Approaches to Developing Tomorrow's Engineering Problem Solvers

(based on the Candidate Academy and Numbers and Needs Experiences)

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FACT OR FICTION?

There is a shortage of engineers

There is a shortage of experienced engineers

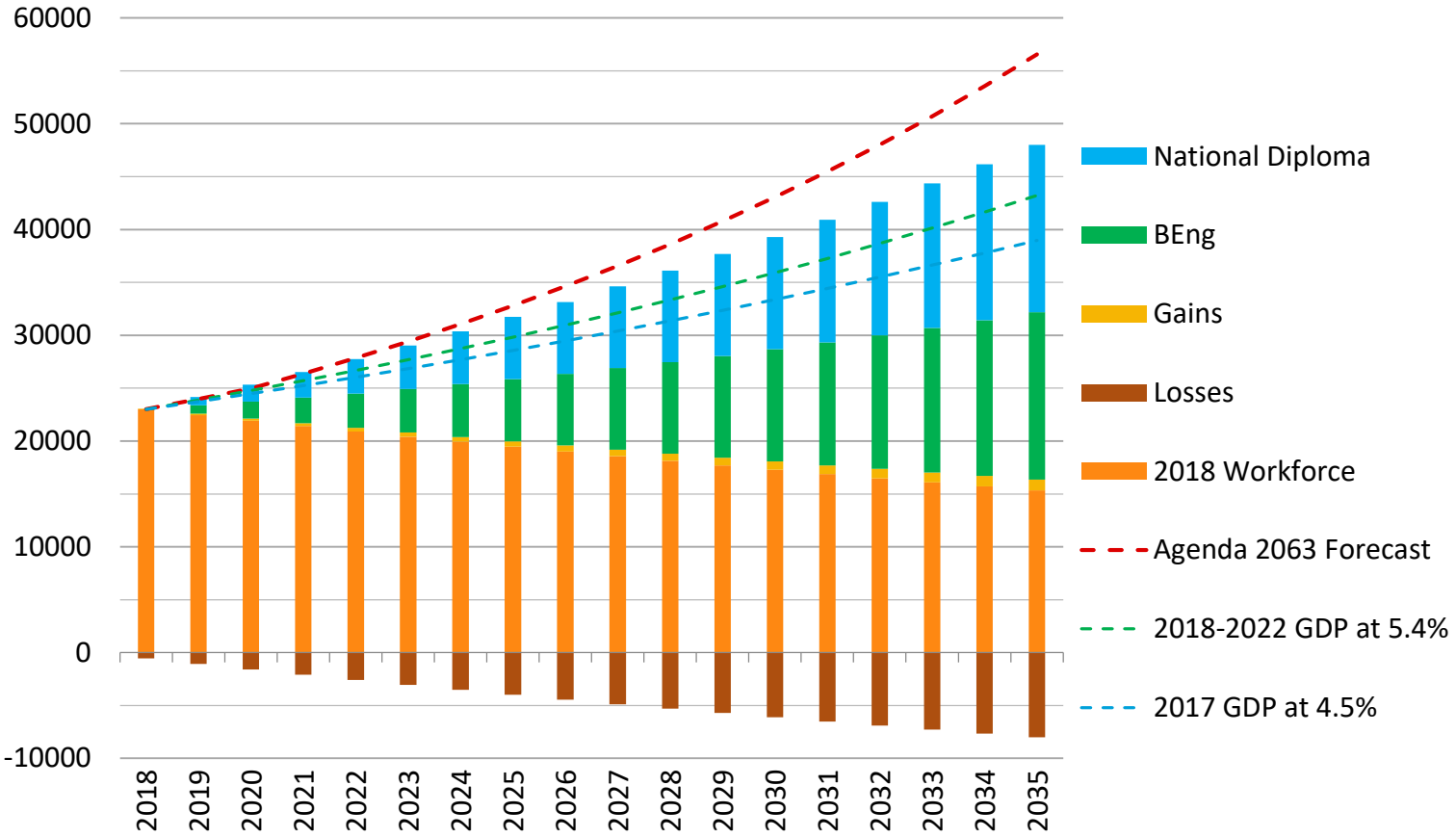
Graduates are unemployable

THE SADC ENGINEERING NUMBERS AND NEEDS STUDY

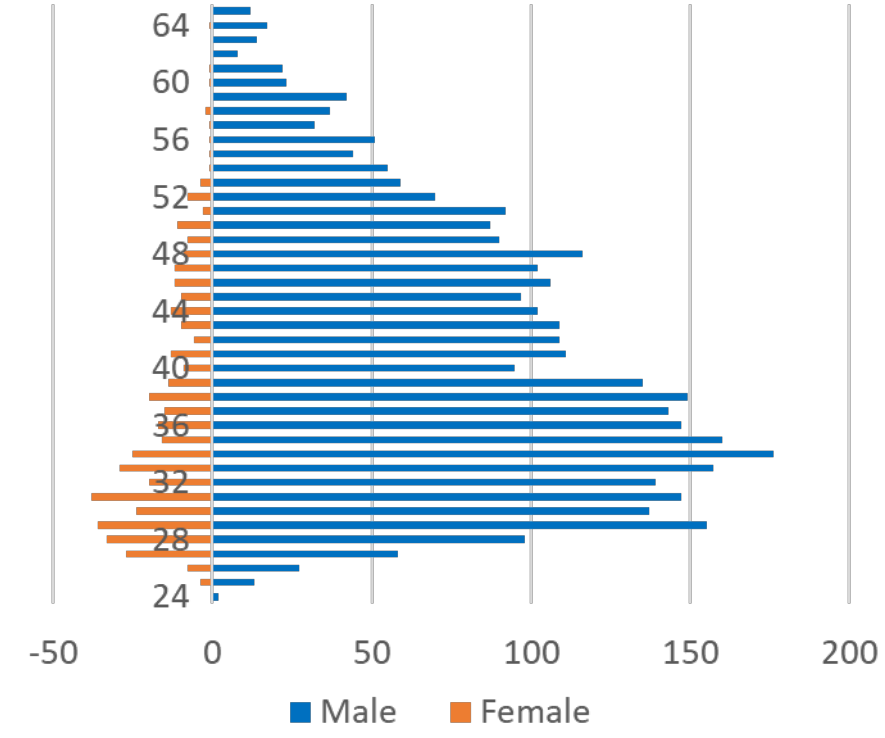
To address industrialisation in the SADC region (15 countries) determine the adequacy of the engineering workforce, gaps and solutions. Need to:

- Determine numbers in the workforce
- Determine needs based on current workload, demands of policies and planned projects
- Determine inflows from higher education and immigration
- Identify successful initiatives in place and lessons learned
- Determine gaps and how to address them by following existing successful models, and/or developing innovative solutions

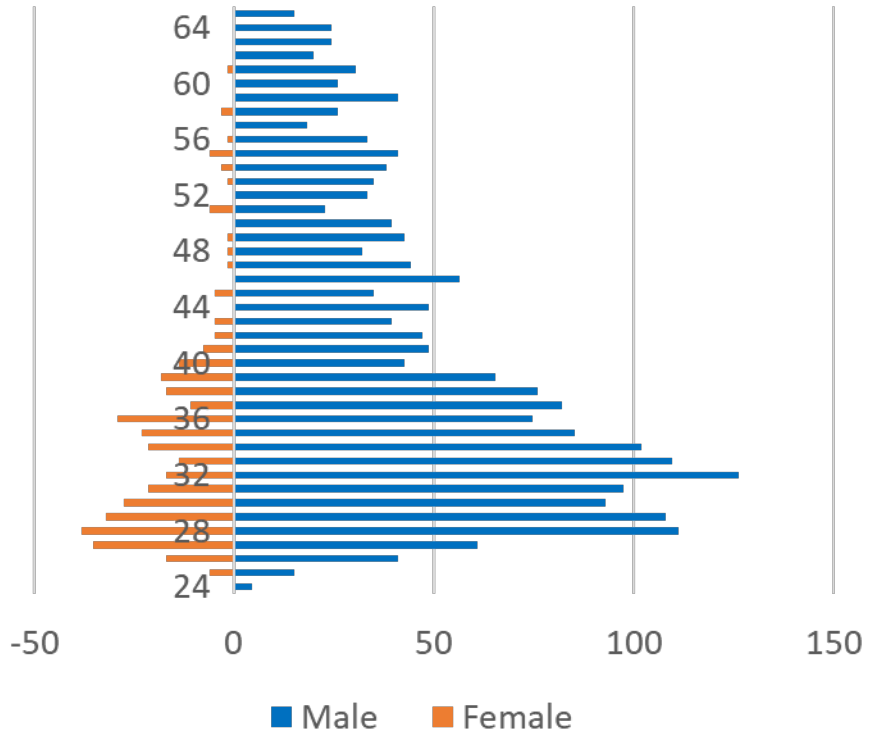
FLOW OF SKILLS



EXCESSIVE NUMBER OF GRADUDATES & TOO FEW WITH EXPERIENCE TO DEVELOP THEM



Botswana 2015



Namibia 2017

SO WHICH ARE THE MYTHS?

