | > 80.0

Node 1

Category	%	n
■ Success	7.7	14
■ At risk	42.3	77
■ Failure	50.0	91
Total	20.8	182

Node 2

Category	%	n
■ Success	16.9	28
■ At risk	56.0	93
■ Failure	27.1	45
Total	19.0	166

Node 3

Category	%	n
■ Success	30.4	28
■ At risk	55.4	51
■ Failure	14.1	13
Total	10.5	92

Node 4

Category	%	n
■ Success	47.5	84
■ At risk	40.1	71
■ Failure	12.4	22
Total	20.2	177

Node 5

Category	%	n
■ Success	77.8	63
■ At risk	21.0	17
■ Failure	1.2	1
Total	9.3	81

Node 6

Category	%	n
■ Success	93.8	166
■ At risk	6.2	11
■ Failure	0.0	0
Total	20.2	177

WTW126_first
Adj. P-value=0.000, Chi-square=35.457, df=4

Sex
Adj. P-value=0.010, Chi-square=9.305, df=2

WTW128_first
Adj. P-value=0.000, Chi-square=26.017, df=1

Split: <= 57.0 | (57.0, 74.0]; <missing> | > 74.0 | M | F | <= 80.0 | > 80.0

Node 7

Category	%	n
■ Success	25.0	9
■ At risk	38.9	14
■ Failure	36.1	13
Total	4.1	36

Node 8

Category	%	n
■ Success	44.4	44
■ At risk	47.5	47
■ Failure	8.1	8
Total	11.3	99

Node 9

Category	%	n
■ Success	73.8	31
■ At risk	23.8	10
■ Failure	2.4	1
Total	4.8	42

Node 10

Category	%	n
■ Success	64.3	27
■ At risk	33.3	14
■ Failure	2.4	1
Total	4.8	42

Node 11

Category	%	n
■ Success	92.3	36
■ At risk	7.7	3
■ Failure	0.0	0
Total	4.5	39

Node 12

Category	%	n
■ Success	80.0	44
■ At risk	20.0	11
■ Failure	0.0	0
Total	6.3	55

Node 13

Category	%	n
■ Success	100.0	122
■ At risk	0.0	0
■ Failure	0.0	0
Total	13.9	122

Summary: **CHAID and Logistic regression results**

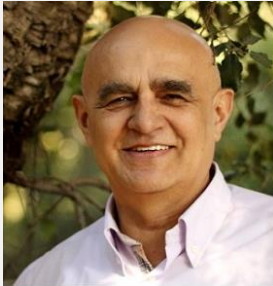| Yr 2, Sem 1 | WTW 211 | ← | WTW 114 | Early predictor |
	WTW 218	←	WTW 128	
Yr 2, Sem 2	WTW 220	←	WTW 211	
	WTW 221	←	WTW 211	
	WTW 248	←	WTW 218	

Sharing the message

- Infograph – posters, study guide

- Class visits by:

HOD   Student advisor   Student advisor
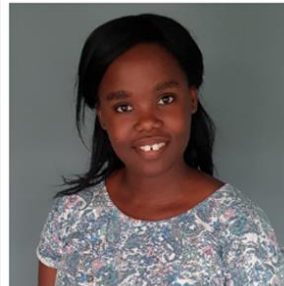
- Advising on Alternative options

