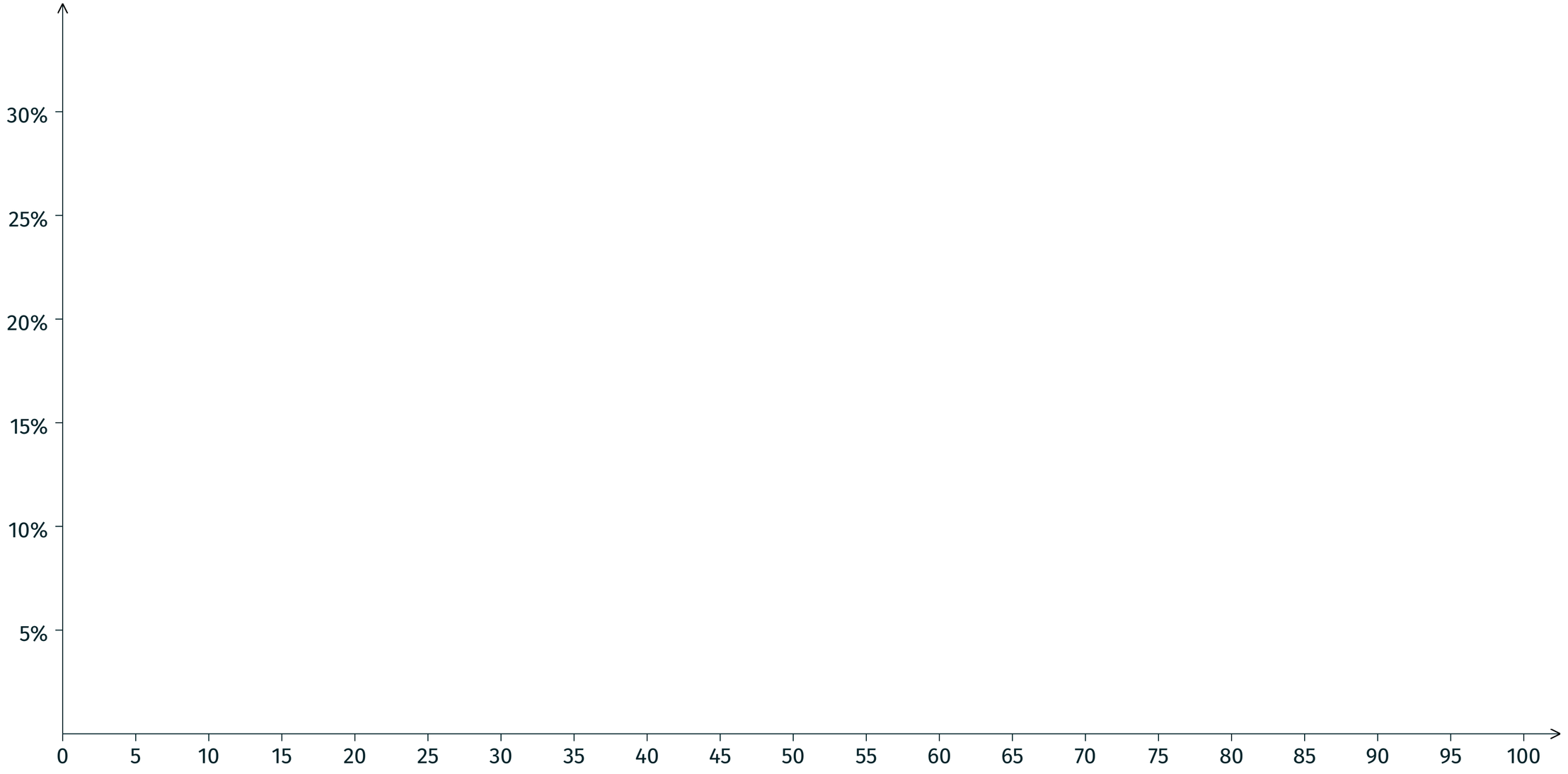
Co-constructive mastery-based learning in mathematics

no exams, no lectures, no due dates, no weighted marks

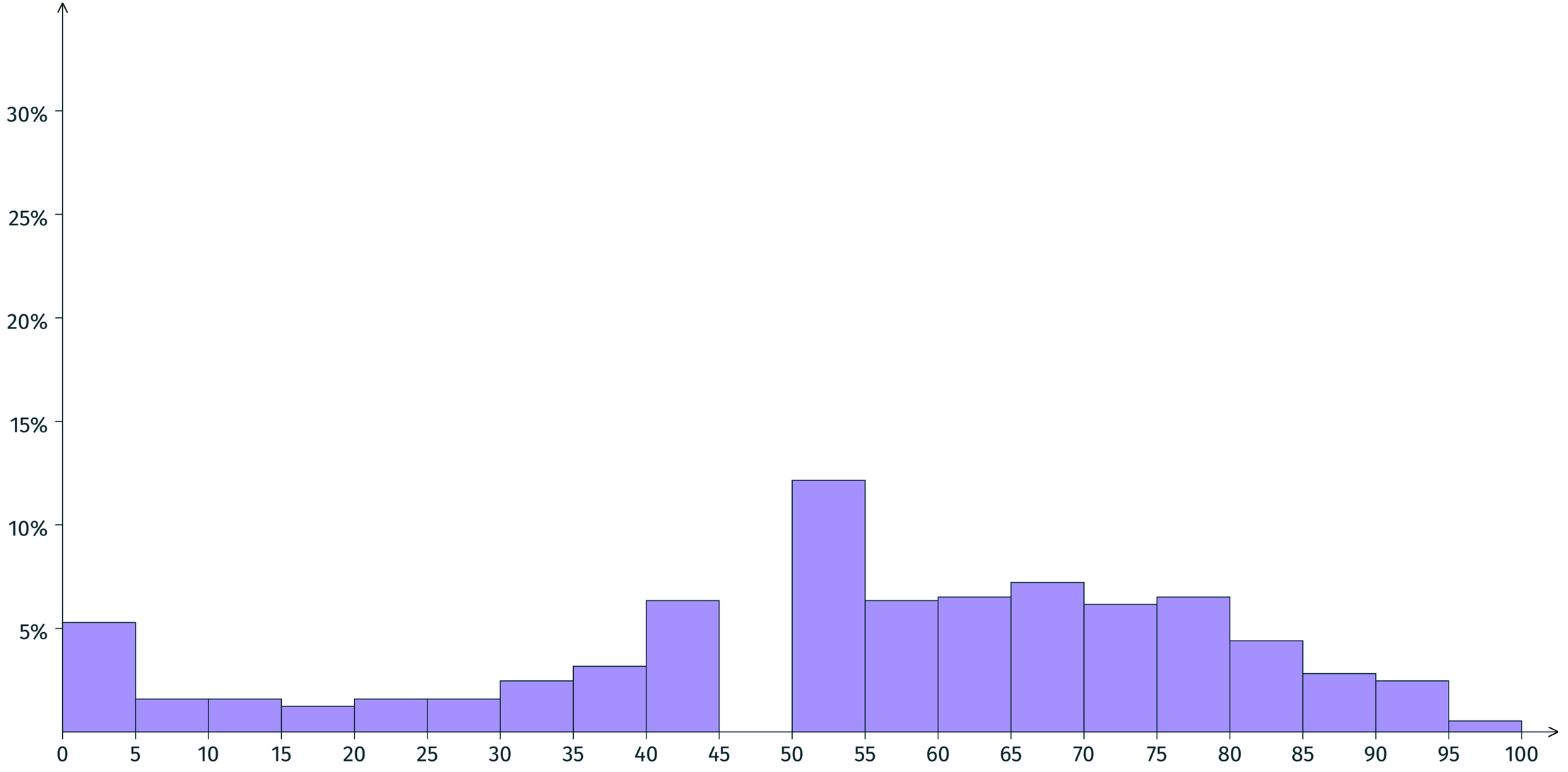
Julien Ugon,Simon James,Kerri Morgan, Laura Tubino, Andrew Cain

Meanjin Delta 23 November 2025

Our result distribution in



Our result distribution in 2019



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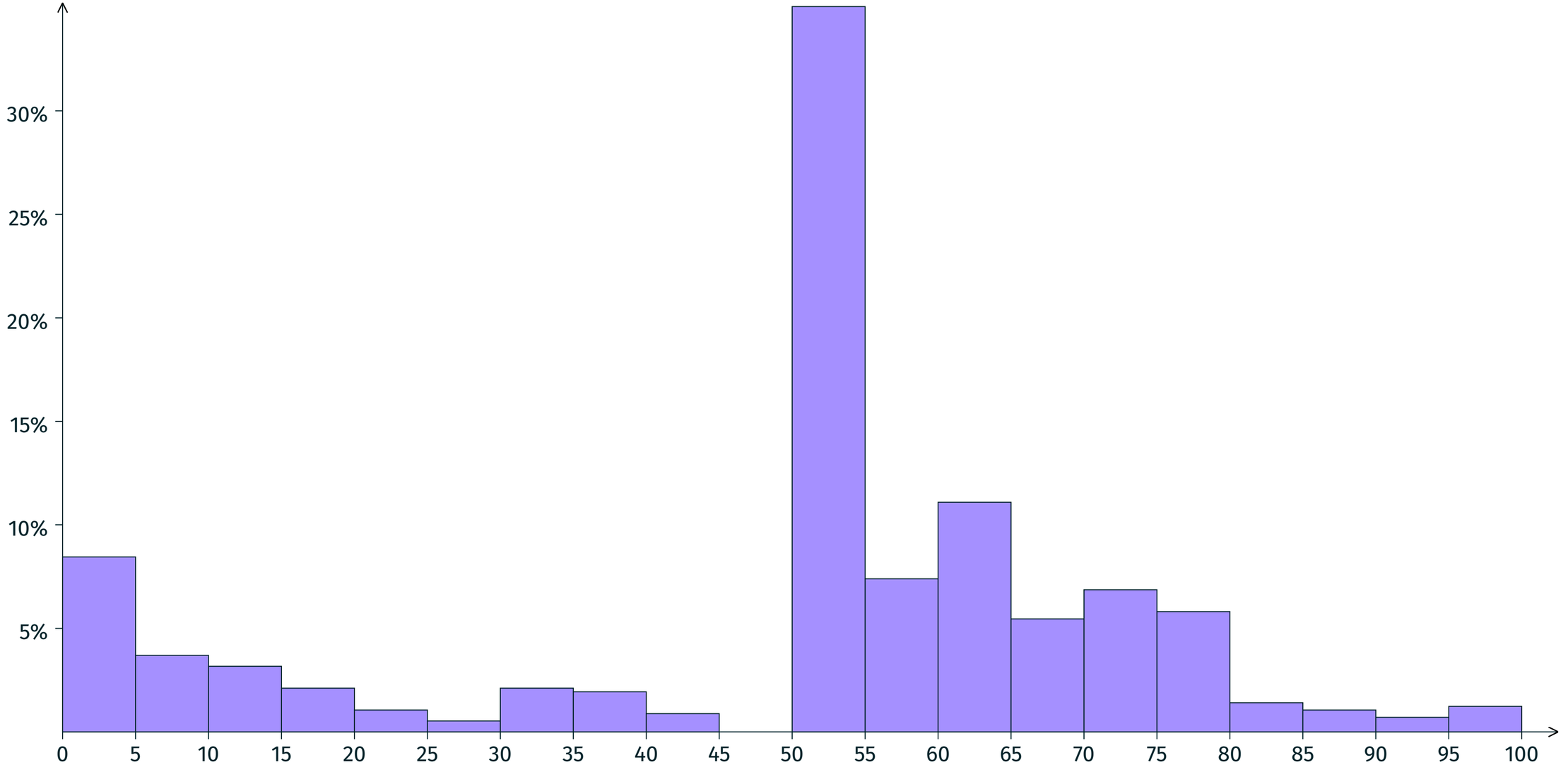
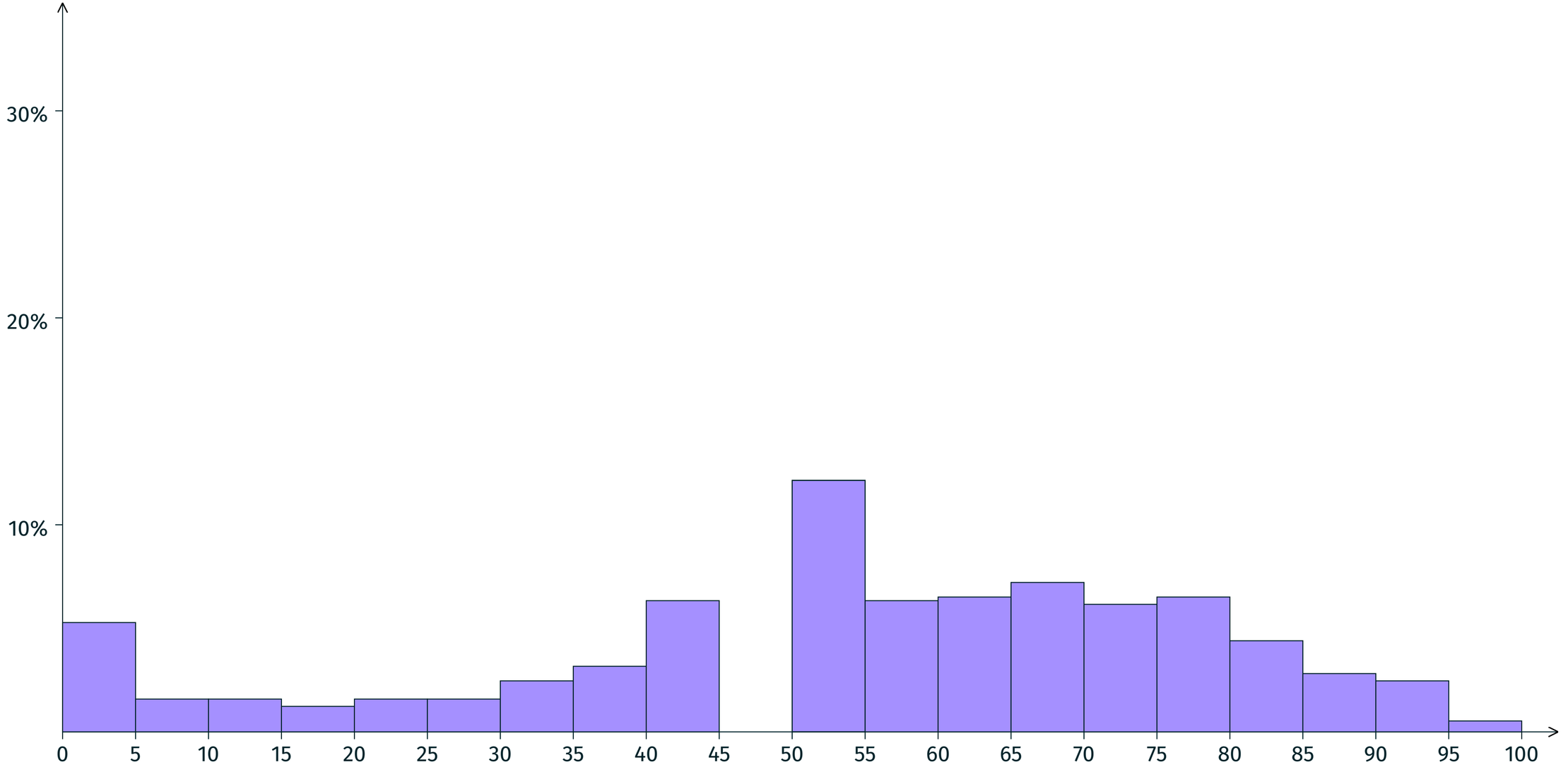


Our issues in 2019



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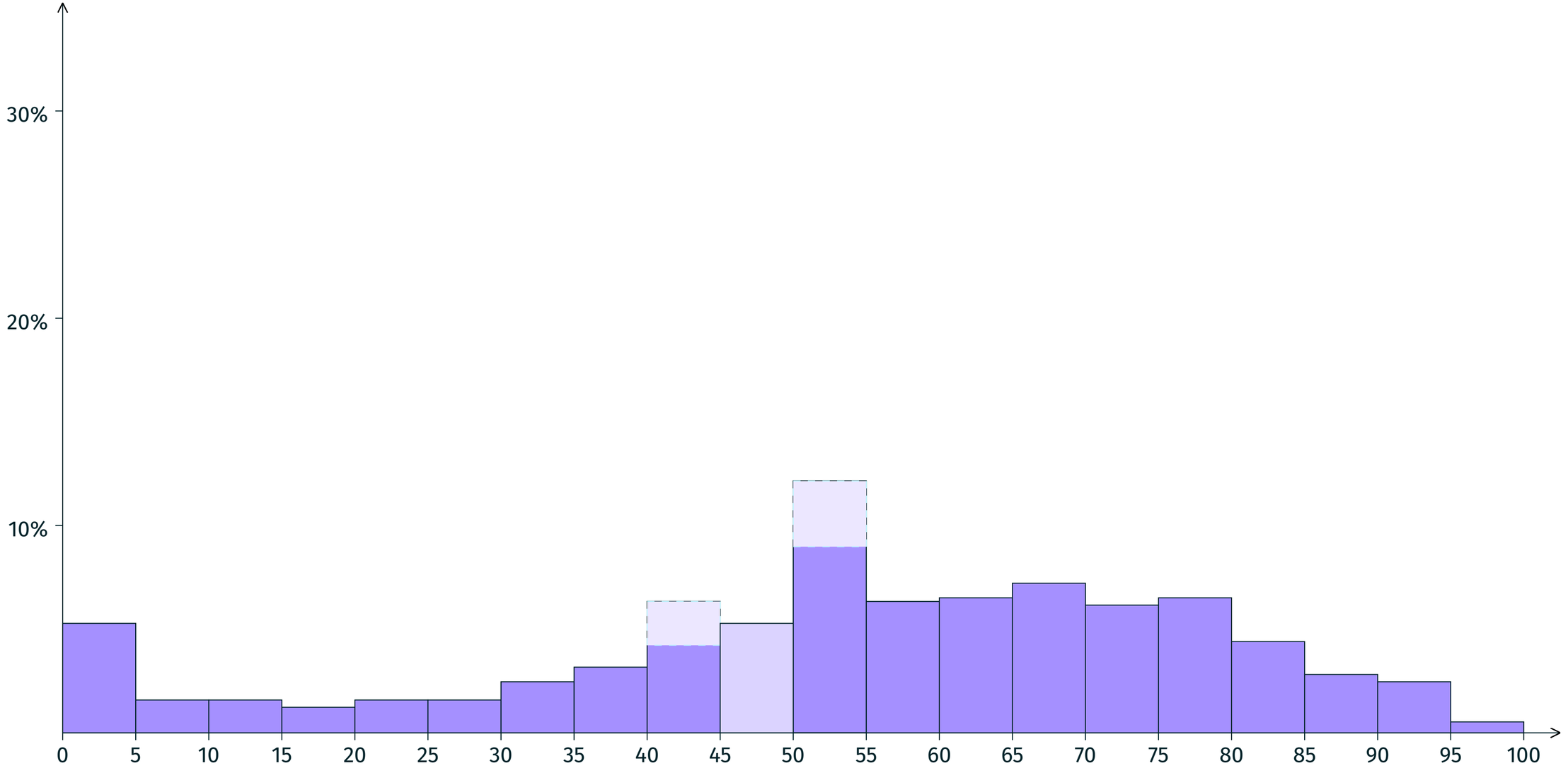

