



# Mathmet Measurement Uncertainty Training Activity:

## lessons learned from a European community workshop

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on behalf of the workshop participants



# Mathmet MU training activity



- Within Euramet EMN Mathmet, volunteering activity
- Led by Katy Klauenberg (PTB)
- Initial phase 2021-2023, but targets long-term self-sustainability
  
- For trainees : single point of contact
- For trainers (consortium) :
  - Sharing training material
  - Establishing a community in MU training on European level
    - Workshop
    - Mutual attendance framework
  
- <https://www.euramet.org/european-metrology-networks/mathmet/activities/measurement-uncertainty-training-activity>

# MU training workshop



- To share best practices in teaching MU : theory and experience
- Listen to needs from different horizons
- Freely share feedback, in an informal manner
  
- Organised on 17-18 May 2022, it gathered 40 participants from 25 organisations
- Introductory discussion on ongoing work to « break the ice », eg. with overview survey of
  - existing courses in EU (NMIs, mostly), often based on JCGM GUM suite
  - examples : in existing training courses and from EMPIR EMUE project

# Overview



- What is Measurement Uncertainty to who ?
- How to best teach it ?
  - Purposes and content
  - Mathematical level
  - Methodologies
- When to teach it ?

# Participants – spanning the horizons



- NMIs :
  - PTB, LNE, NPL, INRiM, METAS, CEM, GUM, IPQ, NSAI, SMD
- Academics : U. Konstanz
- Legal metrology training center : DAM
- Industry : Testo
  
- And their contacts, subsequently



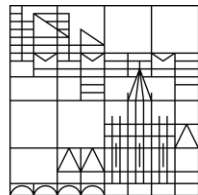
# Participants



Instituto Português da ualidade



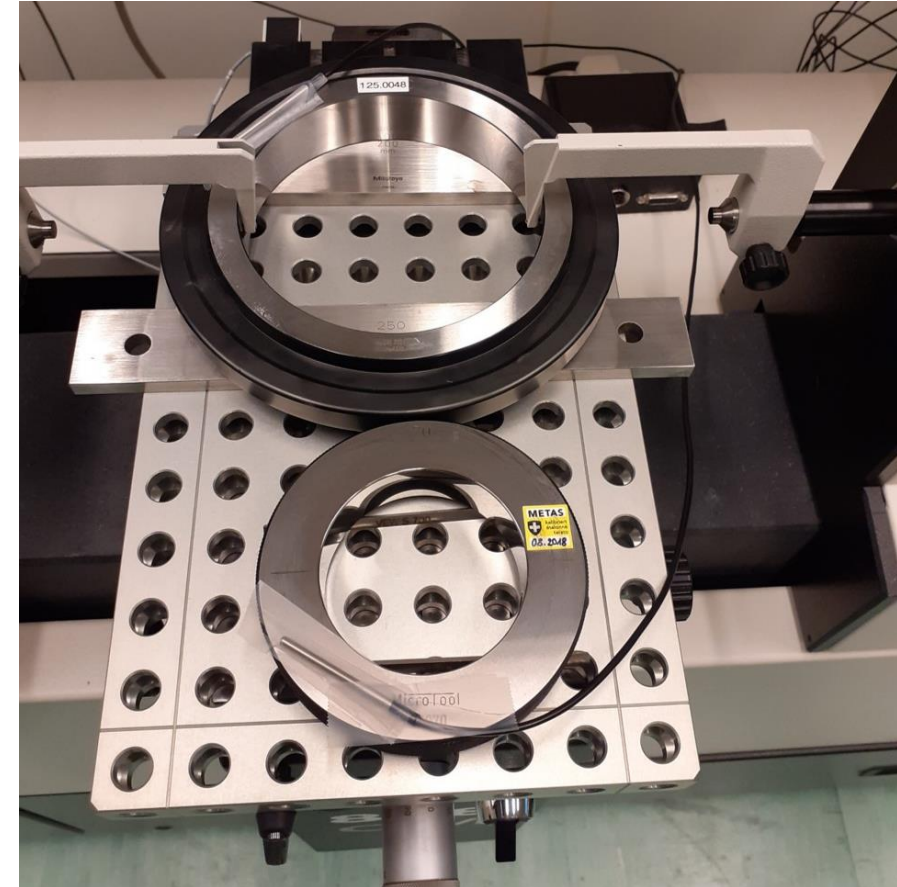
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# Measurement Uncertainty = ???