# c) Bayesian network analysis of Engineering mathematics

The five most influential modules in the BEng programmes
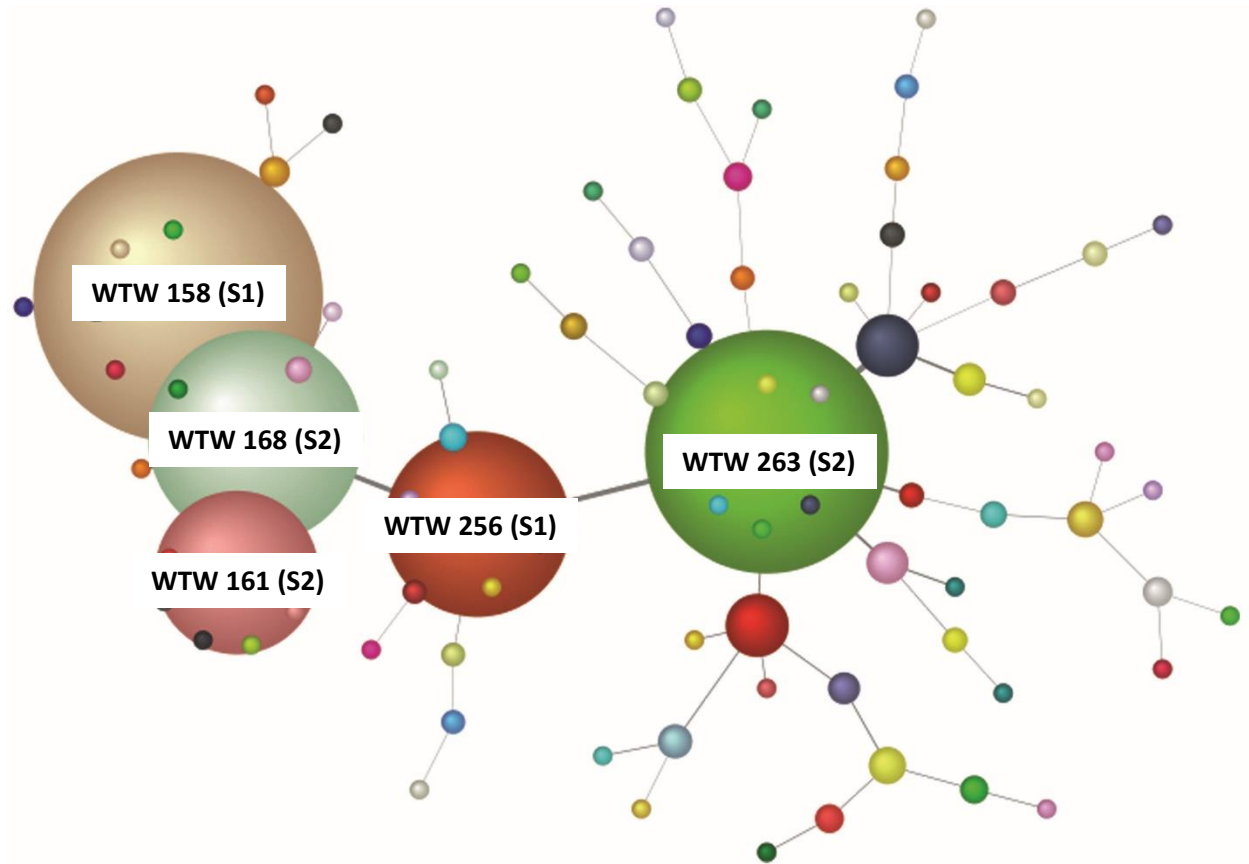
Tier 1: Refine the maths offering

Admission requirements, progression, alignment, differentiation

- Admission requirements: increased for intake of 2015 and 2020.

- Lay the foundation (Extended programme)

- Guided pathways (pipeline *vs* service courses)

- Summer/winter schools

Student support

Staff capacity

Data

The offering (curriculum)
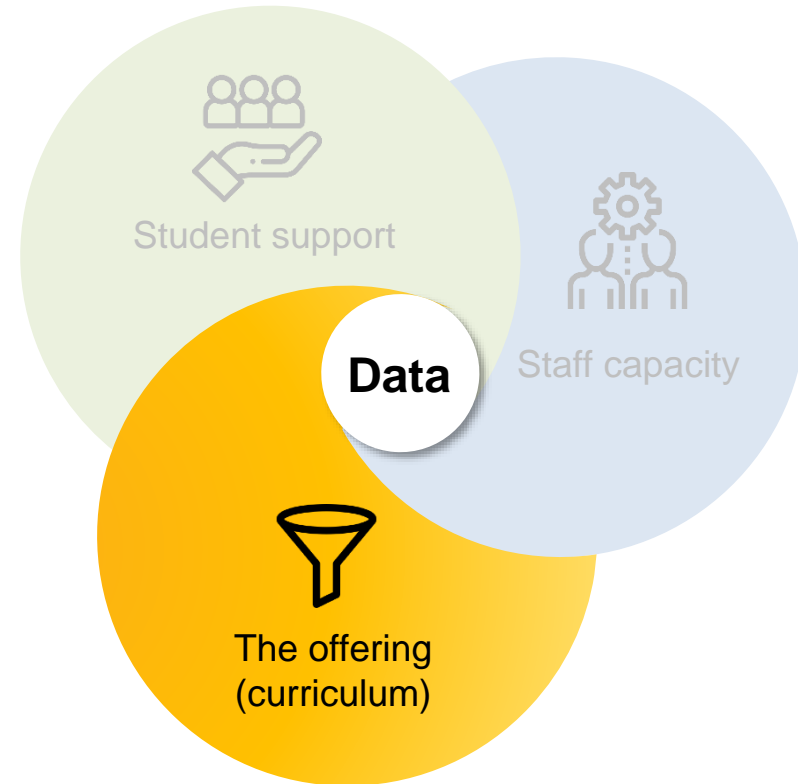
Tier 2: Student support & empowerment