There is a shortage of engineers

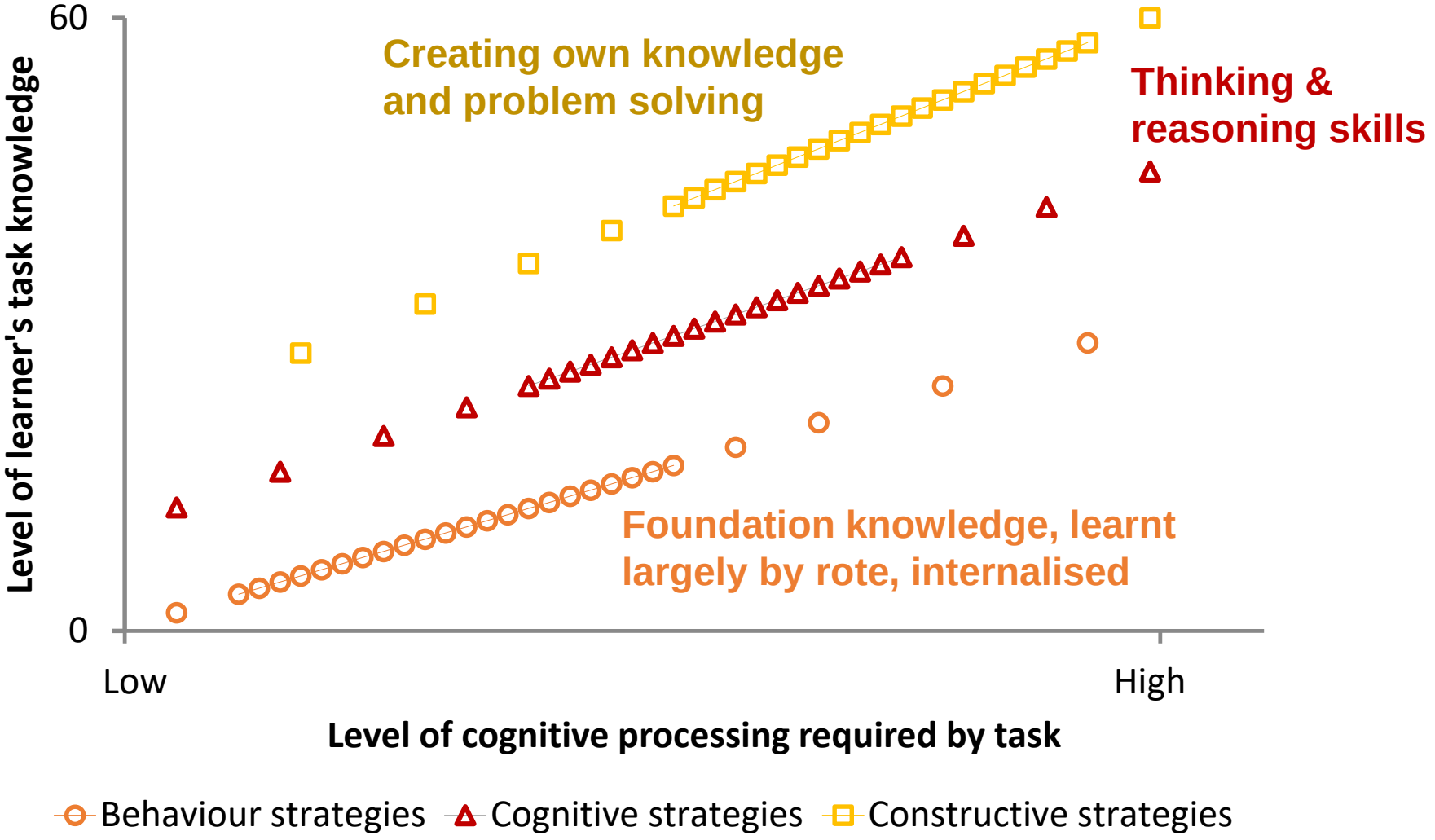
There is a shortage of experienced engineers

Graduates are unemployable

But have we given them appropriate education & training?

(Acknowledgement to the MyBusters)

SCHOOLS – CHANGED TEACHING STRATEGIES in 80s or 90s



(Acknowledgement to Peggy Ertmer)

HIGHER EDUCATON – THE PERRY SCALE (modified with apologies)

Knowledge is received and not questioned – student wants the correct answer to learn (*past exam paper syndrome*)

Subjective knowledge – there may be more than one solution to a problem, or there may be no solution – student needs to find the right solution

Contextual knowledge – there is no right or wrong solution, it depends on the situation – student evaluates viewpoints/options based on source and evidence

Expanding knowledge – student realises the need to look beyond the notes and the lecturer for possible solutions

Constructed knowledge – creates solutions by integrating own knowledge with other sources and reflects

Takes responsibility for the final solution

Acquisition of knowledge must be an ongoing activity

WHAT IS EXPECTED OF PROFESSIONALS?

- Investigate ‘problems’
- Solve ‘problems’
- Execute or implement solutions
- Take responsibility

Have our students grasped this and do we help our graduates understand their role?