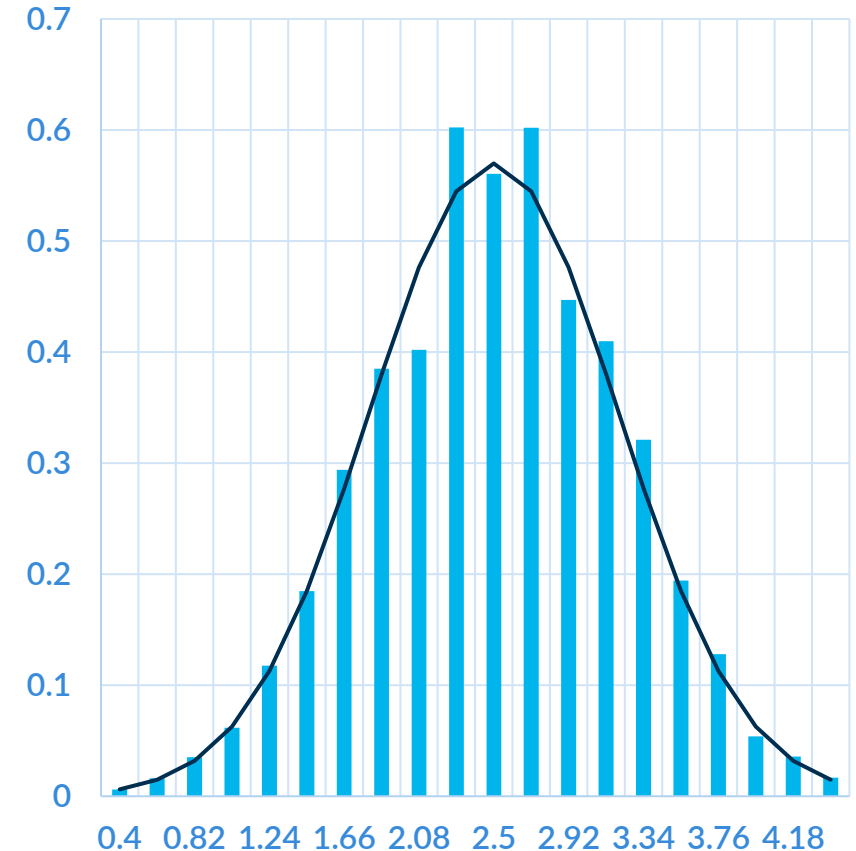
- A concept for doubt in (or fluctuation of) a measurement result
  - Or more interestingly : its sources ?
- A computed value
- A computation
- A budget of uncertainty table
- (Quality System paperwork)