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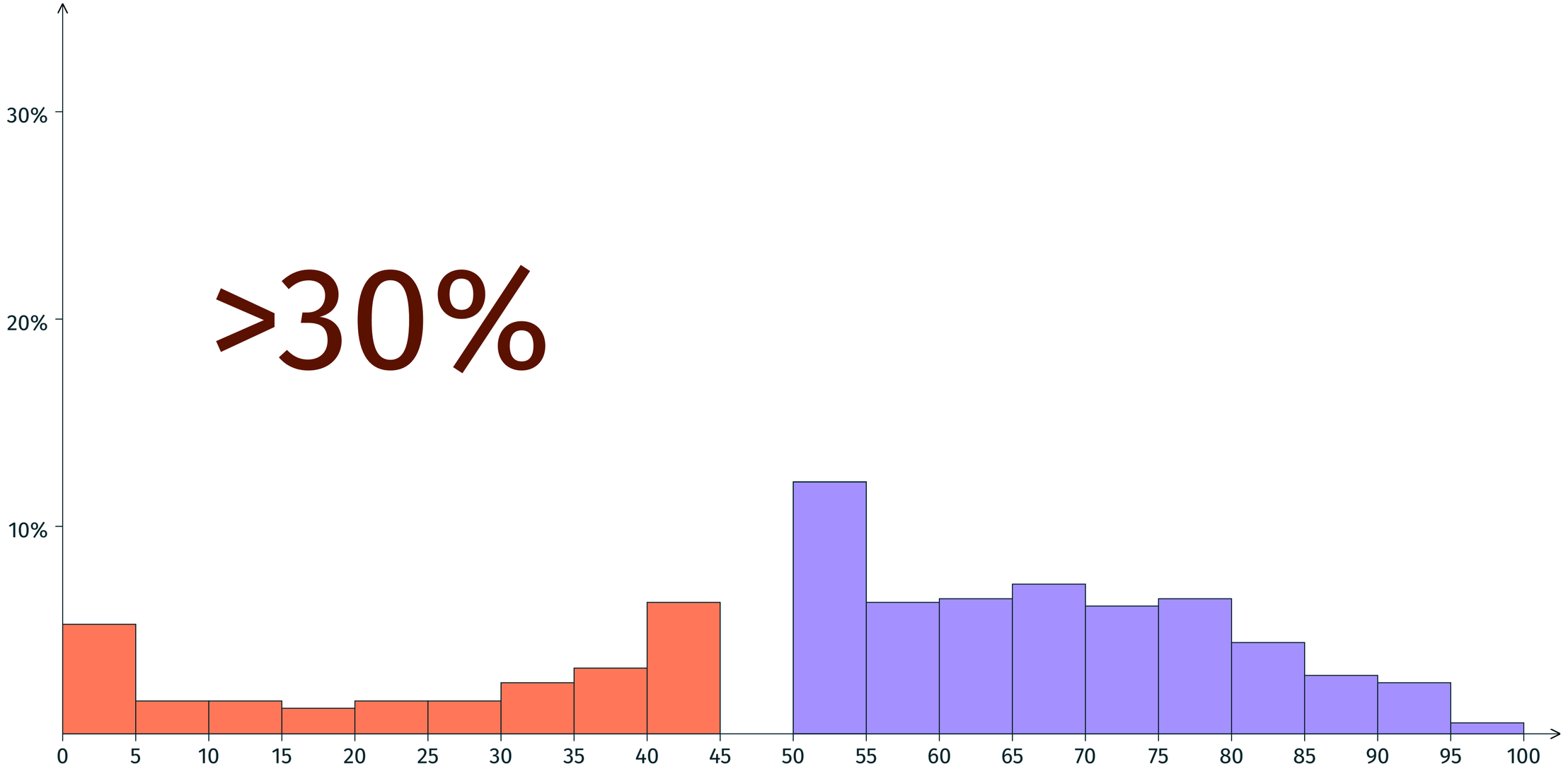

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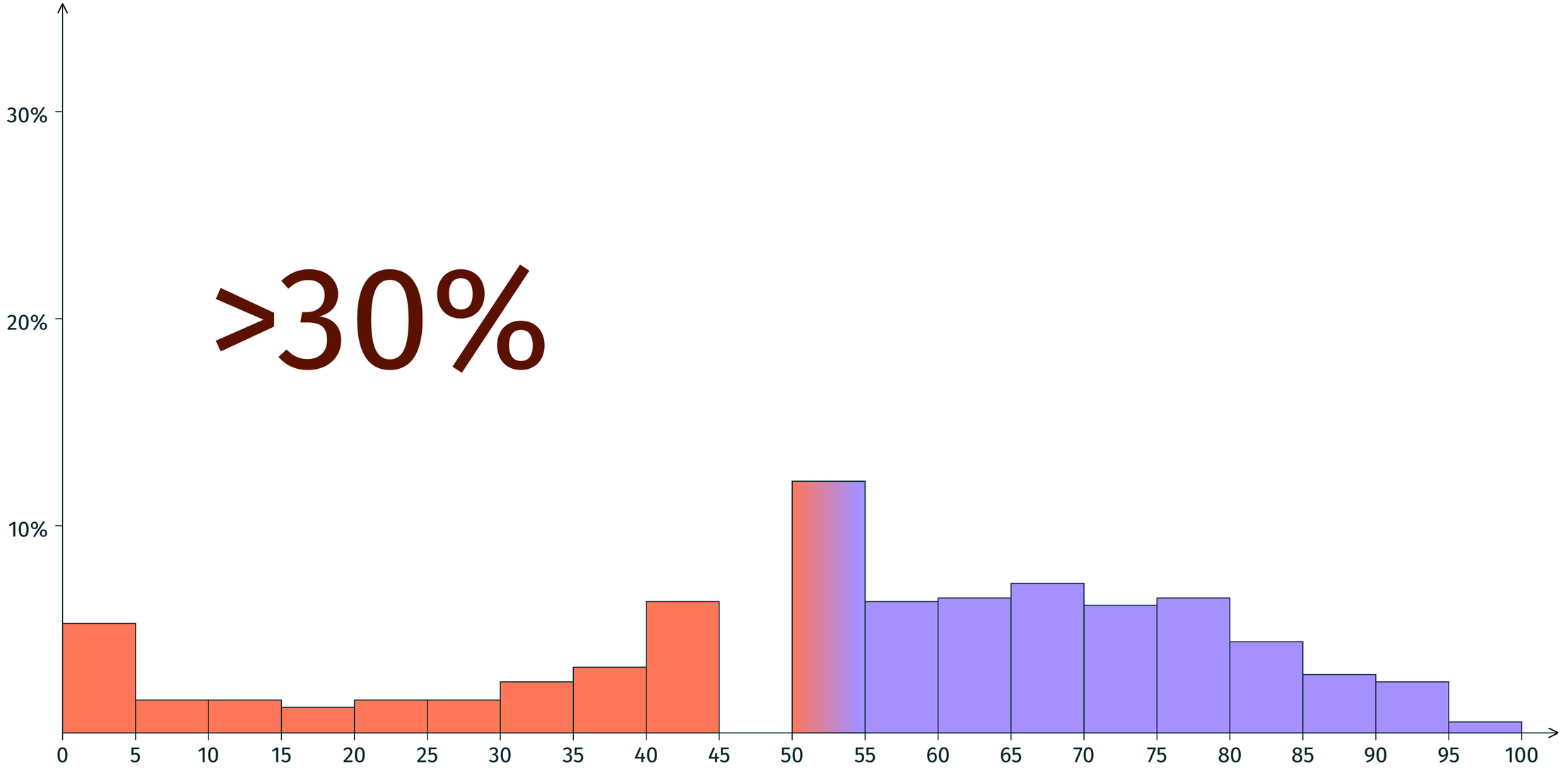

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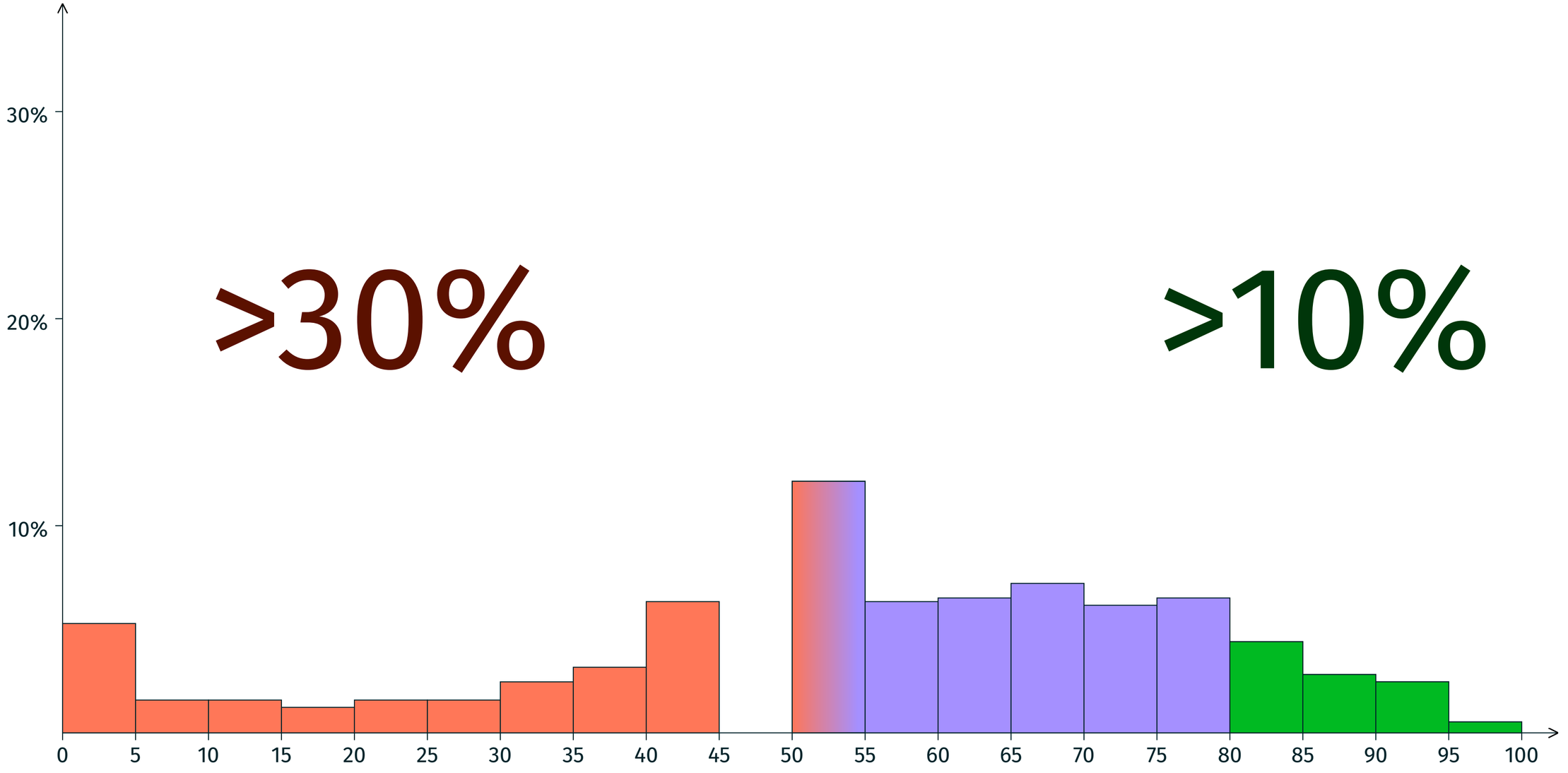

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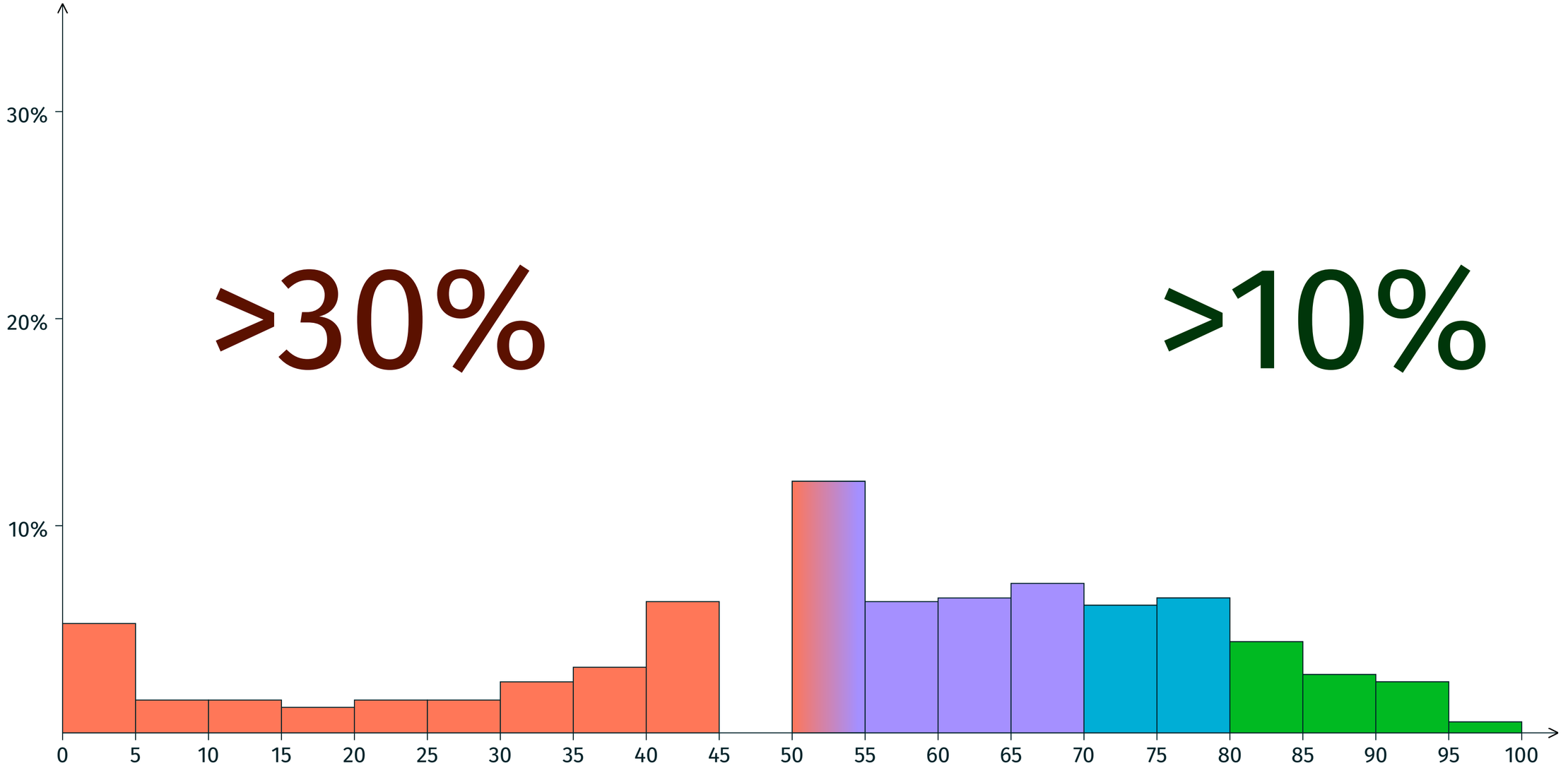


Some challenges for traditional approach

Diversity

Skills, background, motivation, availability, life

Assessments and Exam

- How to evaluate the full range of skills from a 2-hours exam?
- Additive vs deductive assessments.

Engagement

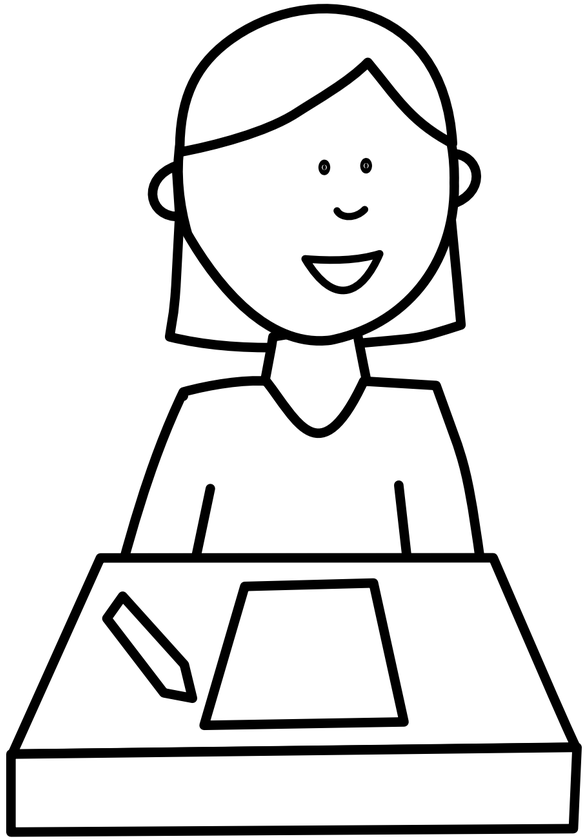
Low Engagement (self-efficacy, motivation)

Poorly characterised grade

What is the meaning of a Pass? Of a HD?