THE WORKPLACE IS WHERE WE MAKE ENGINEERS

- … “the quality and quantity of the learning opportunities afforded by experience at work are the primary factor affecting the quantity and quality of engineers learning” *Peter Senker, Uni of Sussex*
- … “training for new college graduates that was once offered in organisations of all sizes – are now anomalies associated with only the biggest companies” *Peter Cappelli, Uni Pennsylvania*
- … “government is paying millions in tuition fees for engineering students, yet it is not providing an environment for those students to practice once they complete their studies and enter the job market” *Charles Mukwase, Namibia Society of Engineers*
- … “we bring up our children with enormous effort and care from primary school through to university, yet we abandon them when they need us most. Medical students cannot hope to become doctors without practical experience; neither can engineering students become engineers without acquiring practical skills” *Tjaart van der Walt, IMESA*

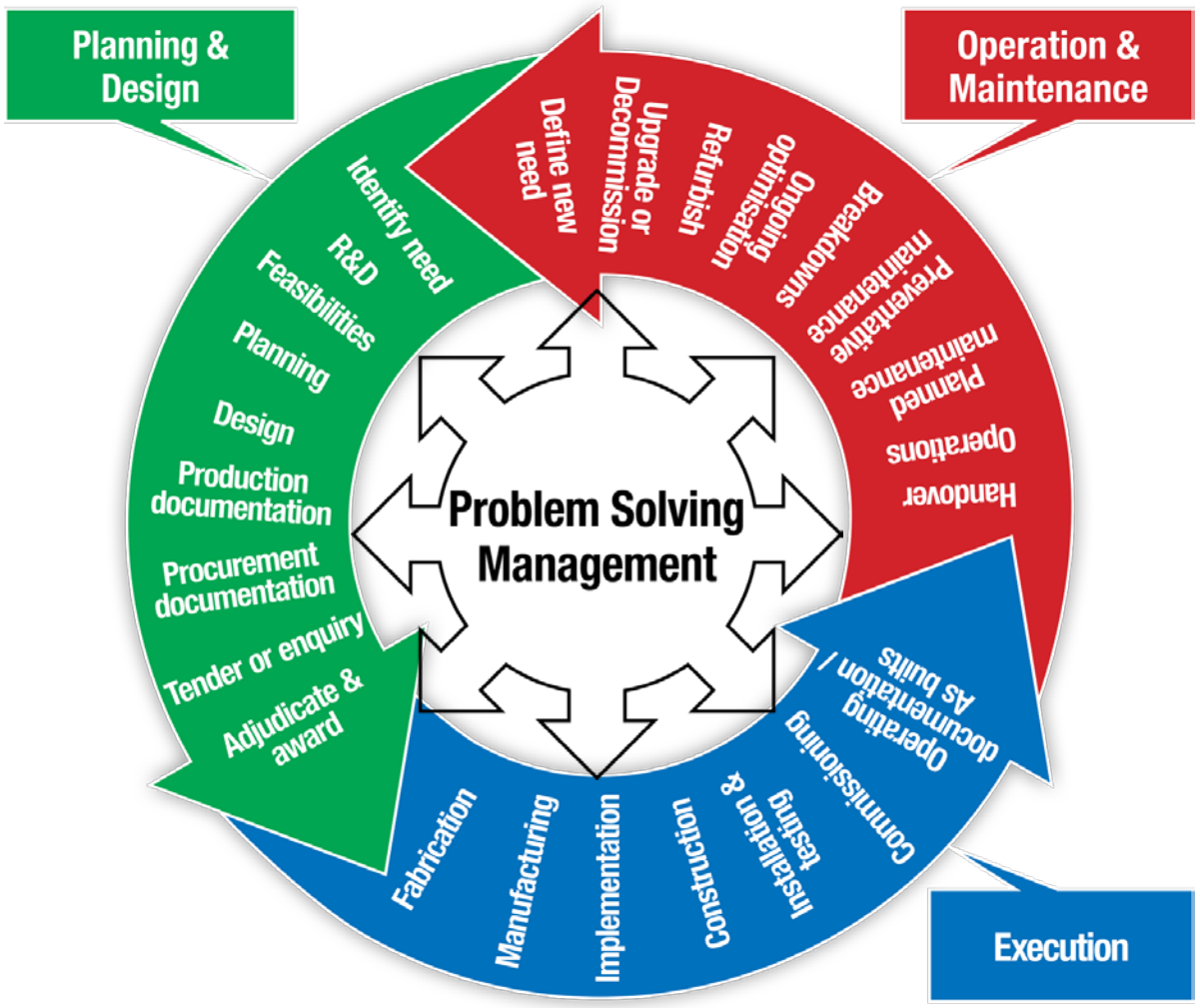
WHAT TO DO IN THE WORKPLACE?

- Establish principles
- Ensure a range of experiences
- Ensure increasing complexity
- Ensure increasing responsibility

WHAT DO WE MEAN BY COMPLEXITY?