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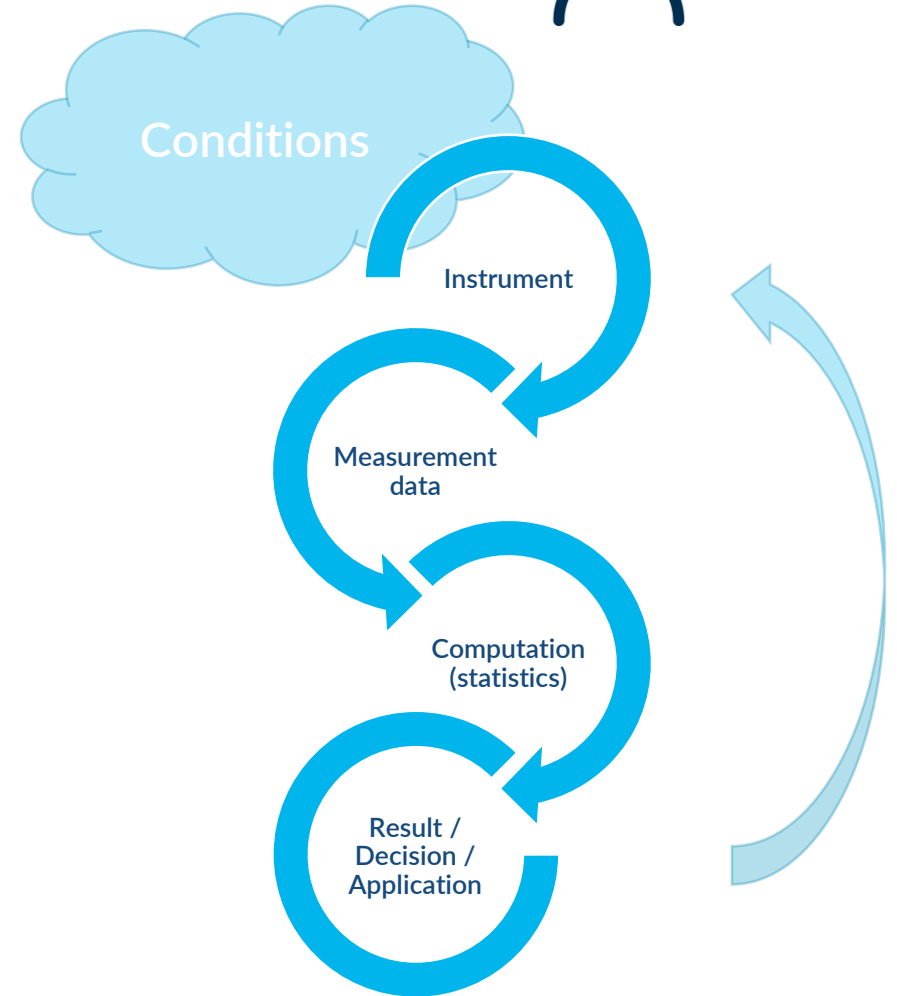