WHAT IS A LEARNING ENVIRONMENT?

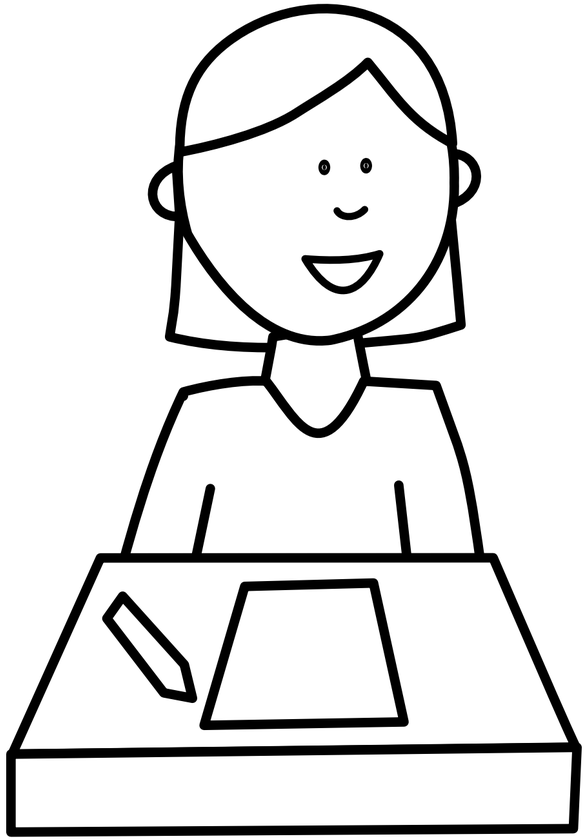
Content and Skills



Content and Skills

Learn

Validate

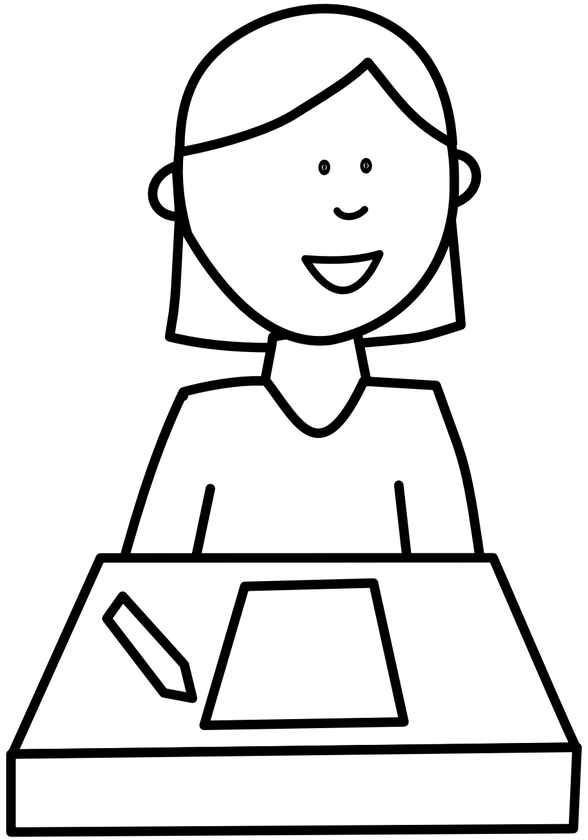


Content and Skills

Learn | Validate

Resources

Bite-sized parts



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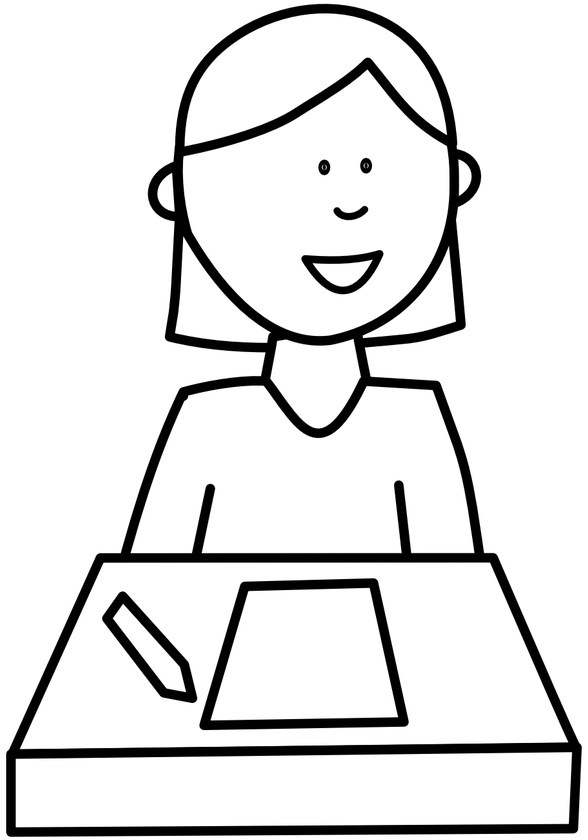
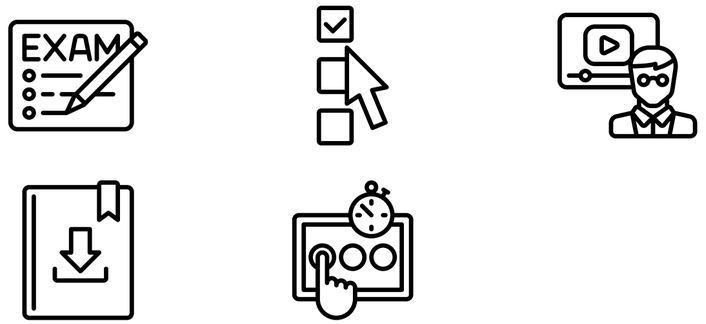


Portfolio of assessments



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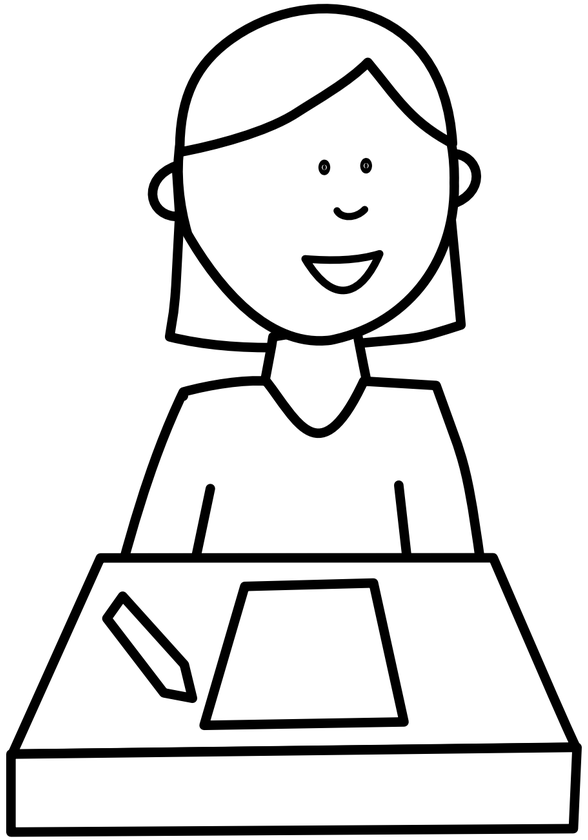

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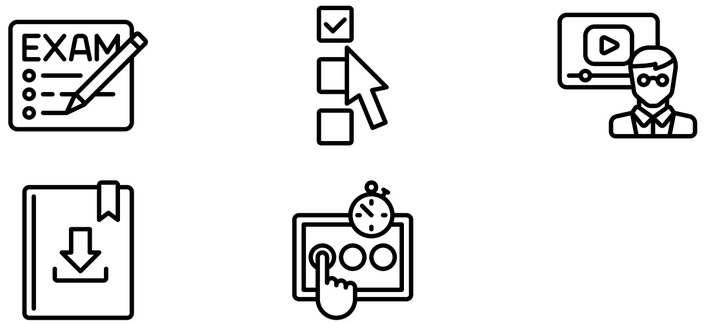

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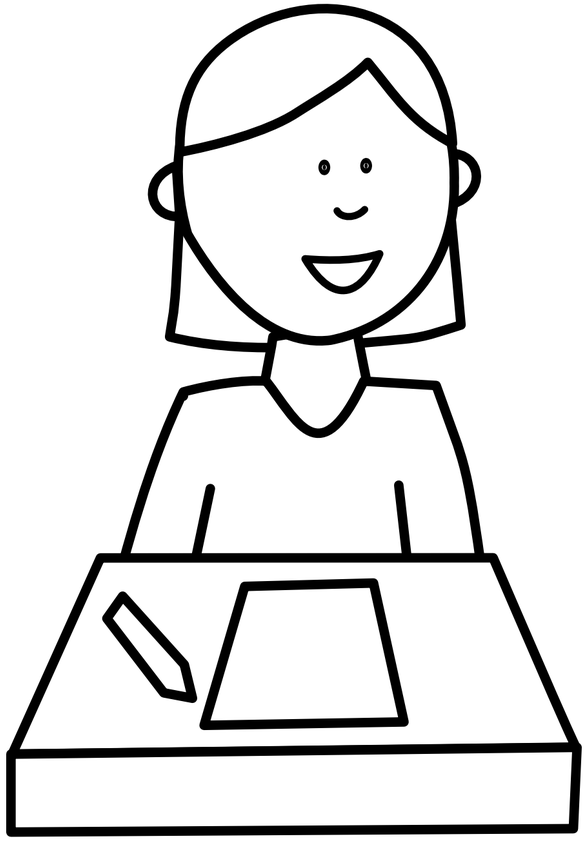

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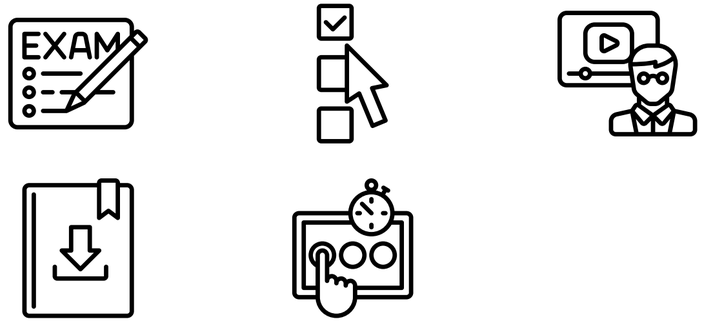

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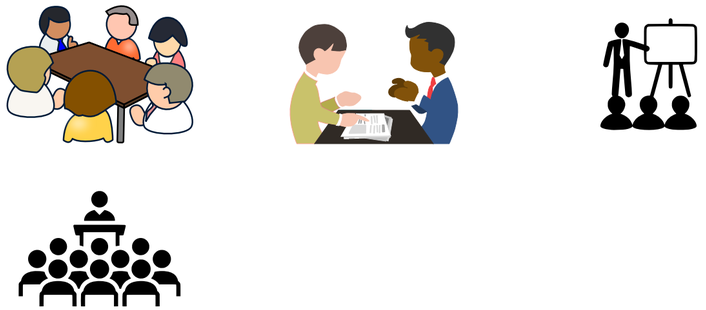
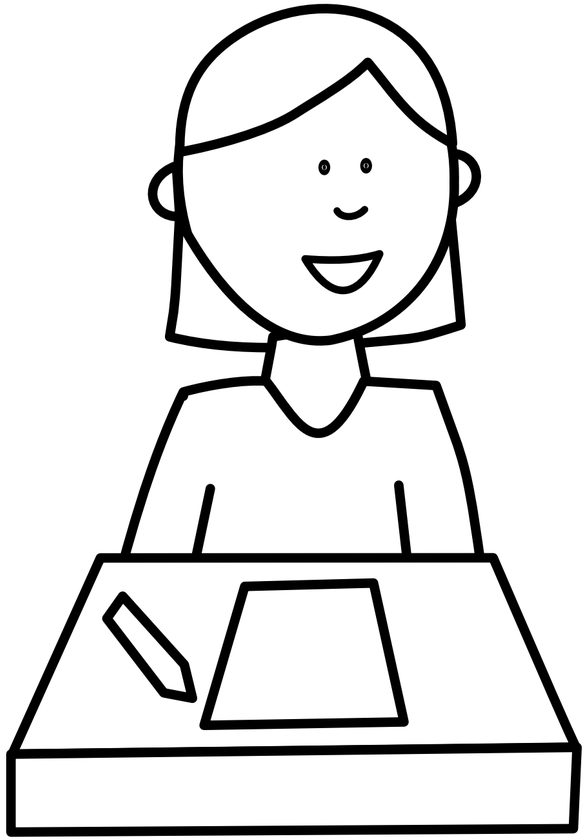
Other People





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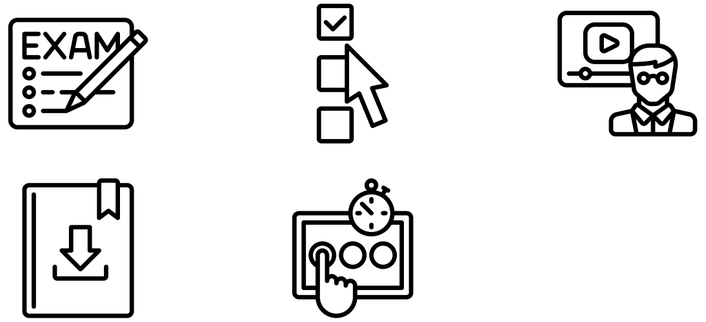

😢 😐 🙂 😀 😁

Our theoretical Framework

- Mastery-based learning (Bloom, 1984; Guskey, 2007)
  - Allow for Differentiation
  - Opportunities for correctives
- Co-constructive learning (Vespone, 2023)
  - Decisions should be made collaboratively
  - Student agency is paramount

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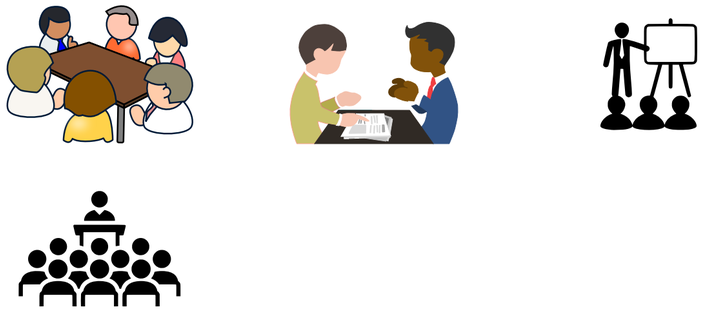

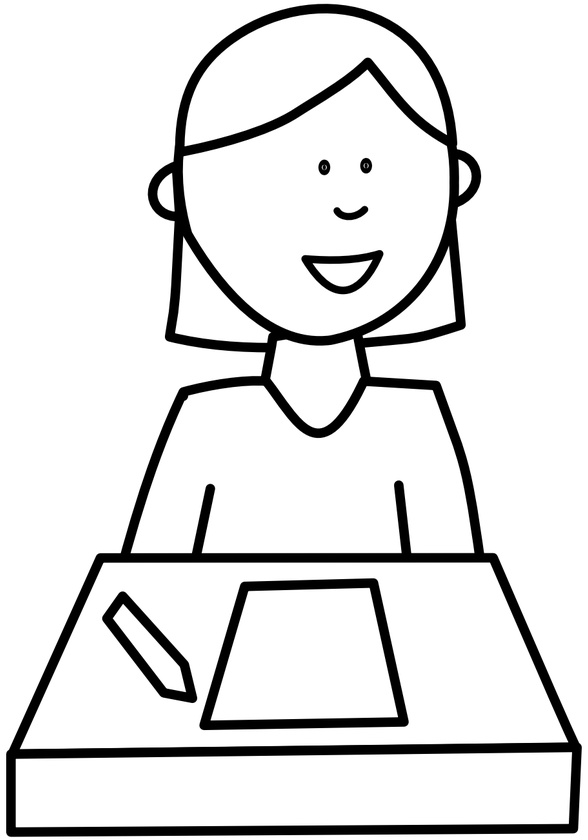

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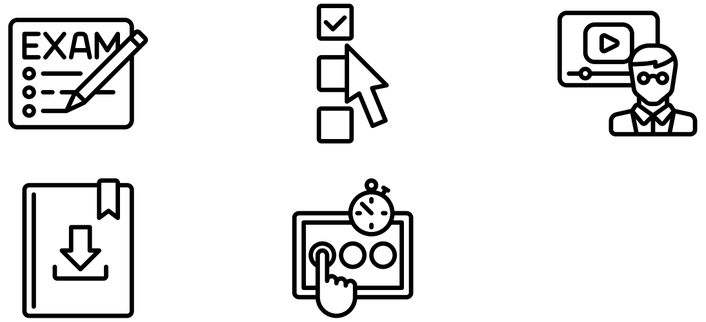

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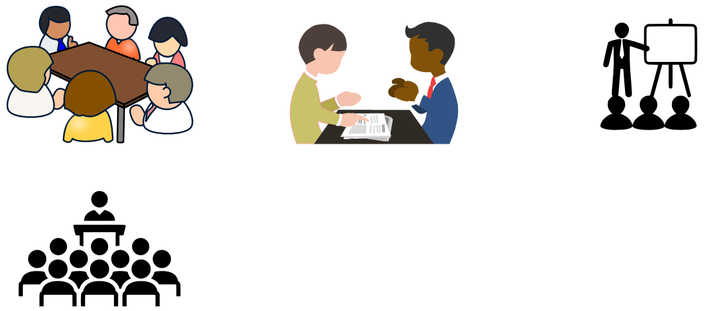