- Solving ill-defined problems
- Developing solutions from first principles
- Considering a range of options
- Handling multi-disciplinary challenges
- Recognising, planning for and responding to risks

A RANGE OF EXPERIENCE



INCREASING RESPONSIBILITY

Level	Nature of work : The Candidate	Responsibility of Candidate	Level of Supervisor/ Mentor Support
A. Being Exposed	Undergoes induction, observes work of competent practitioners	No responsibility	Mentor explains challenges and forms of solution
B. Assisting	Performs specific processes under close supervision	Limited responsibility for work output	Supervisor / Mentor coaches, offers feed back
C. Participating	Performs specific processes as directed with limited supervision	Full responsibility for supervised work	Supervisor progressively reduces support
D. Contributing	Performs specific work with detailed approval of work outputs	Full responsibility to supervisor for immediate quality of work	Candidates articulates own reasoning and compare it with those of supervisor
E. Performing (Responsible but not accountable)	Works in team without supervision, recommends work outputs	Responsibility to supervisor is appropriate to a registered person	Candidates takes on problem solving without support, at most limited guidance

THE SOLUTION – ACTION LEARNING

- L= P + Q, where
- L = Learning
- P = Programmed or existing knowledge including historical knowledge and beliefs from textbooks, lectures, coursework and the likes which are unlikely to exactly match current needs
- Q = Knowledge gained by questioning, investigation and experimentation

(Revan's formula)

Activity

Who can build the tallest free standing tower using 12 pieces of paper and sticky tape in 10 minutes which must stand for at least one minute after completion

candidate academy

the road to registration – tower above the rest

WHAT EMERGES

SO WHAT IS THE THEORY?

Overturning moment $M_o = F_o \times H$

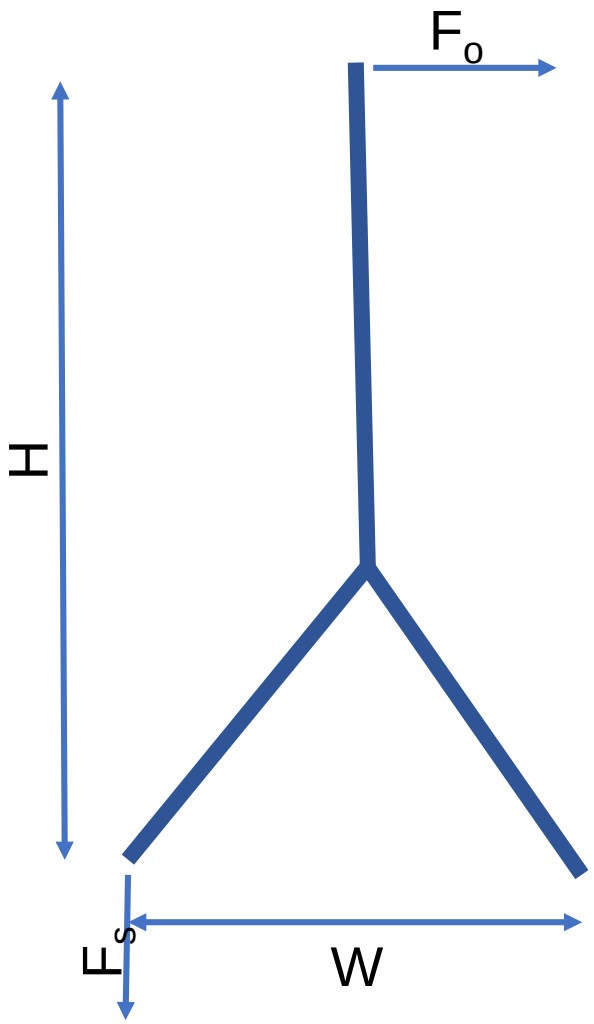
Stabilising moment $M_s = F_s \times W$

To stand (balance) $F_o \times H = F_s \times W$

$$H = \frac{F_s \times W}{F_o}$$

What are the most important variables to maximize H?

(Don't forget about rigid connections)



AND THE TALLEST ONE?

- Each sheet cut in half vertically

AN ALTERNATIVE – USING MORE MATERIAL ….