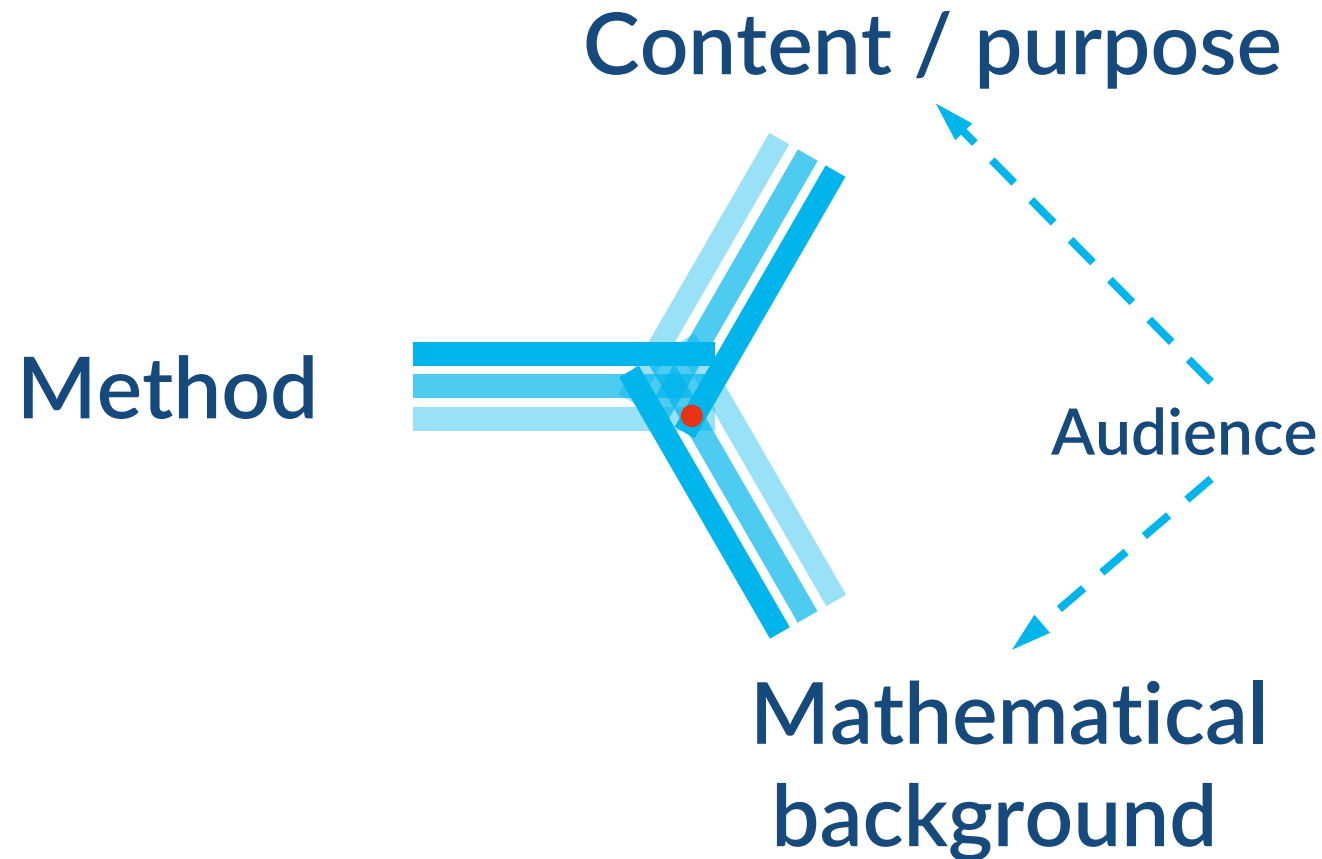
# The MU process and its purposes



- What MU means to a given user depends on the purpose of MU :
  - MU itself
  - What does it mean ? Risk eval. , conformity, tool for decisions (equipment)
- Depending on the purpose, some aspects will be emphasized
- It can be quantitative or mostly assessment of its contributions/sources
- Who needs it ? Anybody dealing with metrology !
- At least one common question :  
« How to read a certificate ? »
  - Central value, uncertainty, its evaluation, measurement method, ...



# Best practices



- Best practices depend on a conjunction of factors
- Audience is mostly defined by the purpose, but also mathematical background
- A single lecture can address several audiences (mathematical background)
- Also some generic conclusions

# Purposes and content



- Families of content :
  - Raise awareness
  - Use for technical purposes → industry, legal metrology
  - Evaluation → NMI, cal. labs., accredited assessors
- Industry, legal metrology interests :
  - source of variability, understanding biases, acceptance criteria, diagnosing ; instead of mathematical fundamentals  
→ Practical implications + (non-mathematical) concept of uncertainty
- Purposes :
  - Process precision
  - Evaluation of specifications
  - Conformity assessment
  - Support for decision on equipment suitability
  - Support explanation of decisions (legal metrology)
- Know your « customers' customers » profile for a better content tuning !

# Specific points



- **Industry**
  - More about precision
  - Advanced topics :  
When is GUM relevant ?, BoU optimization, correlations
- **Support staff**
  - How to know if a certificate is correctly filled in ?

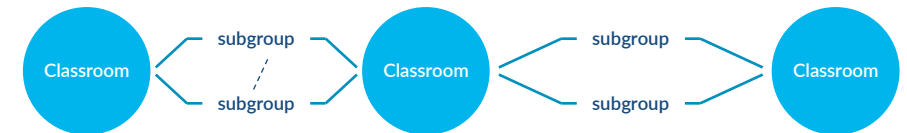
- **Legal metrology**
  - Calibration vs. verification
  - MPE vs MU
  - Sampling
- **Accreditation world**
  - Cal labs : MU is part of measurement ; model oriented
  - Testing labs : less math ; support for conformity decision, ask for guidance



# Mathematical proficiency level



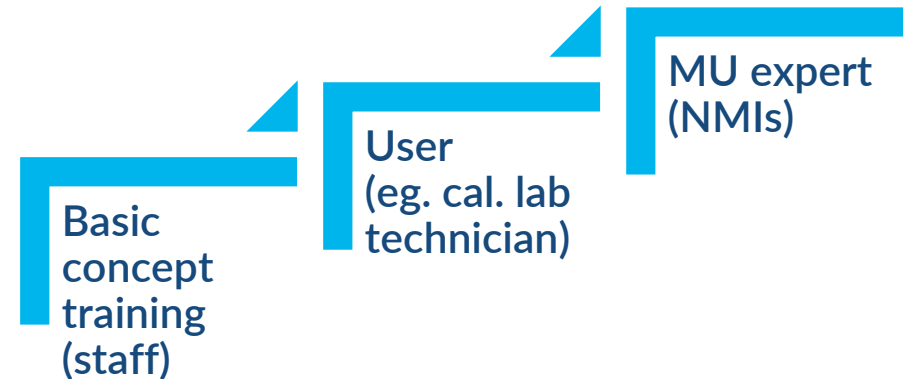
- Calibration laboratories
- Testing laboratories
- Industrials
- NMI
- Support staffs
- School/univ. students : tests / flipped classrooms
  - concept of uncertainty, set of measurements, constantly bridging Theory ↔ Experiment
- Metrology field inspectors :
  - blended approach for flipped classrooms