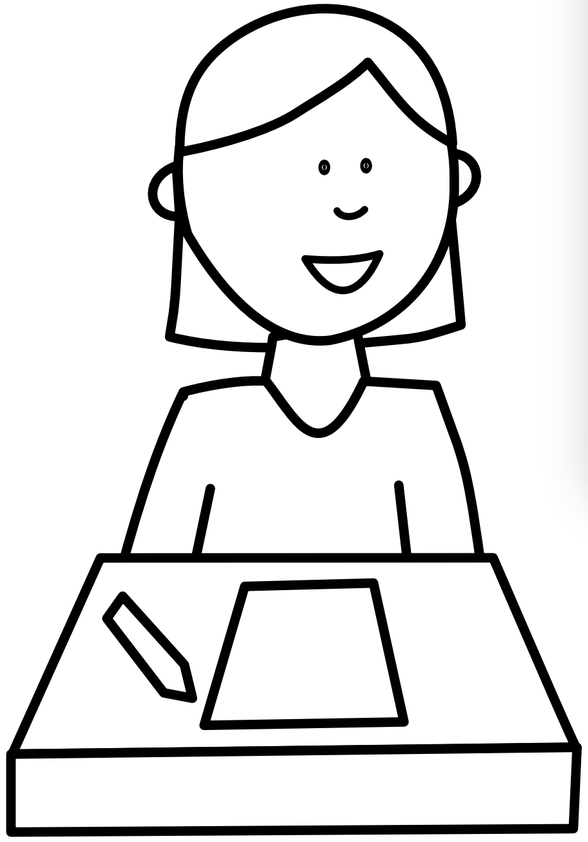

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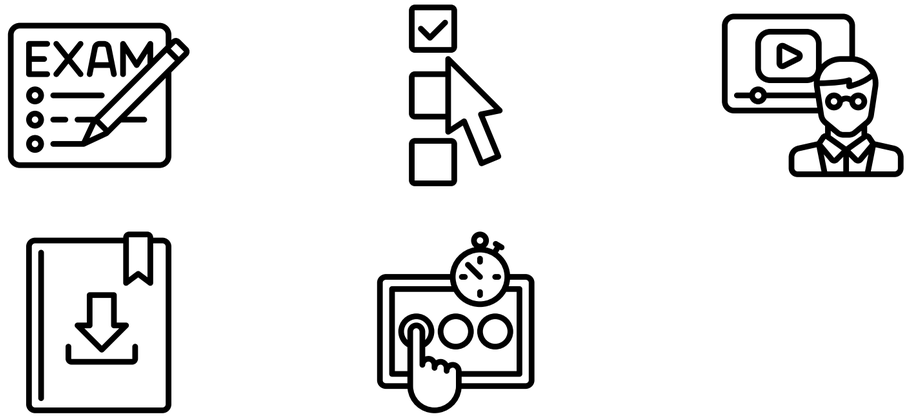

What are our goals?

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Transparency

How well do students understand their grade? How well can they predict it?

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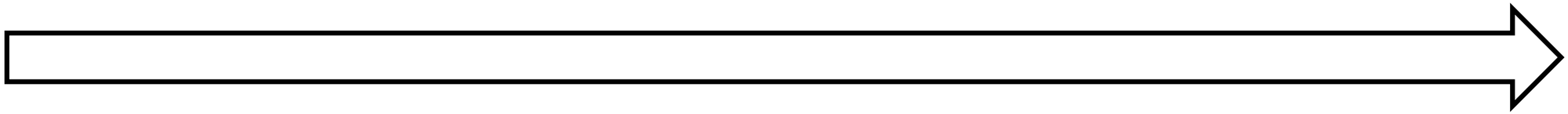
Integrity

How do we know the student did the work?

Portfolio-based assessment

A single summative assessment, explicitly aimed at demonstrating the learning outcomes.



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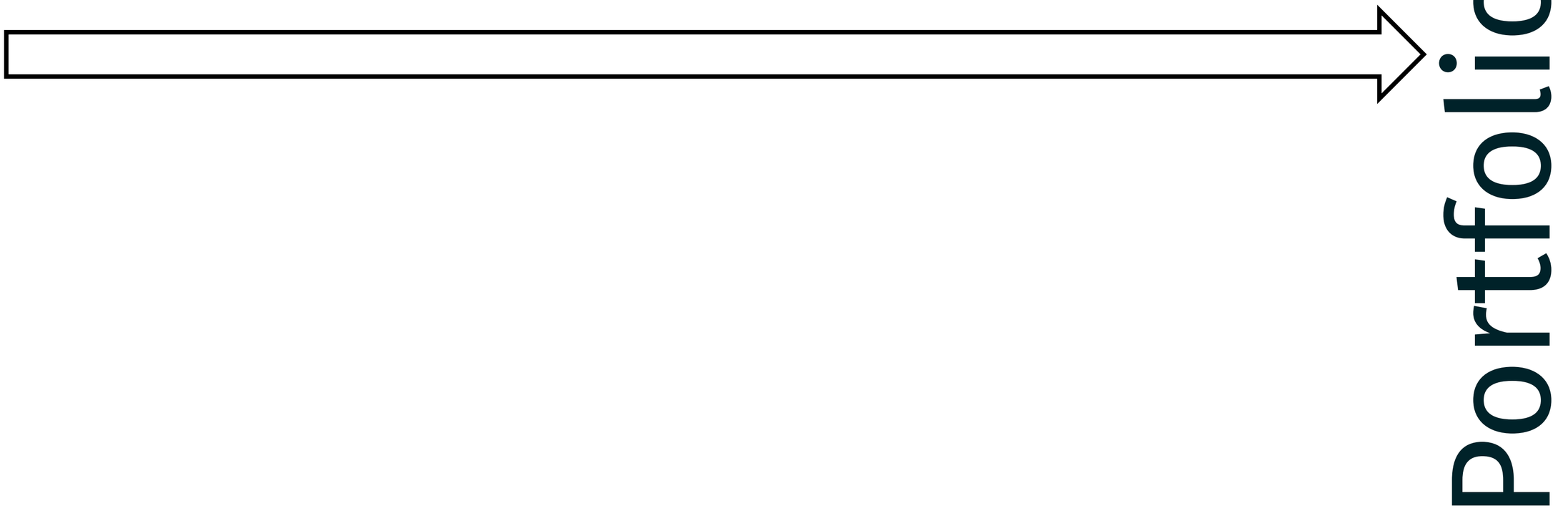

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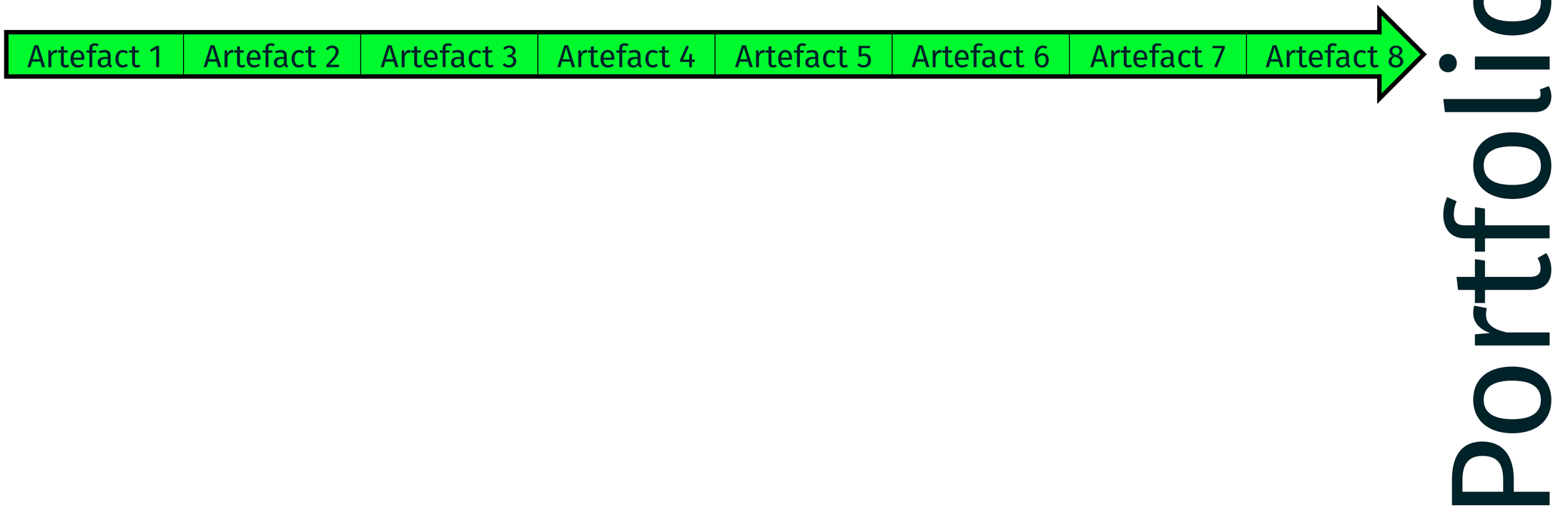

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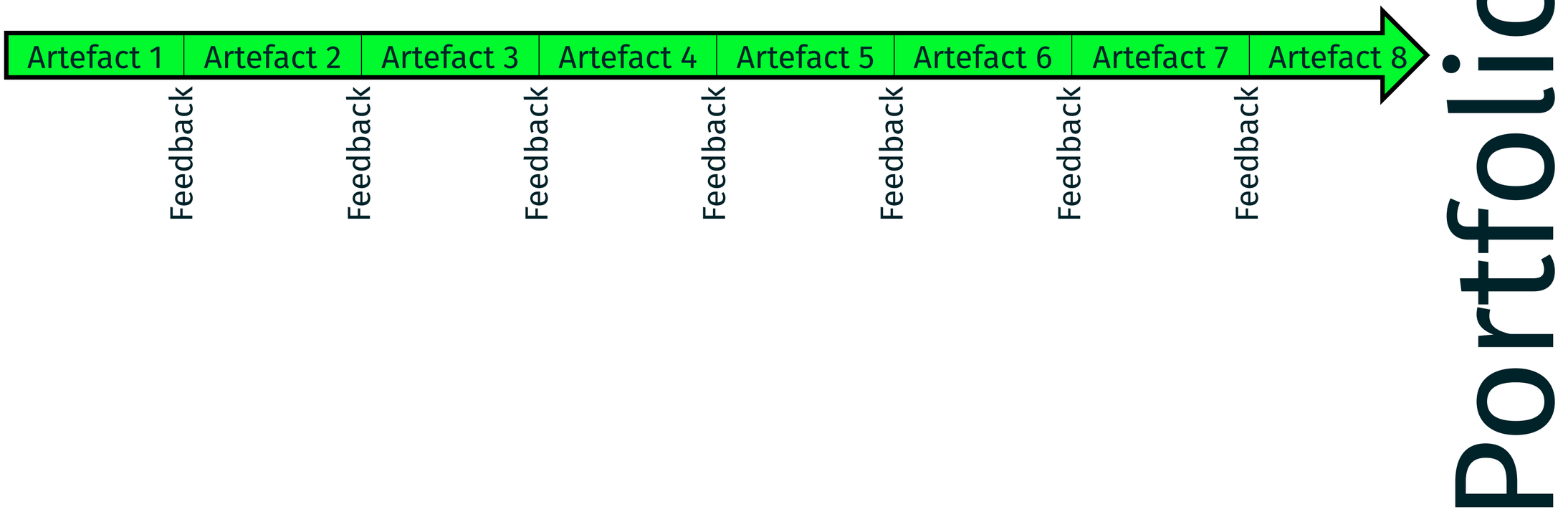

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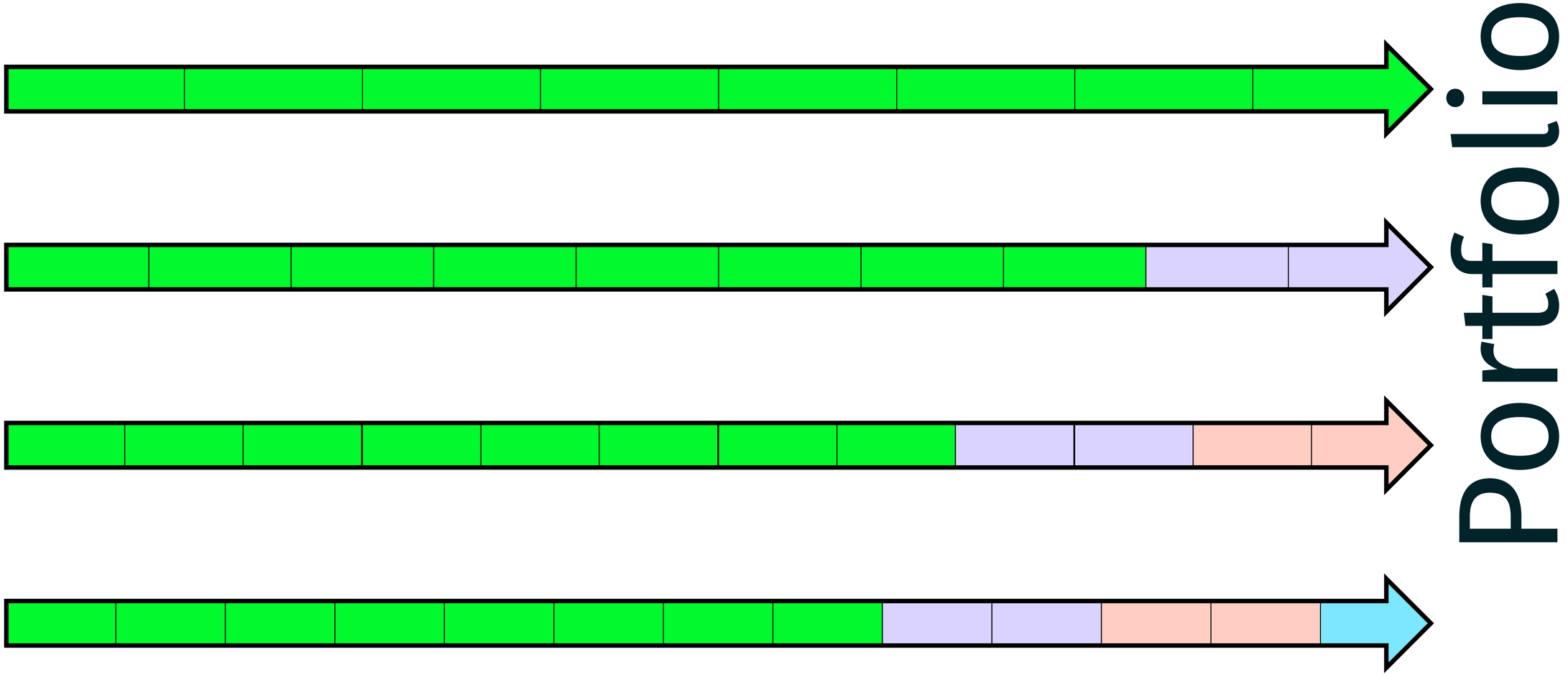

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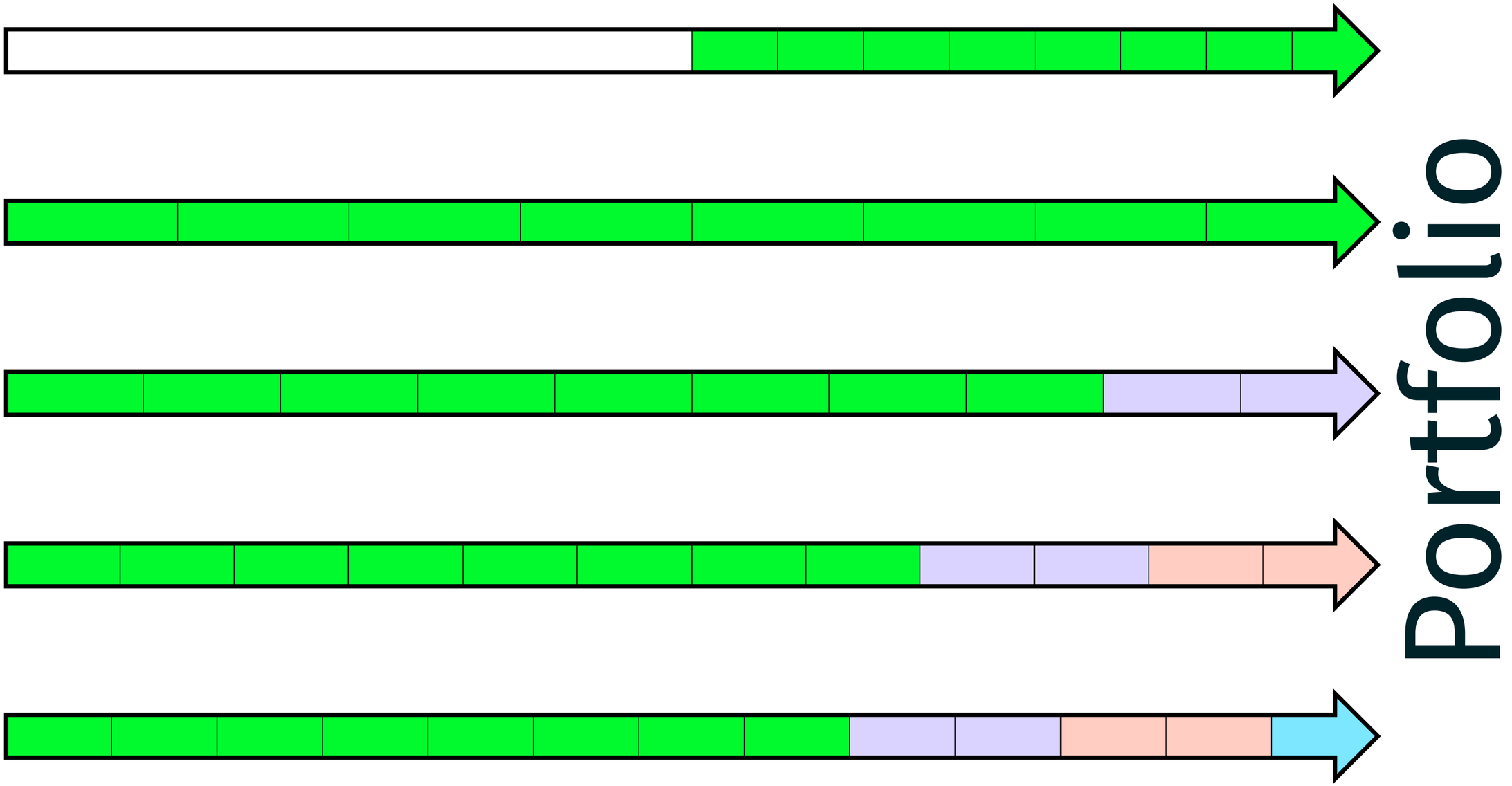

How we redesigned out maths assessment

Each module is (formatively) assessed separately

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Constructively aligned

- Assessment drives and supports learning.
- Learning Support help completing assessments

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Self-paced and scaffolded

Students submit their task once they are ready for feedback.