- Motivation, mindset and persistence

- Make the right choices (#FLY@UP with Maths)

- Mitigating repeated failure: learning communities for senior students at-risk

- Maths buddies for first-year students

- Boiler Room, involvement of Crypto Giants

Student support

Data

Staff capacity

The offering (curriculum)
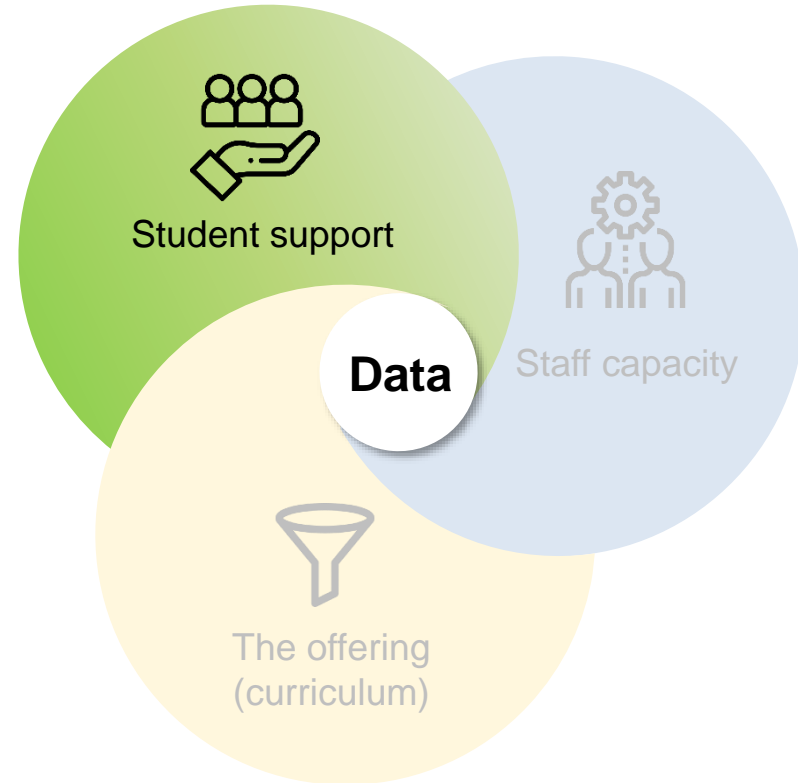
2a) Motivation, mindset and persistence

- O-week: Onboarding & Learning strategies for Maths

- Weekly workshops on study methods, time management, preparation for tests and exams

Mid-semester class visits:

- Reinforce messages given during O-week

- Prerequisites – gateway courses

- Make the right choices (#FLY@UP with Maths)

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2b) Learning communities for senior students (pilot)