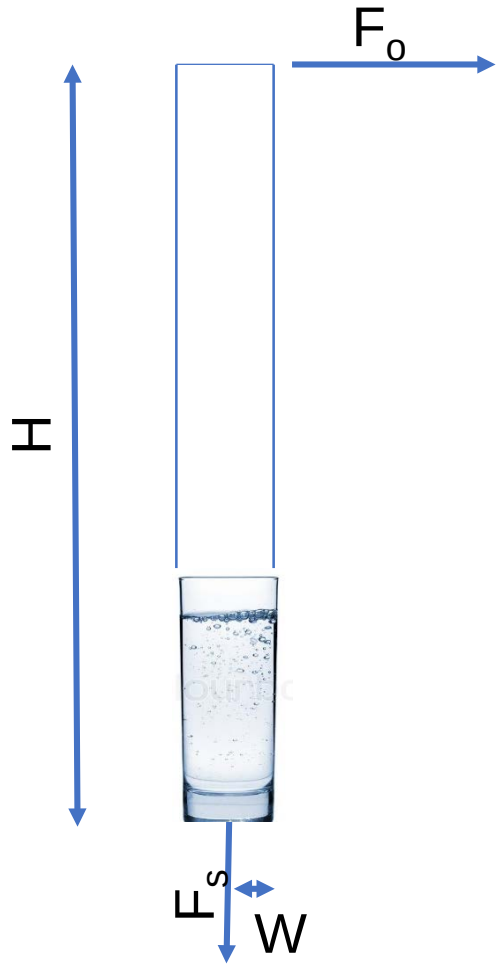
Overturning moment $M_o = F_o \times H$

Stabilising moment $M_s = F_s \times W$

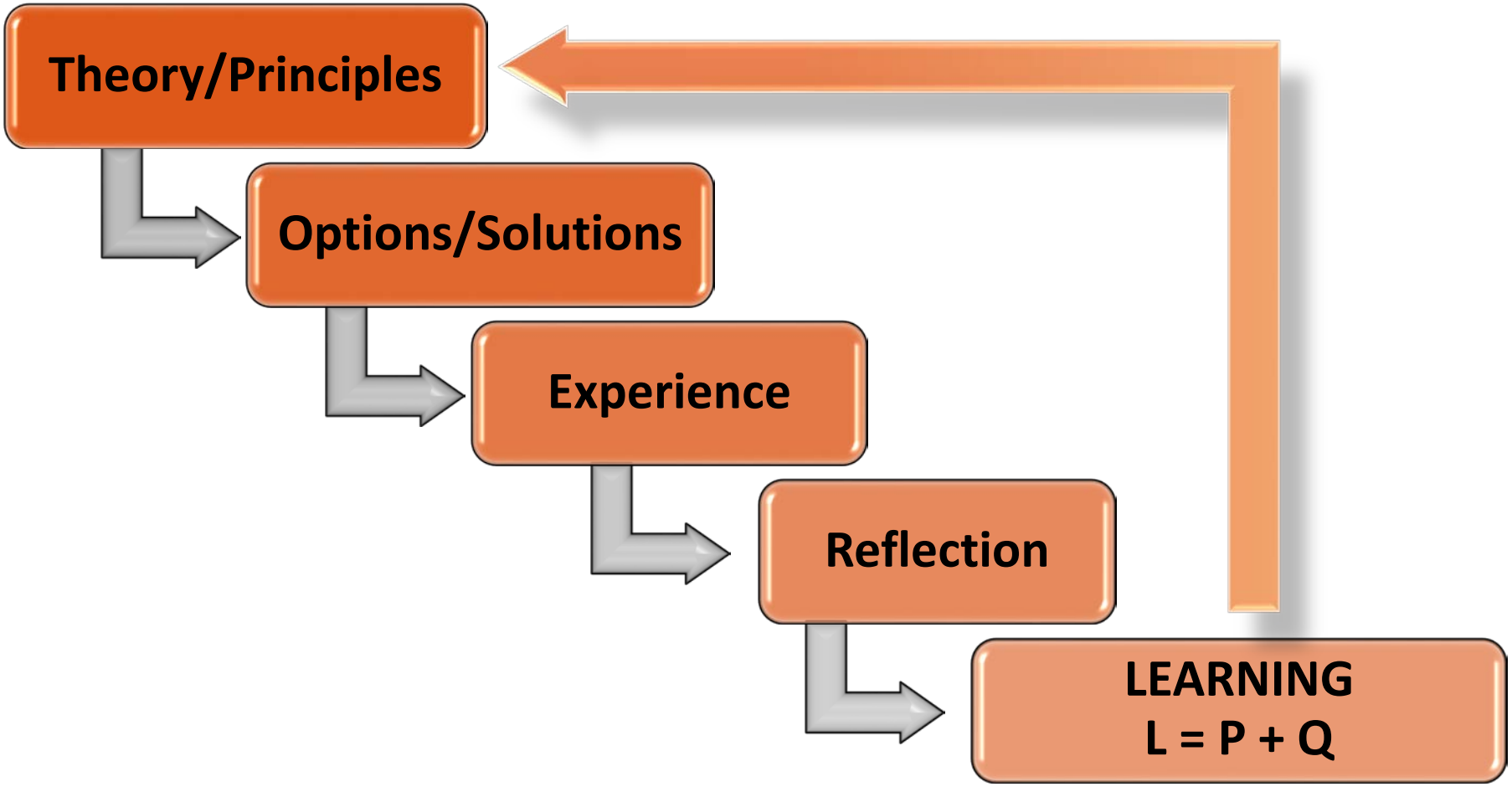
To stand (balance) $F_o \times H = F_s \times W$

What was the most important variable to maximize H?