Lesson Reviews

- Student submits their *lesson review* when it is ready for feedback
- Student receives feedback on their submission.
- Opportunity to resubmit until minimum standards is achieved.

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Once the student and tutor agree on the task, the student includes it into their portfolio, to be compiled and submitted at the end of the trimester.

Formative assessment process

Must demonstrate the minimum standard for each module: *“Show us that you have achieved the learning objectives.”*

- Must showcase both conceptual and procedural mastery.
  - Procedural skills: shown by providing evidence.
  - Conceptual skills: shown through a conceptual summary of content
  - We provide a randomised quiz to facilitate evaluation of low level procedural skills.

Content and Skills

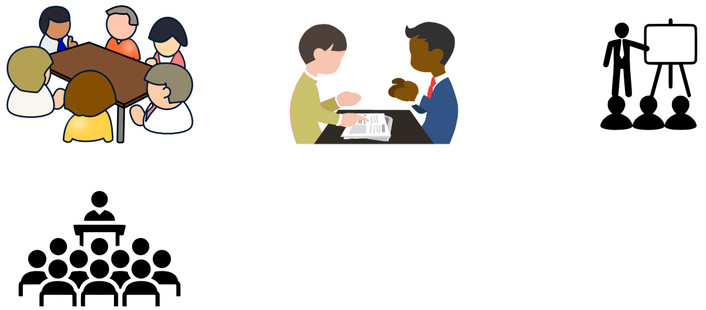
Learn

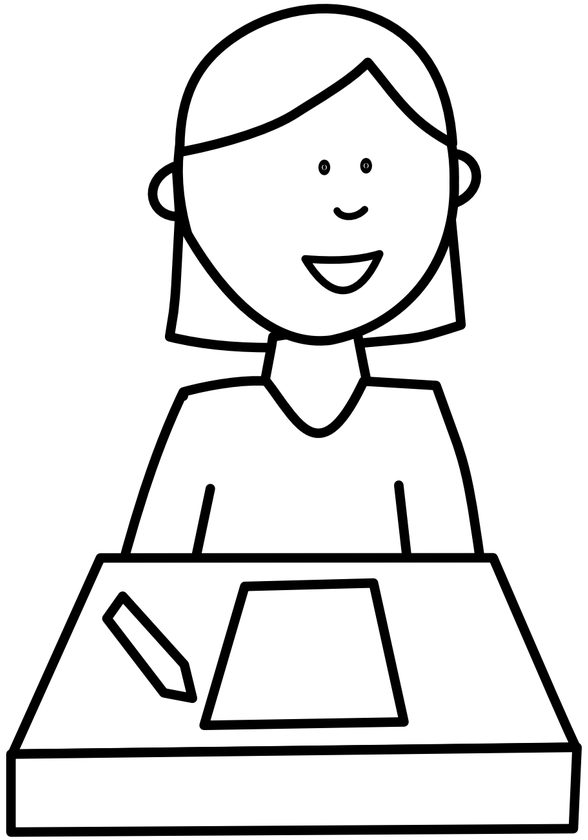
Validate

Resources

Bite-sized parts

Other People





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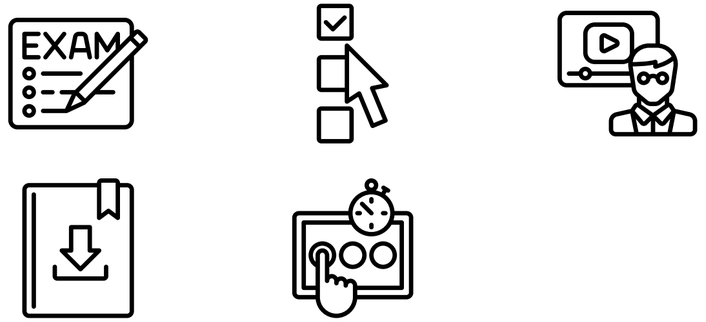

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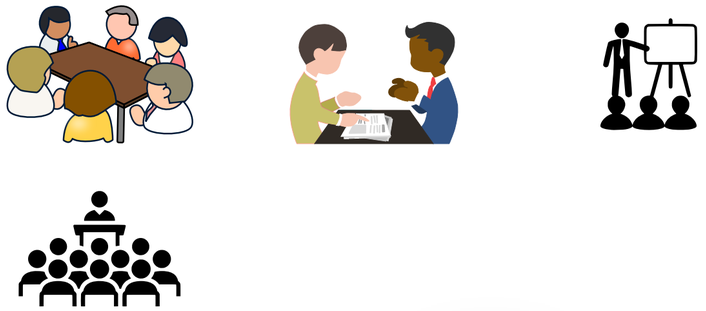

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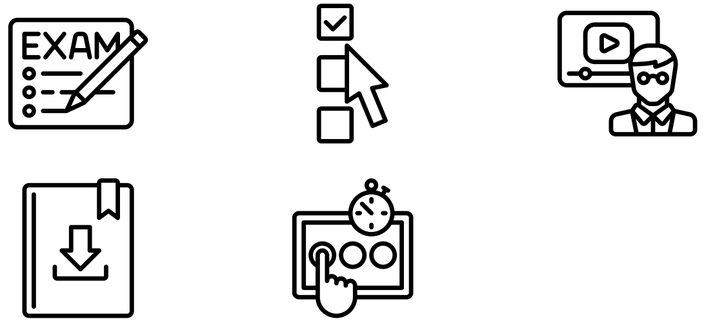

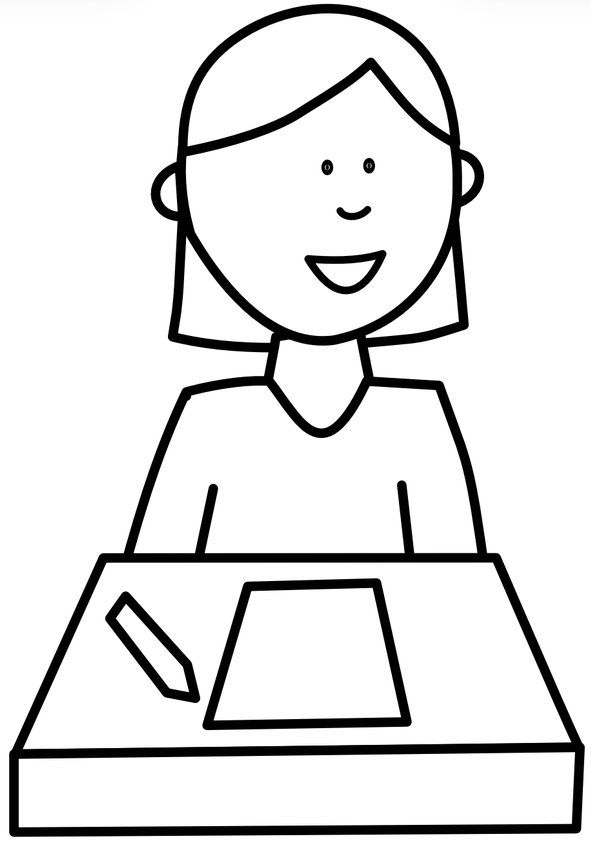

SETTING UP THE LEARNING ENVIRONMENT

Clarifying expectations

What does it mean to pass a university maths subject?

P

C

D

HD

Clarifying expectations

What does it mean to pass a university maths subject?

P	Minimum Core Competencies
C	
D	
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HD	Beyond the Content

Modular Design

We split each unit into modules.

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Six Steps of Mastery Learning

1. Define Learning Objectives
2. Diverse Instructional Methods
3. Formative Assessment
4. Corrective Feedback
5. Reassessment
6. Enrichment or Advancement

(Guskey, 2007; *Kantathanawat, 2025*)

Modular Design

We split each unit into modules.

1. Learning Objectives
2. Learning Resources and Activities
3. Separate formative assessment
4. Focused on mastering the Learning Objectives
5. Possibility to review/resubmit

Six Steps of Mastery Learning

1. Define Learning Objectives
2. Diverse Instructional Methods
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6. Enrichment or Advancement

(Guskey, 2007; *Kantathanawat, 2025*)

Co-constructing the modular Design

- The content/skills are split into core and elective content.
- Pass the unit iff they demonstrate their mastery of the *entire* core content.
- Higher grades by electing to demonstrate additional skills. Can work toward higher levels of complexity, abstraction, etc.
- Highest grades focus on independent learning, creation, communication. Must go beyond what is taught in the modules.

Example: discrete maths

Core

- Number Theory
- Propositional Logic
- Predicate Logic
- Proofs
- Set Theory
- Combinatorics
- Graph Theory
- Sequences

Electives

- Advanced Number Theory
- Advanced Graph Theory
- Complexity Theory
- Mathematical Induction
- LaTeX

Content and Skills

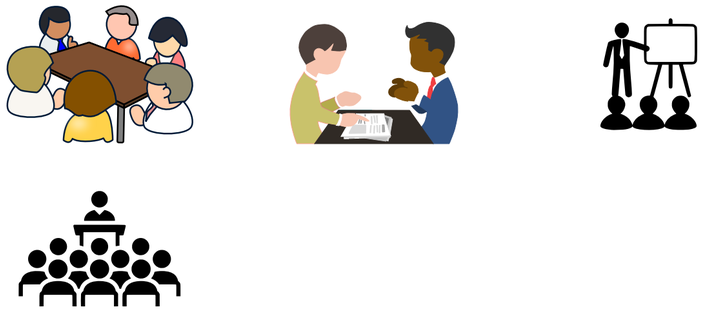
Learn

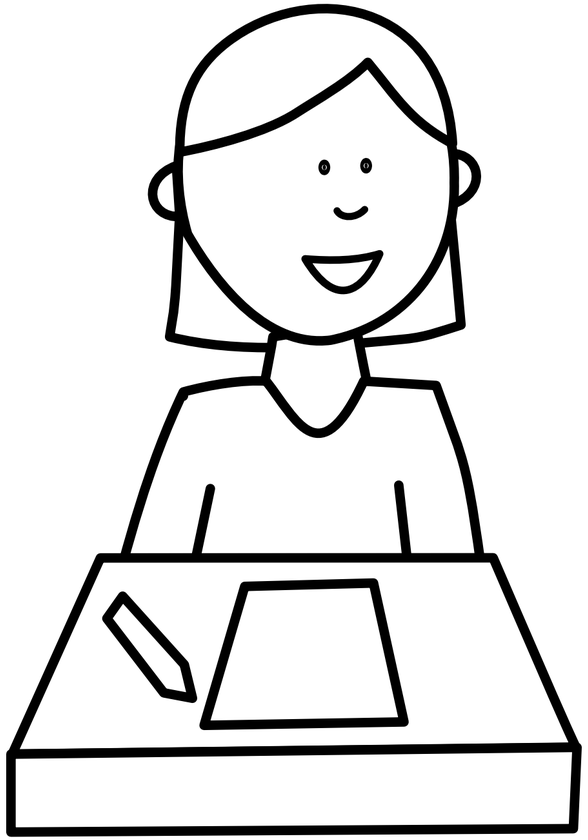
Validate

Resources

Bite-sized parts

Other People





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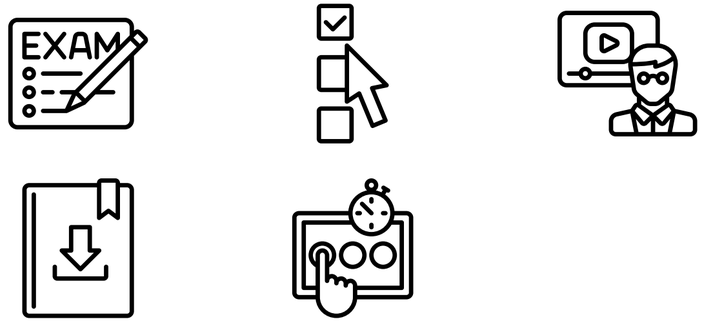

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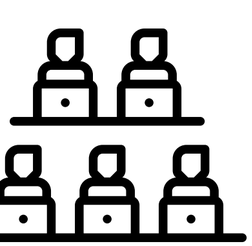

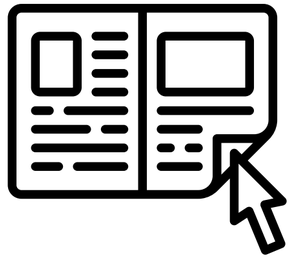

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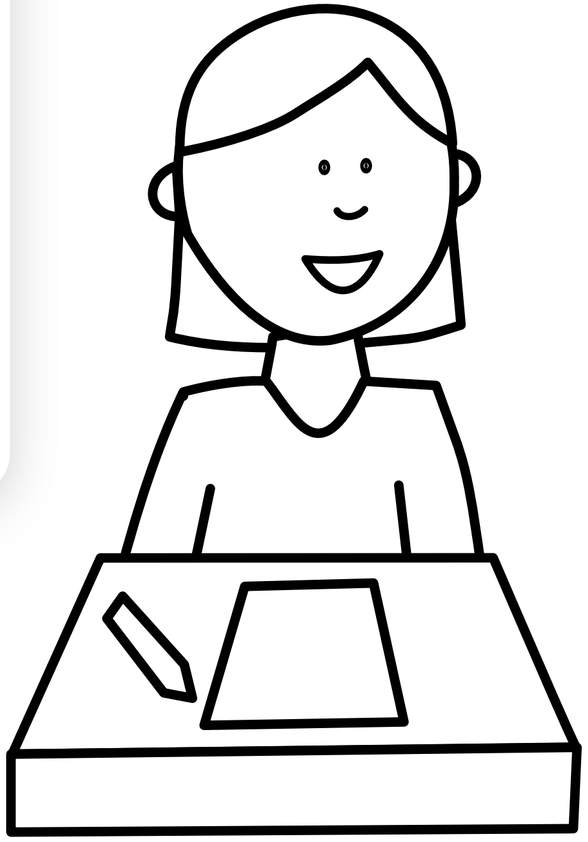

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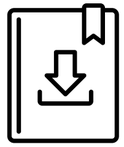
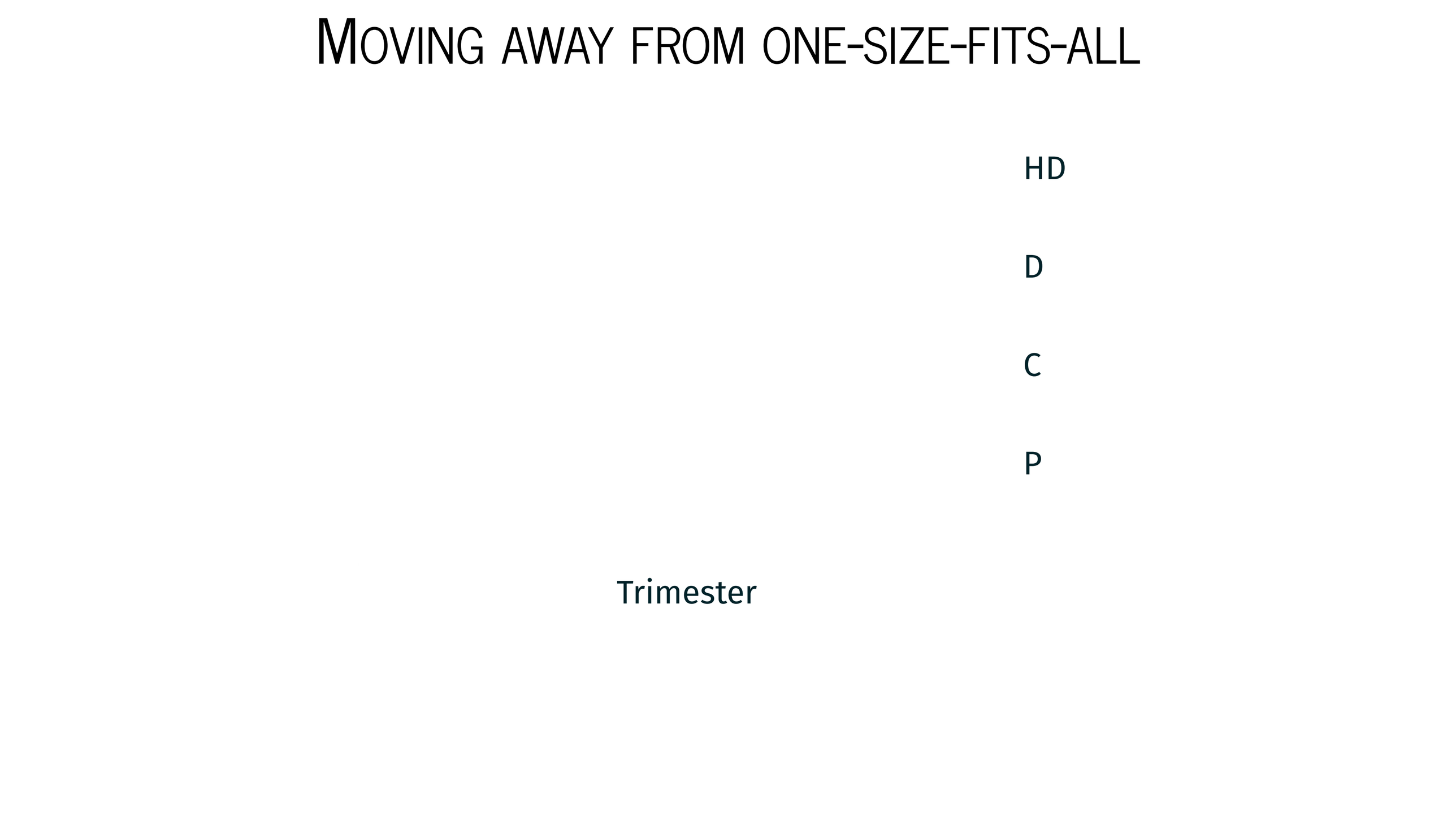