Mitigating repeated failure

- 15 participants at risk of final dismissal

- WhatsApp group monitored by Student advisor

- Strict requirements for participation

- Tutor assistance before major assessments

2c) Maths buddies for First-year students

- Peer learning

- Accountability, confidence

- Constructive academic behaviours

> *My name is [Dinah] and I am a WTW 114 student. I do have a Maths Buddy and it was really helpful.*
>
> *I think that having Maths Buddies for WTW 124 (the next module) is an awesome idea.*
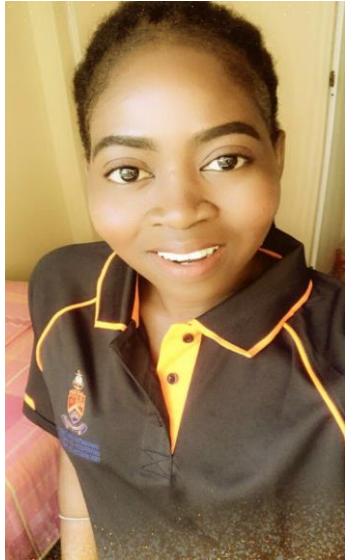
Dear Dr Mmadi
Thank you for everything you do to ensure that we do our best at UP. We really appreciate it. Life would have been a whole lot harder for us in our first semester. Continue doing an amazing job.

2d) Boiler Room

Social learning space

2e) Crypto Giants



**Muvhuso Phatela,
deputy chair**

The Crypto Giants are in the Boiler Room, Monday to Thursday 14:30 – 17:20.

Students can walk in anytime for consultation or just to do maths and will be assisted should they struggle.

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Tier 3: Building staff capacity for teaching

a) CPD training

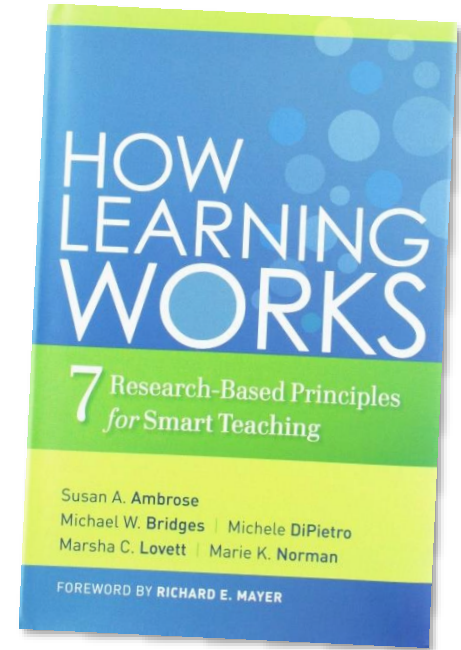b) FLY@NAS brown bag events

c) T&L@NAS Bulletin
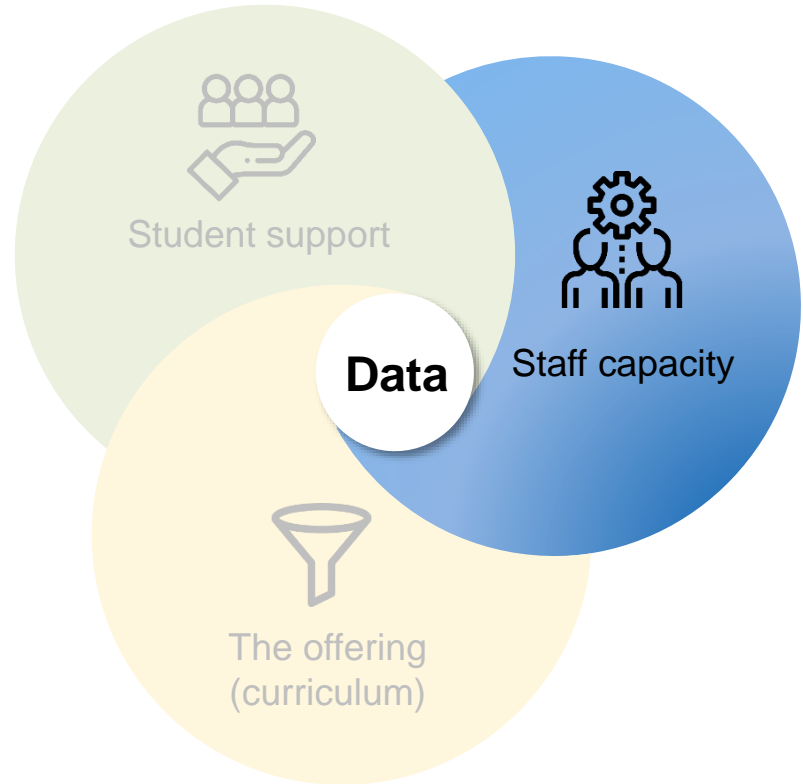
3a) CPD training

- Education consultant

o How learning works

o The art and science of presenting a lecture

o Writing Learning Outcomes (LOs) with Bloom in mind (Study guide improvement)

o How to Flip without Flop

o How to foster a Growth mindset

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Impact of CPD training (2018 data)

16 sessions, 450 academics in Faculty
62% of academics in Maths Dept

Feedback:

Art & Science of presenting a lecture

"Thank you for sharing the "expert blind spot". I will find my blind spot and recognize it!"