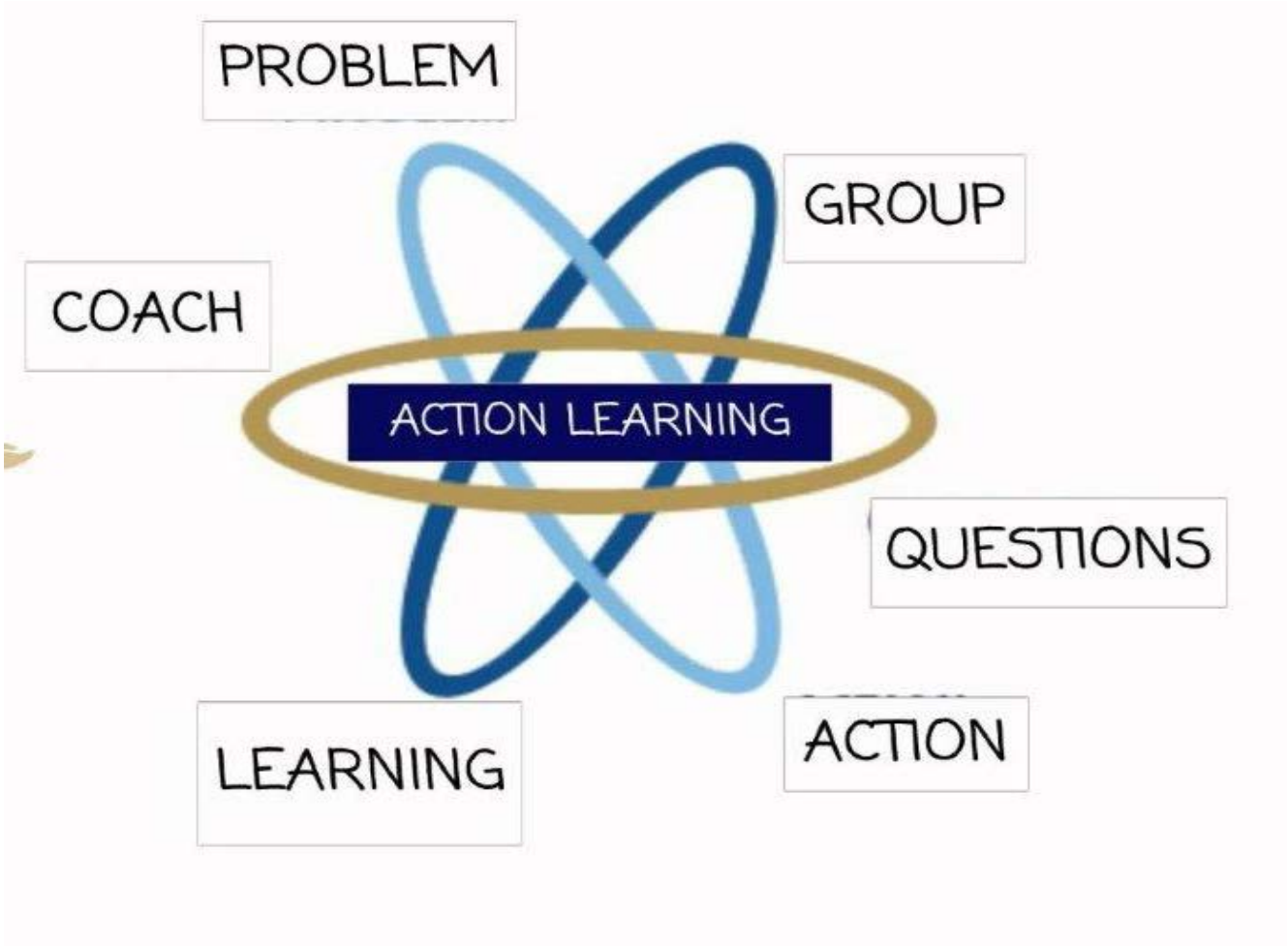
$$H = \frac{F_s \times W}{F_o}$$



THE ACTION LEARNING CYCLE



NOTE WELL – THE NEED FOR COACHES



(Image source, Wendy Brooks, 2016)

THE ROLE OF COACHES AND MENTORS

- Plan work, challenge and ask questions

  HOW do you plan to do it – forces problem solving

  WHICH variables are critical – requires decision-making

  WHY have you chosen that solution – analysis of cause-and-effect and the relationship between variables

No more instructions please, graduates must work things out – when they are independent problem solvers, all the other attributes will develop

PROBLEM SOLVING

And bring more than one concept for discussion!