Moving away from one-size-fits-all



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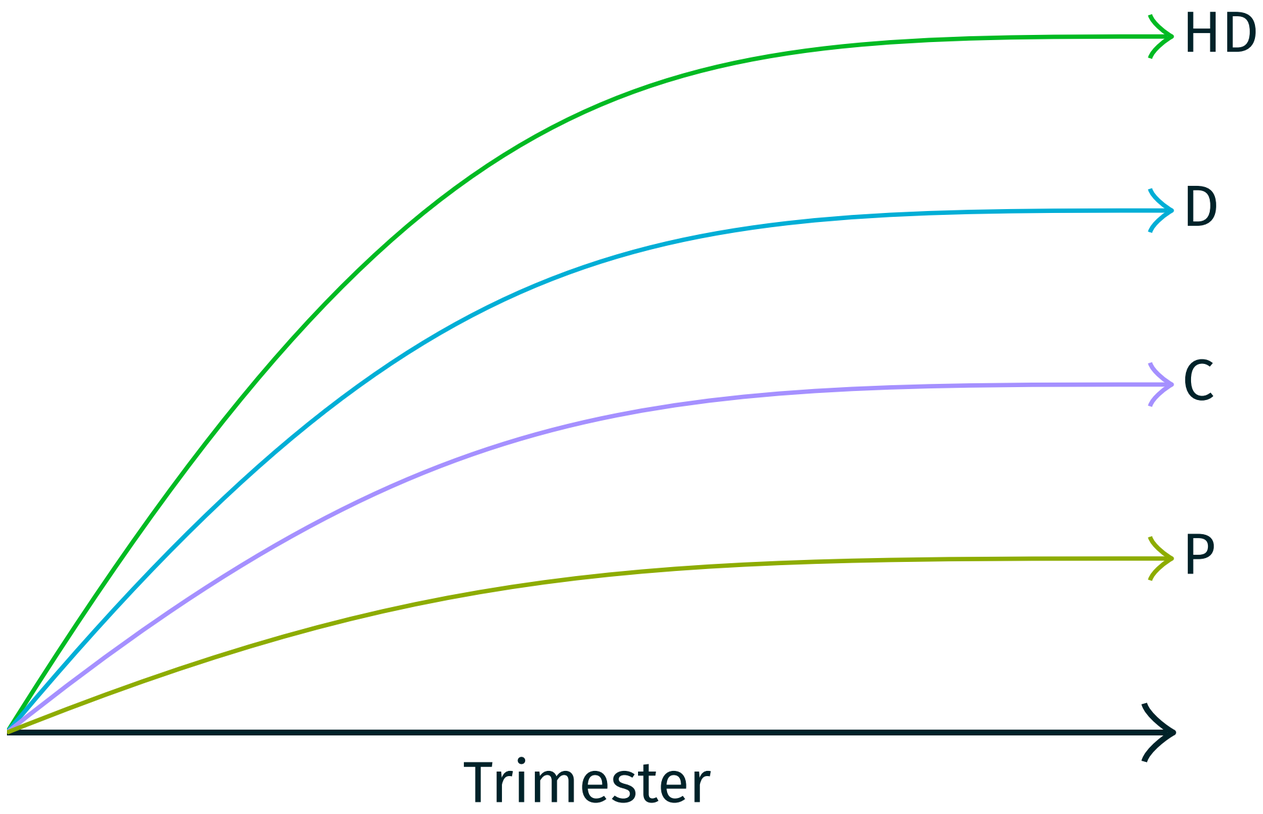

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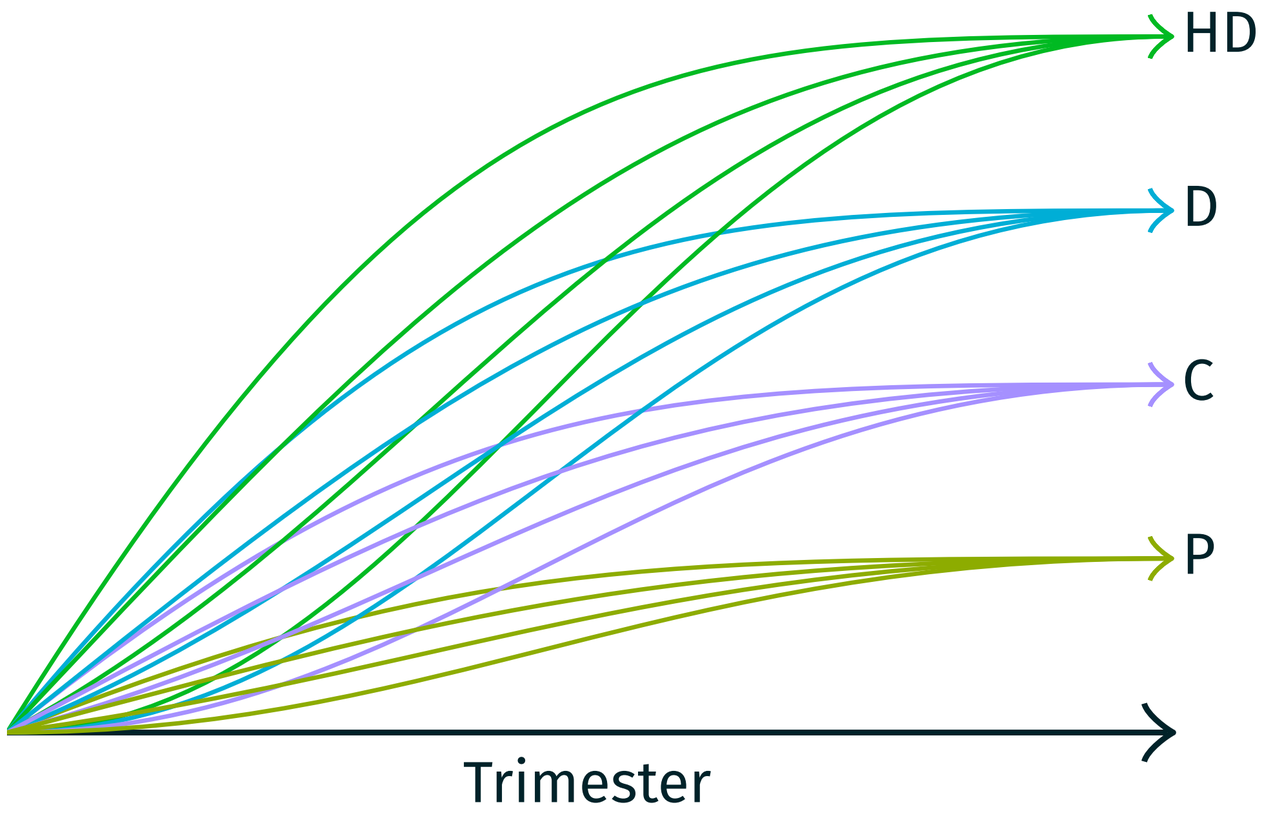


Learning Resources

Each module comes with its own set of resources.

- Aligned to Learning Objectives.
- All the resources are available from the start.
- Availability in a range of formats (interactive, videos, text).
- Students can work through them at their own pace.

Content and Skills

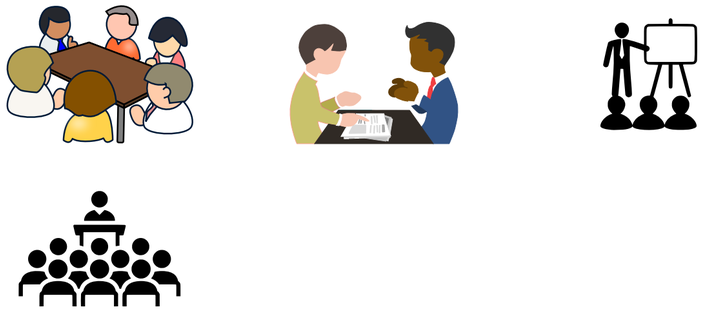
Learn

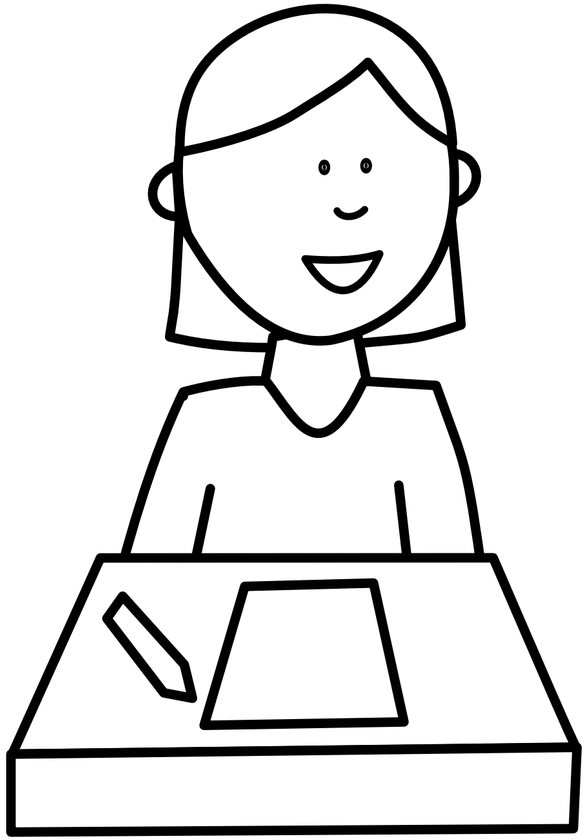
Validate

Resources

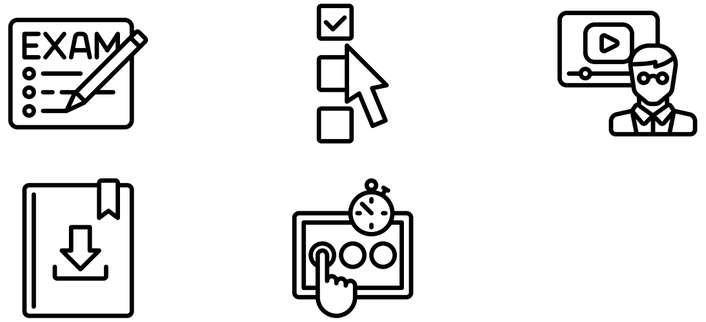
Bite-sized parts

Other People





Portfolio of assessments



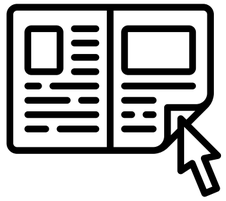
😢 😐 🙂 😀 😁

Content and Skills

Learn

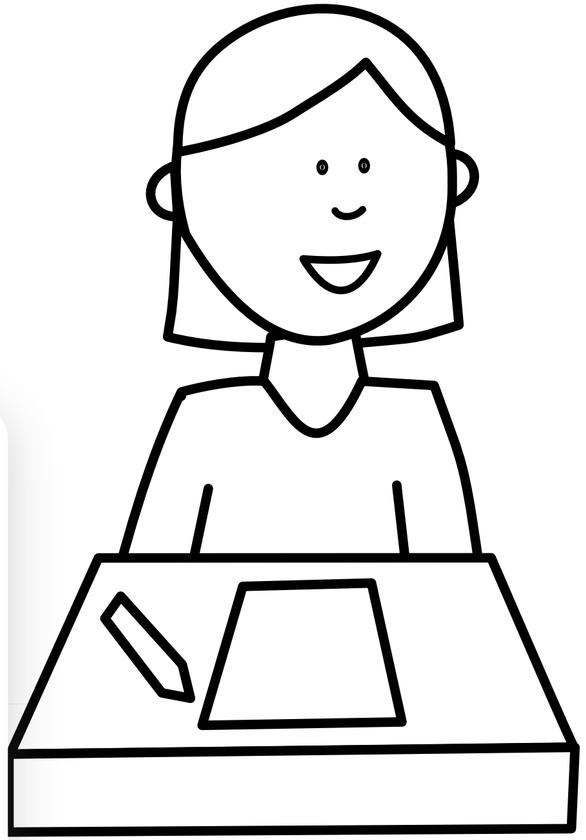
Validate

Resources



Bite-sized parts

Other People



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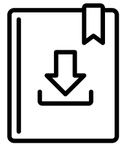

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The Nature of support changes

P

C

D

HD

The Nature of support changes

P	Structured
C	
D	
HD	

The Nature of support changes

P	Structured
C	Scaffolded
D	
HD	

The Nature of support changes

P	Structured
C	Scaffolded
D	Self-Directed
HD	

The Nature of support changes

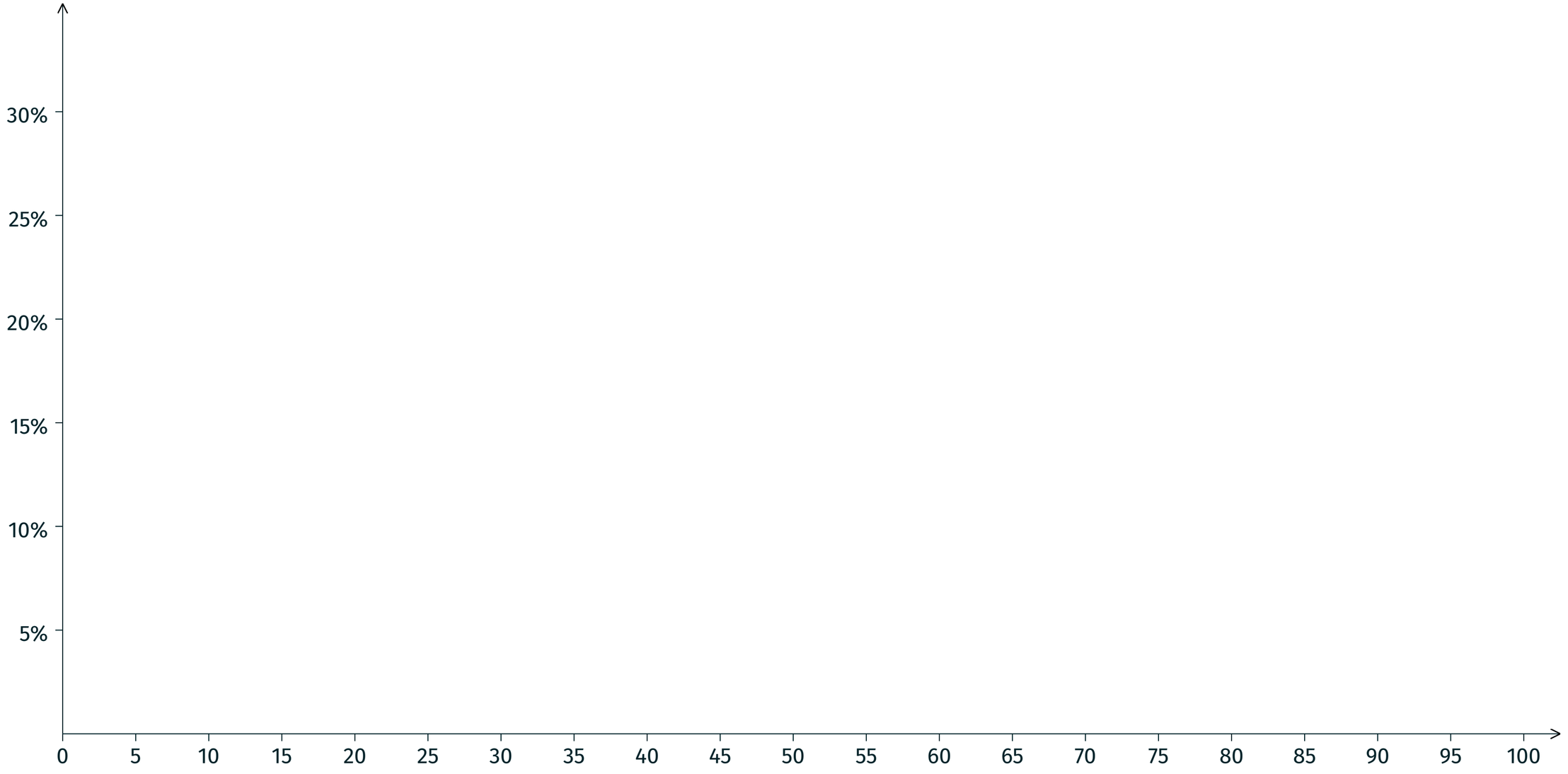
P	Structured
C	Scaffolded
D	Self-Directed
HD	Negotiated and student-led

What are classes for?