"The idea that I will immediately introduce is minute papers. I love it!"

How to foster a Growth mindset (GM)

"The whole session gave me insight in how I say things in class. I should inspire a GM, not a FM".

"Great presentation. You gave me more ideas on how to improve myself first. Thank you."

"I learned so many useful things, how can I list only three?"

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3b) FLY@NAS brown bag events

- Informal CoP events for lecturers

- Practitioners share successful instructional approaches
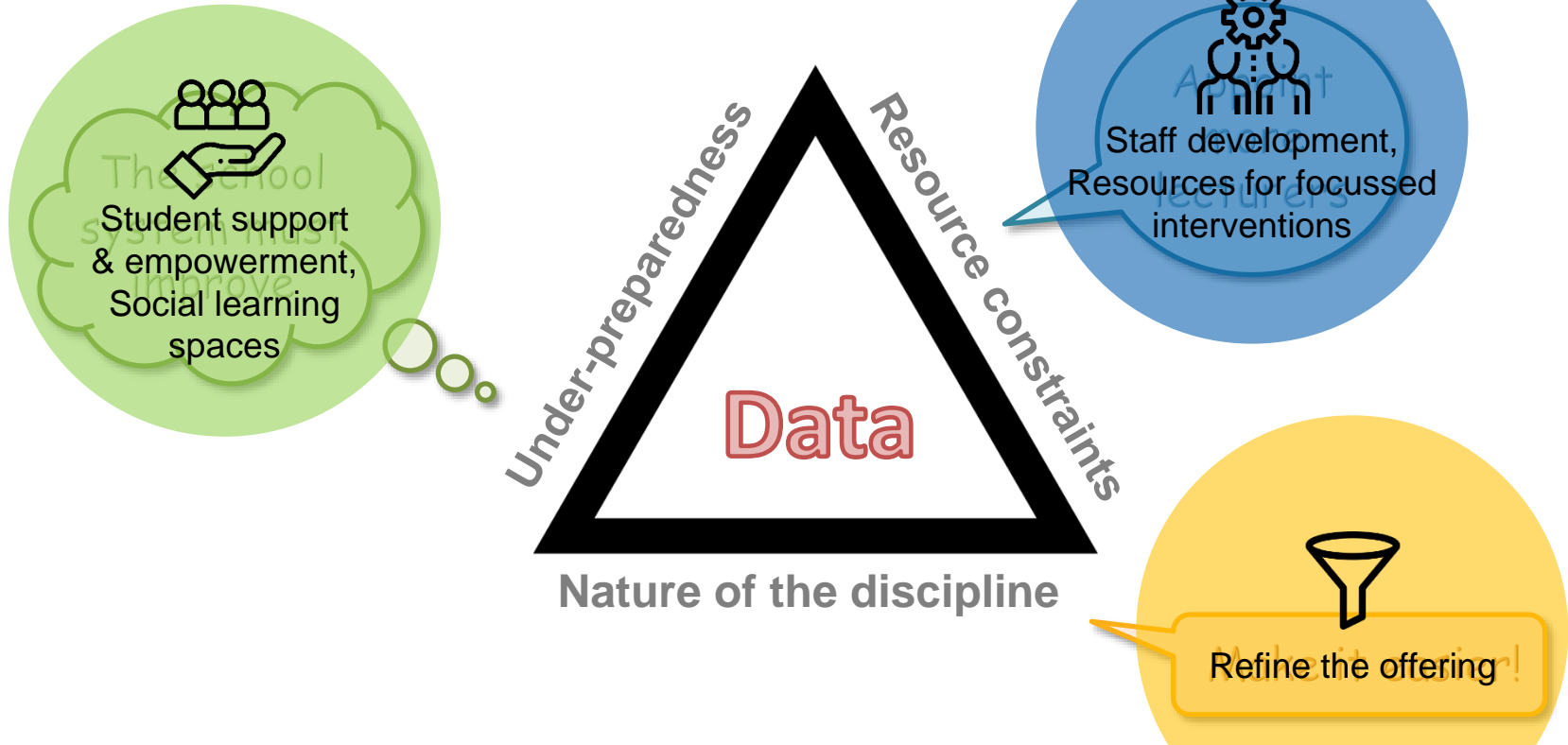
- Toolbox event 29 May: 76 attendees