THE PETER SCALE

Listening – getting to know the graduate and forming a strong relationship

Understanding – get graduate to understand roles, responsibilities and possible career path

Contextualising – tackling problems and using engineering judgement

Developing – what tools to be used – reference materials, standards, applications, challenge and expand graduate horizons

Engaging – support graduate with decision-making in practical situations – site, plant visits, negotiations etc

Empowering – "Who authorised you not to take a decision or give an instruction?", graduate gains confidence

Encouraging – encourage the graduate to take control

Releasing – fully delegate but ensure graduate continues to take on increasingly complex work





Groups comparing notes





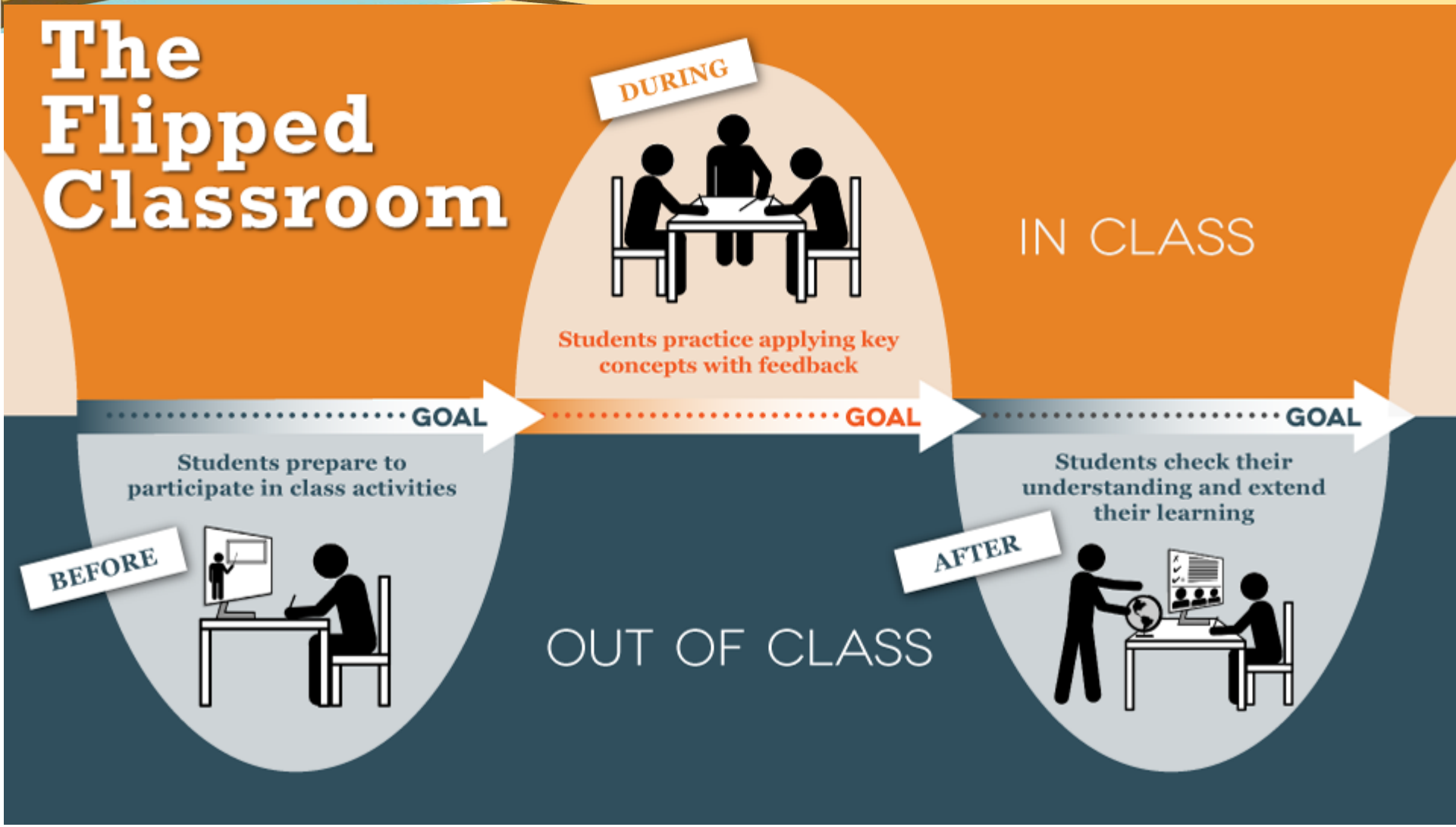
Questions, discussions & implementation

FORMAL GRADUATE SUPPORT URGENTLY REQUIRED

- **Tanzania** – Structured Engineers Apprenticeship Programme
- **Mauritius** – government funded two years after graduation (only introduced 2016)
- **South Africa** – training of graduates and apprentices to be quoted as part of all public sector projects
- **Angola** – oil industry to train as part of their licences with government
- **Mozambique** – private university offering employability workshops (£20 – 24 hours applied problem solving)
- **Electricity parastatals** – generally still developing graduates, but very procedural

Need more problem solving, challenging approaches to development!

FLIP THE WORKPLACE TOO!



THANK YOU