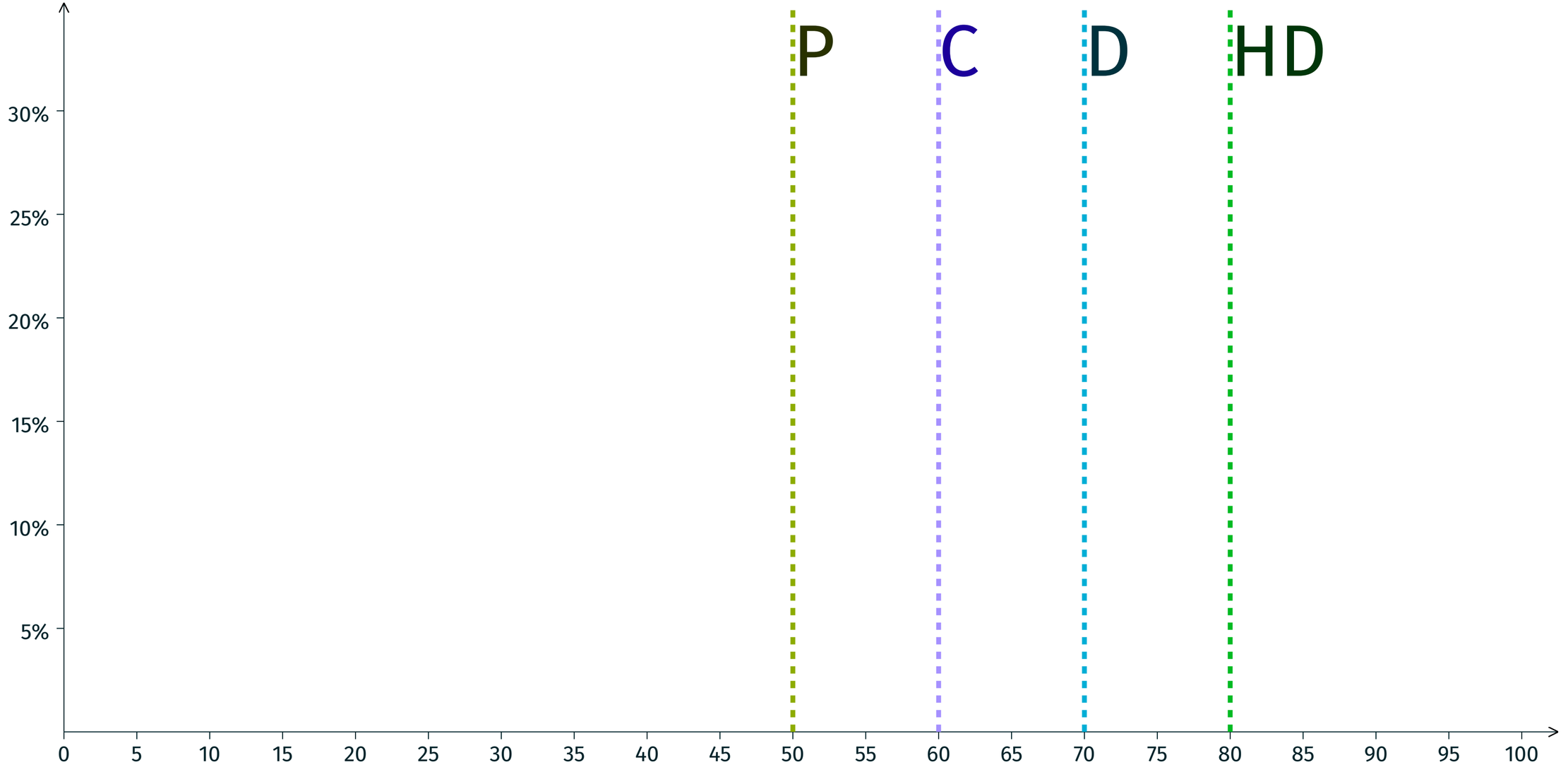
- Designed to maximise interactions.
- Students work on different topics during the class.
- Other support mechanisms: forums, drop-in...
- Also used to verify the integrity of the work.

Reflections and Observations

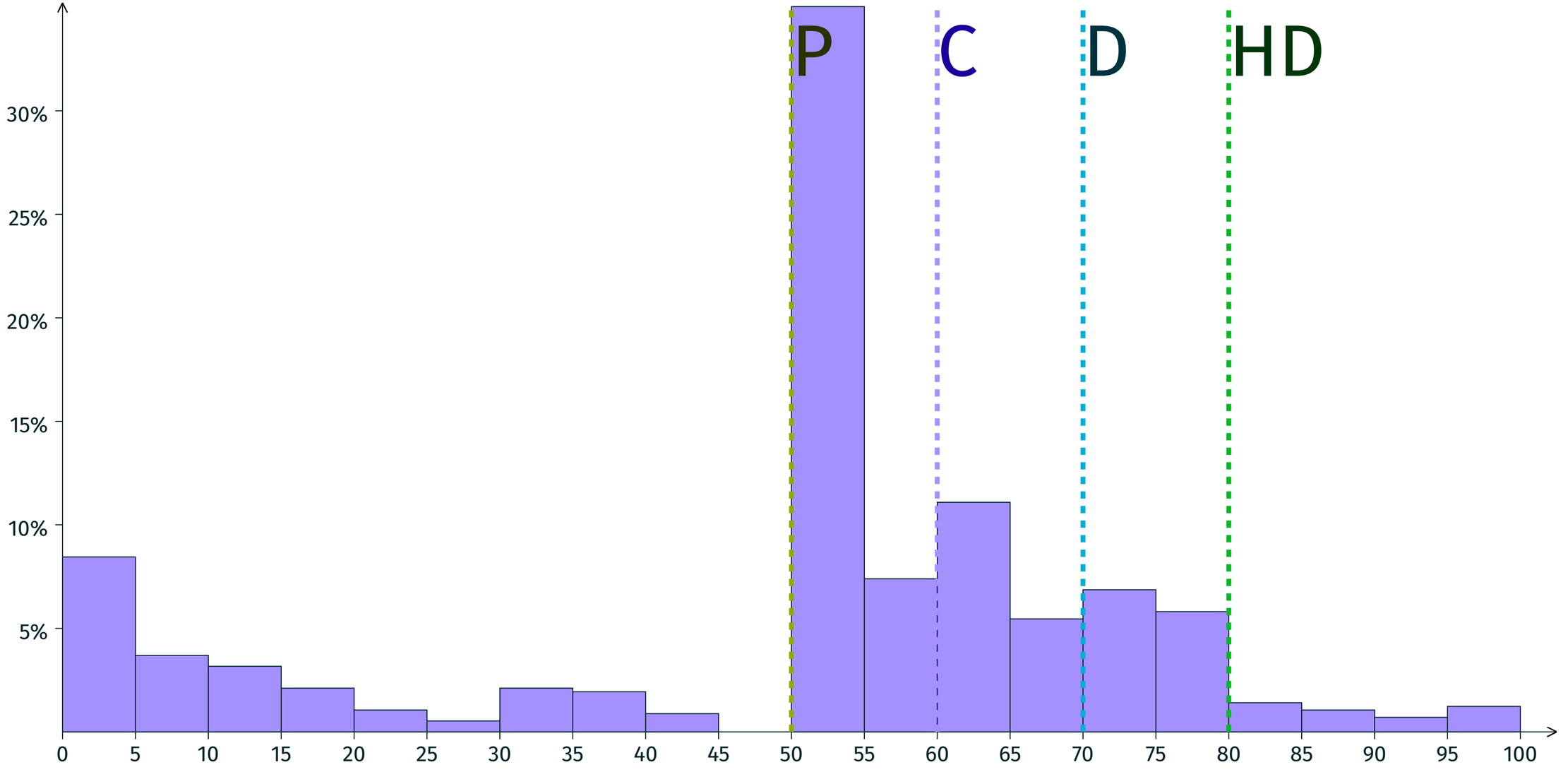
Our result distribution in 2024



Our result distribution in 2024



Our result distribution in 2024



Beyond Individual units

- Improved Grade distributions and Fail rates across maths units
- Pathway for keen students (one is starting her PhD in December!)
- Mathematics Yearbook!
- Resilience to change
- Enhanced reputation within school/faculty

When I started this subject, I was terrified, I thought it was going to be really difficult and I ruled [out] almost immediately trying to get a HD. But when you open yourself up to learn, and become willing to experience new things, you get to learn about your own capabilities that you often don't even know you have.

I learned to push the limits of my capabilities in this subject to achieve far greater outcomes than I anticipated and I'm incredibly proud of my hard work to achieve such a high level of completion in this subject.

the most important thing I learned in this subject is that maths is used in EVERYTHING. Every aspect of your life involves mathematics and things that don't seem like maths (graph theory) are indeed maths. I didn't realise the importance of maths in my degree, or the career I want prior to starting this degree. I was a bit confused why I had to study this subject, which was very quickly changed when I started actually learning.

I have a horribly tough time picking my favourite for this subject [...] But, if I could pick my own topic module, I would pick that. That was one of the coolest things I've made in my degree so far, and its up there with creating malware. So it was pretty cool!

Mathematics has never been my strongest subject. Having left high school nine years ago, I was a little concerned with this unit, the provided readings helped get me started before engaging in this unit.

I would be delighted to discuss each of my submissions in detail to highlight the reasons behind my High Distinction achievement. However, I genuinely believe that by reviewing them, you will readily recognise the tremendous effort I have dedicated to this unit. I want to emphasise that my intention is not to boast but rather to express my sense of accomplishment, one where I am very proud of.

his unit has taught me how to genuinely appreciate mathematics, fostering the ability to read and comprehend even the most challenging topics with a greater level of conceptualization – though not amazing yet, it has put a little confidence in me and a little passion to pursue it more!

I have come to realise the immense importance of mathematics in various fields. It is a fundamental tool that permeates every aspect of our lives. I struggle to think of any discipline that would not benefit from its application.

I believe this is the MOST important part that helped with my learning is the OnTrack feedbacks, I felt that the feedback process really helped me my learning. Most importantly, it was very motivating and so helpful to know where to look to when you needed help.

I do believe that allowing me to use programming with the mathematics really helped my understanding. Of course, I am studying Data Science and I have been programming for a while now. Being able to translate the mathematical problem into a coding problem really deepened my understanding because I can now think deeply about it – this actually then improved my ability to understand mathematics without translating it into a programming problem. I found this helped a lot.

This unit has had a profound impact on me, and I genuinely mean that. It has made me realise many things and ignited a strong passion within me [...]. This unit has sparked a significant amount of curiosity in a subject I had previously overlooked, and for that, I am immensely grateful.

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Some Principles

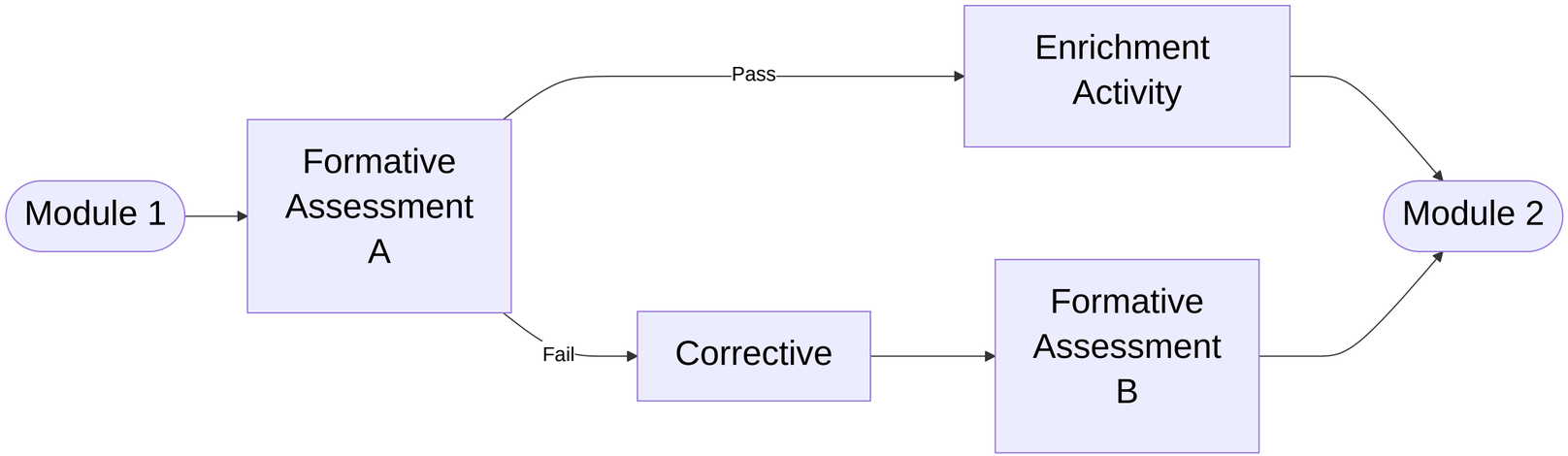
and a bit of theory

The Two Sigma Problem

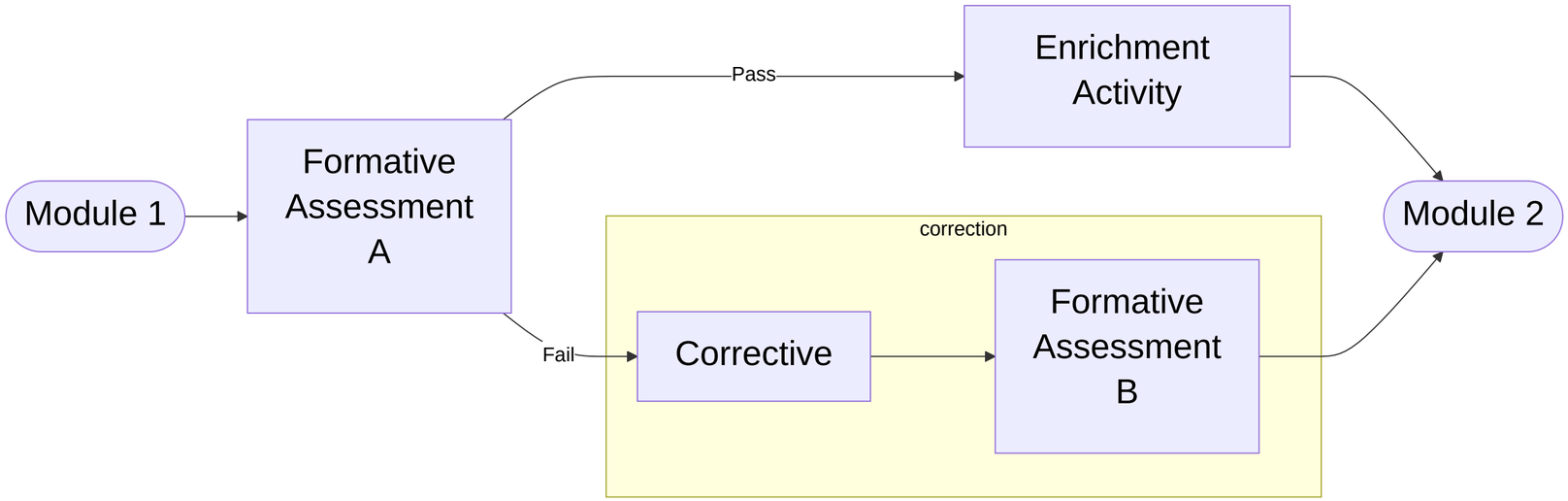
[U]nder the best learning conditions we can devise (tutoring), the average student is 2 sigma above the average control student taught under conventional group methods of instruction.

Bloom (1984)

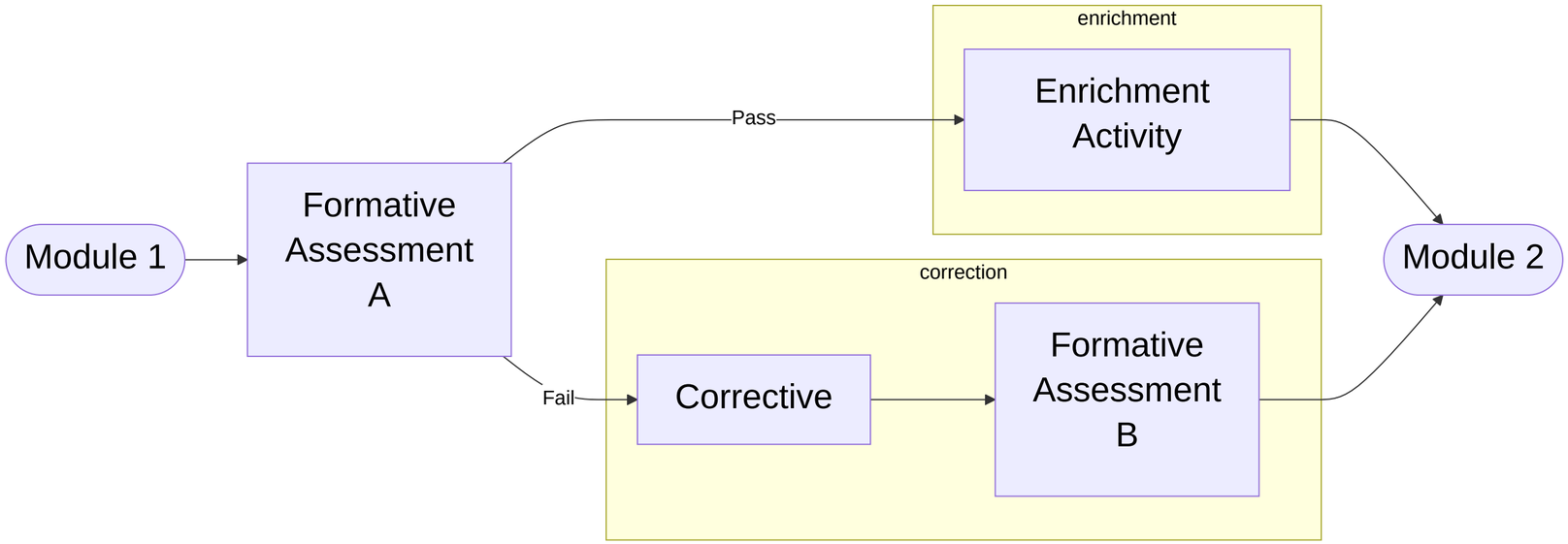
MASTERY LEARNING



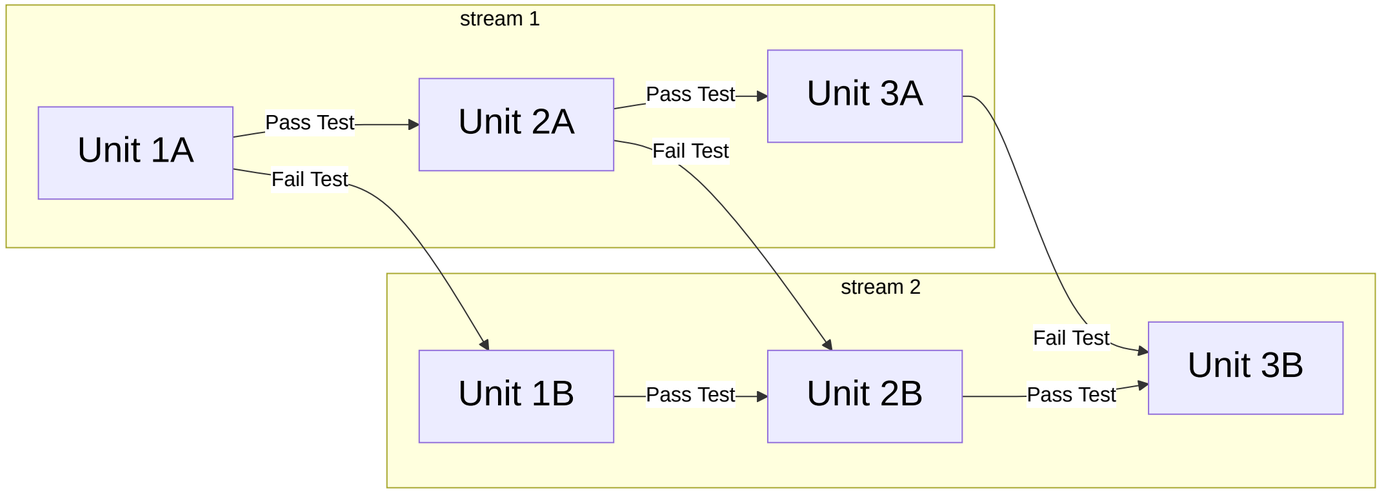
MASTERY LEARNING



MASTERY LEARNING



DIFFERENTIATING LEARNING



Pros and Cons of Mastery and Differentiated Learning

- Acknowledge the diversity in our classroom
- Opportunities for correctives
- Risk of elitism
- Workload implications