# Best practices – mathematical content



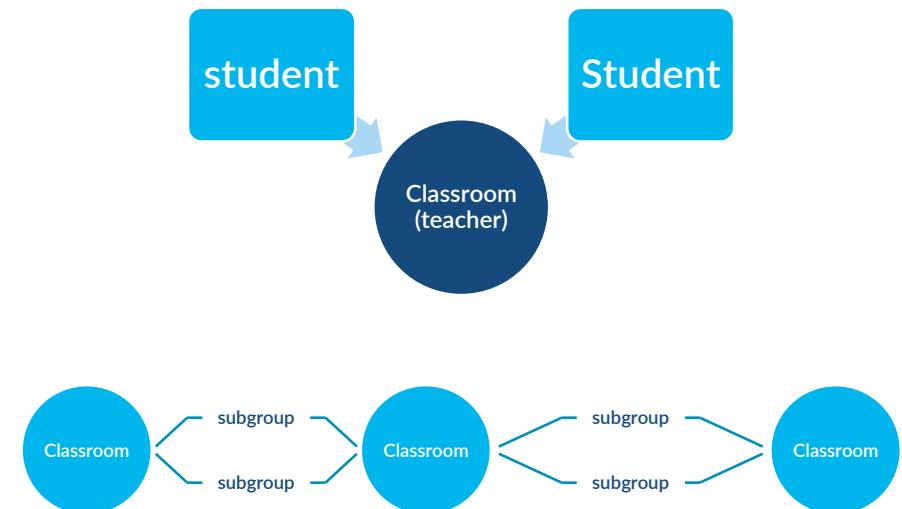
- Basic level reveals to be the most important :
  - Many profiles addressed with basic needs
  - Almost no mathematics needed, concept and feeling instead
- Increasing mathematical background needed
- Multi-level teaching - separate lectures :
  - The second is topical application
- JCGM GUM suite also follows these steps :
  - MC (GUM-S1) can be easier to teach than LPU (GUM), modelling in GUM-6



# Best practices - methods



- Physical attendance
- Flipped classrooms :
  - Secondary school profiles
  - concept of uncertainty, set of measurements
  - constantly bridging Theory <-> Experiment
  - Regular tests
- Blended flipped classroom :
  - Applied for metrology field inspectors
- E-learning :  
deserves a dedicated design



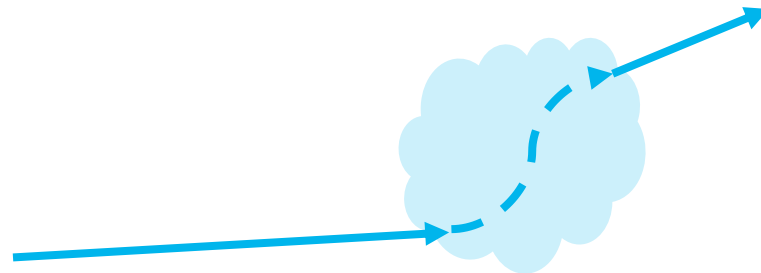
# Best practices - methods



## • Interactions !



- During the lectures : discussion + intermediate evaluation
  - Follow-up contact
- ## • Flipped classroom or blended approach :
- Better problem identifications