3c) T&L@NAS Bulletin

- Brainchild of Rory Biggs, a young maths lecturer, launched 1 August 2018, published biannually.

- To raise awareness of teaching innovations and effective instruction in science disciplines.

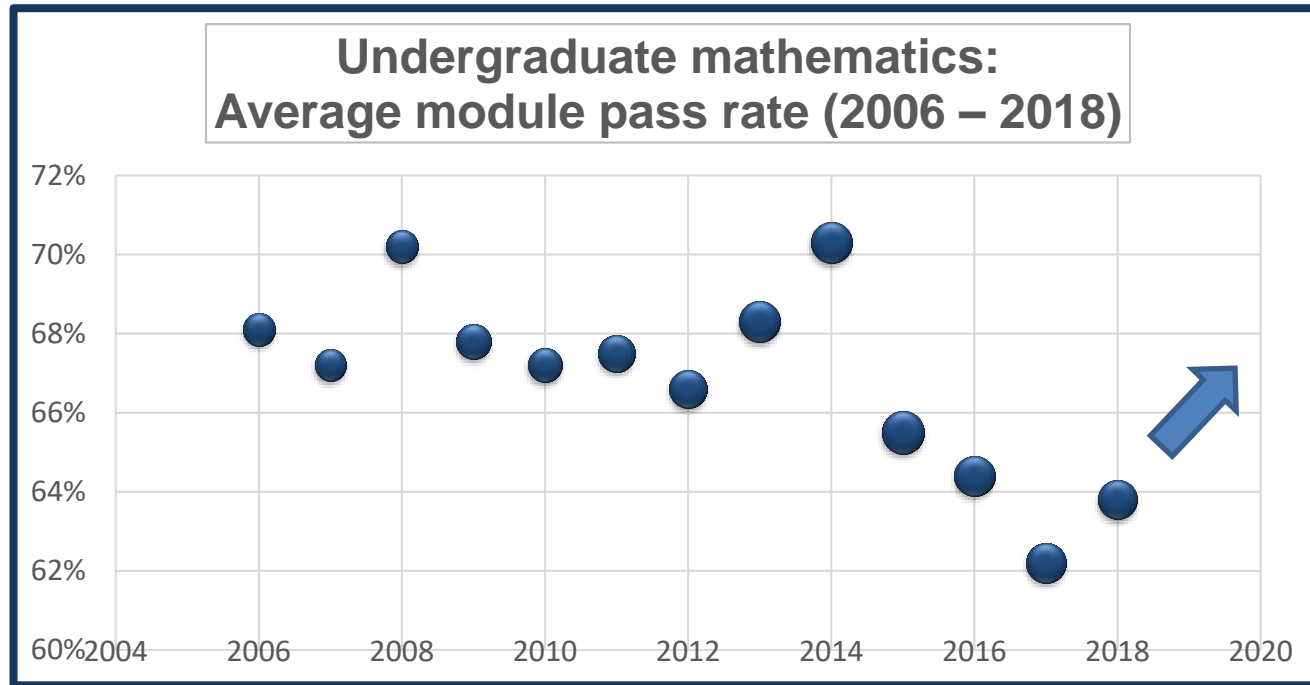- Contains short stories with links to a webpage or tools and a HowTo@NAS guide where appropriate.

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Faculty of Natural and Agricultural Sciences
Fakulteit Natuur- en Landbouwetenskappe • Lefapha la Disaense tša Tihago le Temo

Saving you energy!

Improving student performance in mathematics is a team effort!

Undergraduate mathematics:
Average module pass rate (2006 – 2018)

Thank You

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