Co-constructed learning

Co-constructed learning, rooted in constructivist theory , shifts the focus away from fixed outcomes and expectations (e.g. exam scores, predefined curriculum) and toward an understanding of how learning spaces are shaped (i.e. constructed) in a way that capitalises on available ecological resources, emphasises meaning-making, and promotes an environment most conducive to learning .

(Vespone, 2023)

Co-constructed learni

transformative process.

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(Vespone, 2023)

Co-constructed learning

Physical and mental

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(Vespone, 2023)

Co-constructed learning

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Zone of Proximal Development

(Vespone, 2023)

Content and Skills

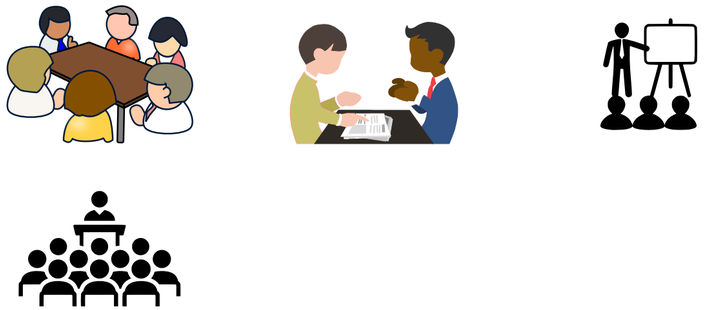
Learn

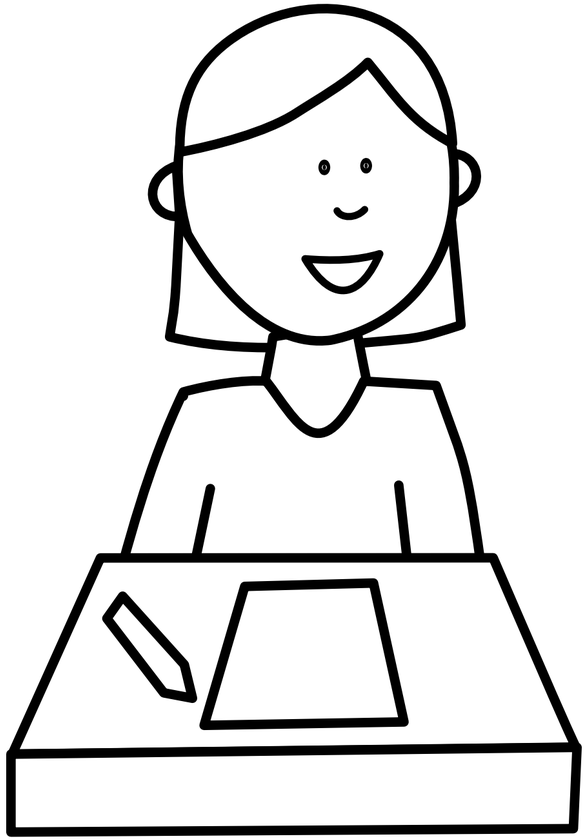
Validate

Resources

Bite-sized parts

Other People





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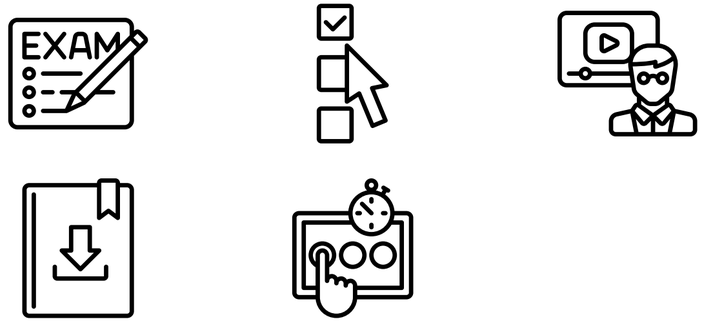

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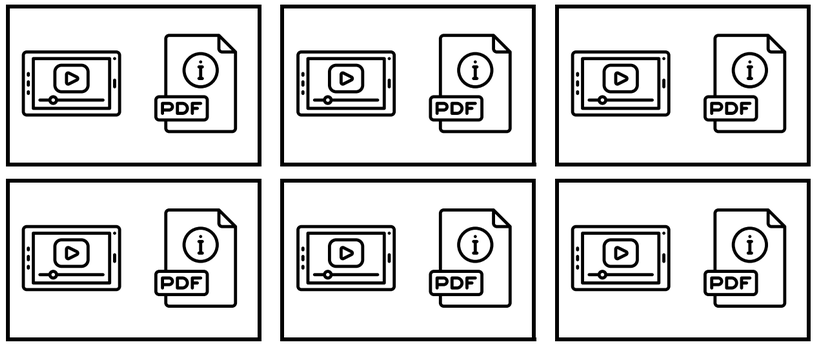
Content and Skills

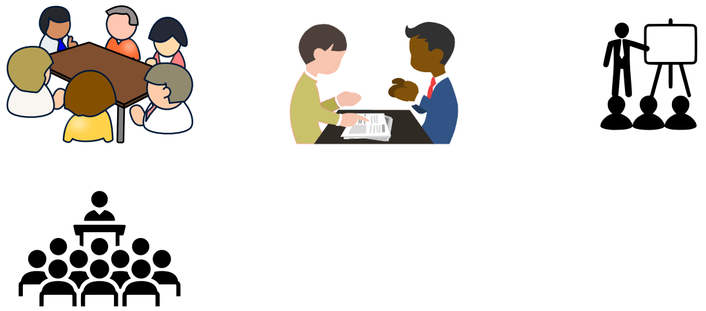
Learn

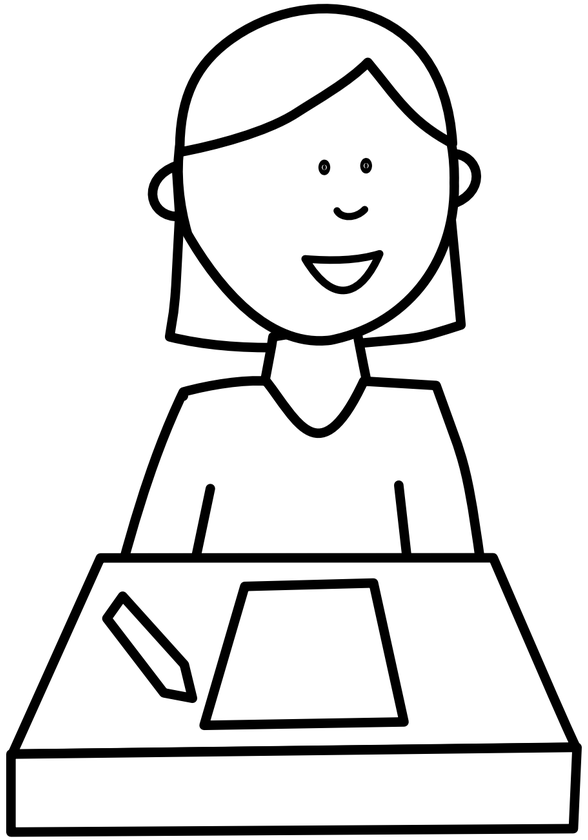
Validate

Modules



Other People





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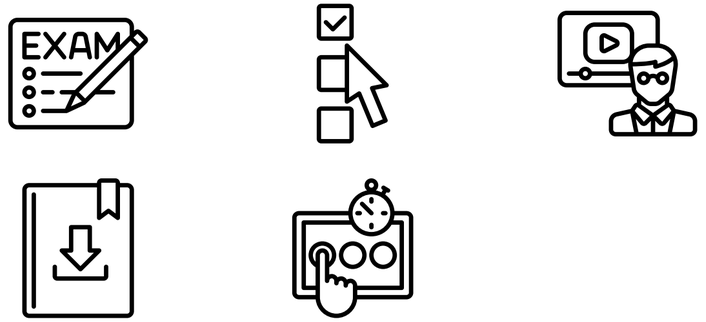

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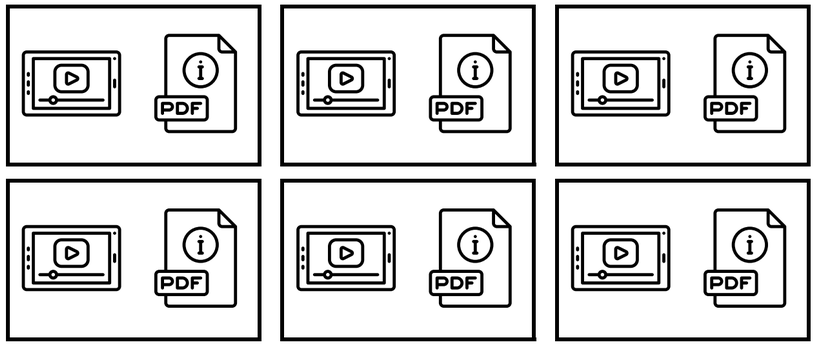
Content and Skills

Learn

Validate

Modules



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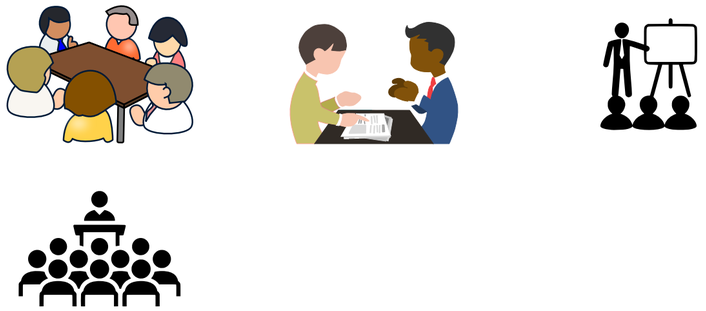
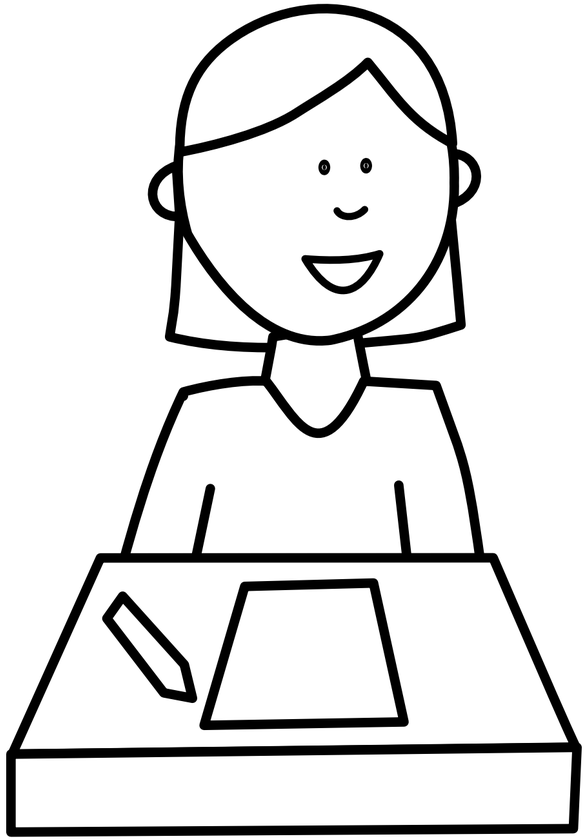
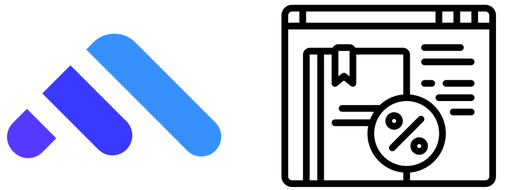




Portfolio of tasks



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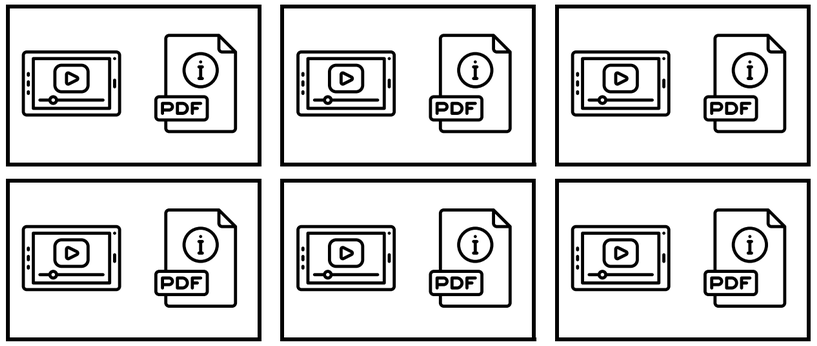
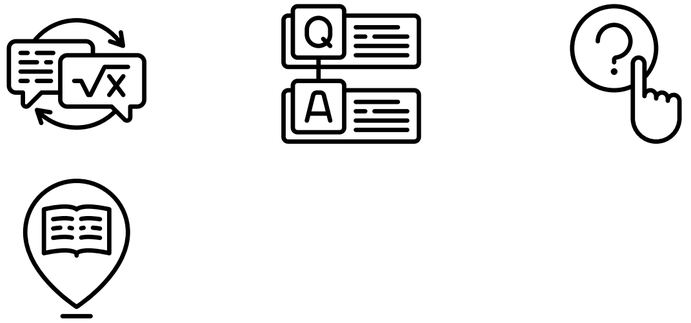
Content and Skills

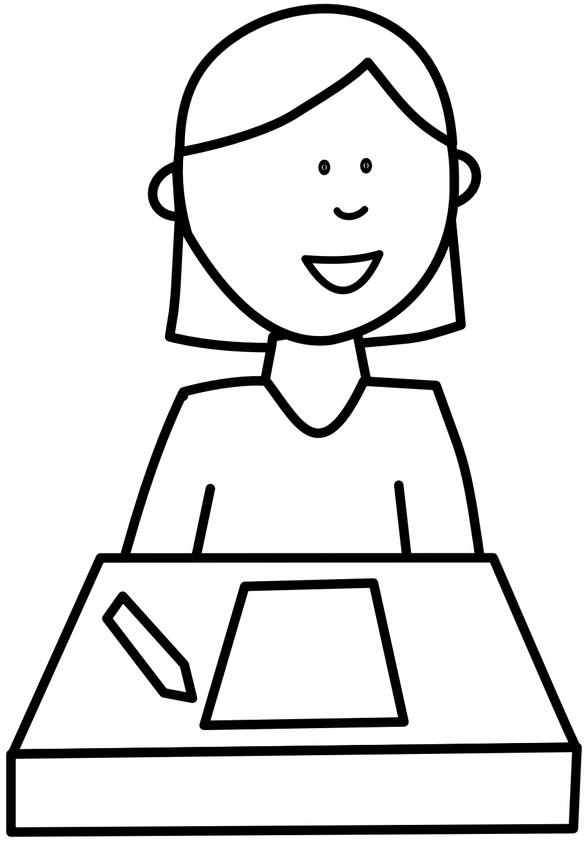
Learn | Validate

Modules



Seminars, Forums, etc.





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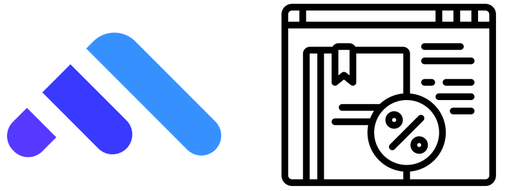

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Construct Truth Tables

Learn

Validate

More practice

Construct the truth tables of the following expressions (you can find the solutions in the pdf notes):

- $p \wedge \neg q$
- $p \vee (q \wedge \neg p)$
- $(p \wedge q) \rightarrow r$
- $(p \wedge q) \leftrightarrow r$