## Design in progressive steps :

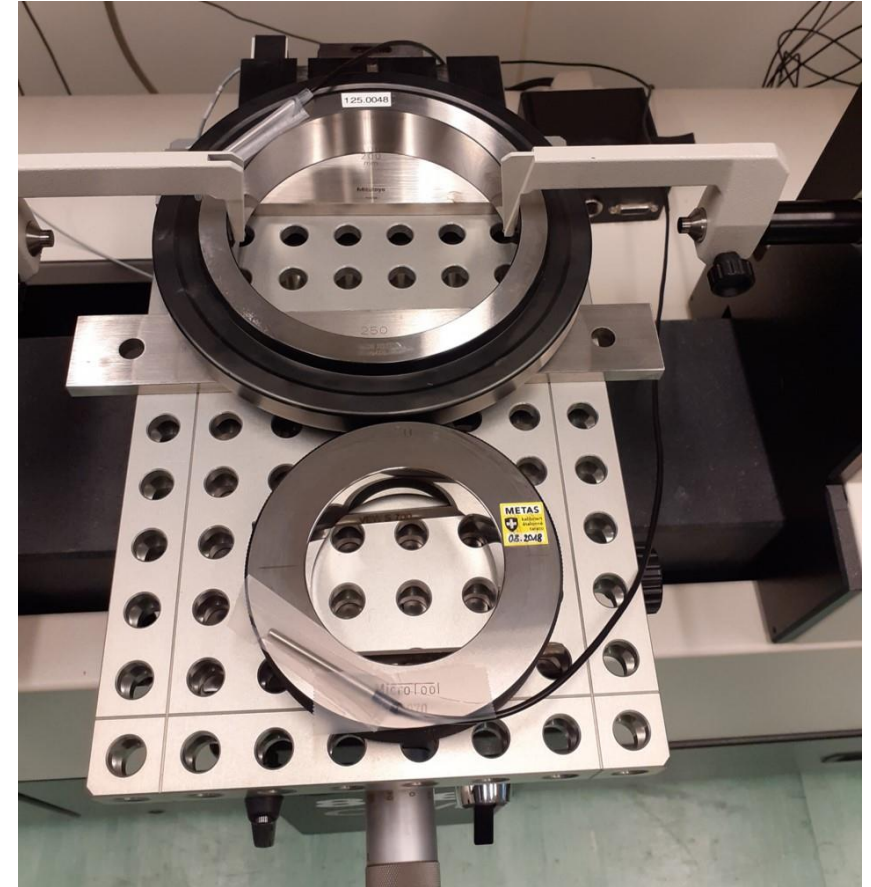
- Use & learning steps: Bloom's taxonomy : from remembering to creating
- Mitigate/limit cognitive overload and conceptual cliffs
  - Withstandable info flow : adapt to students
  - Intermediate quizzes
  - Ex. of cliff : formulation step (support : GUM-6)



# Best practices - methods

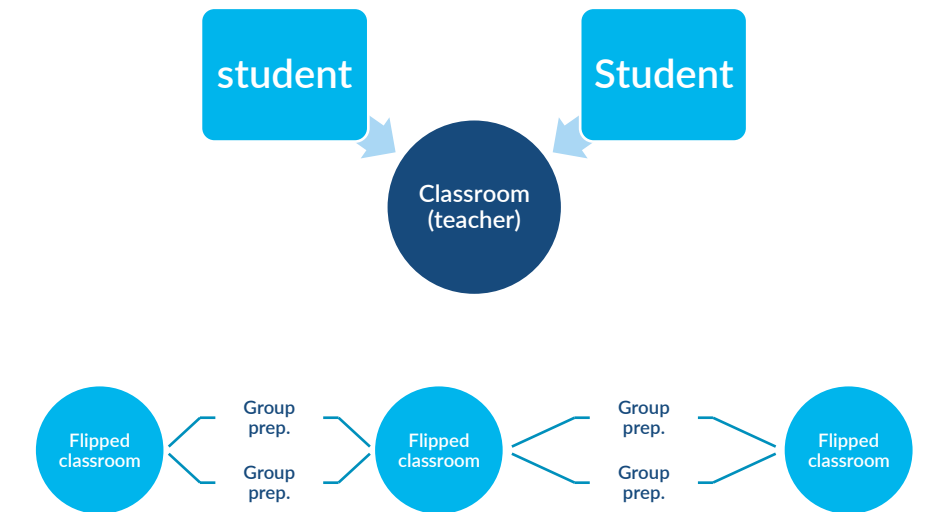
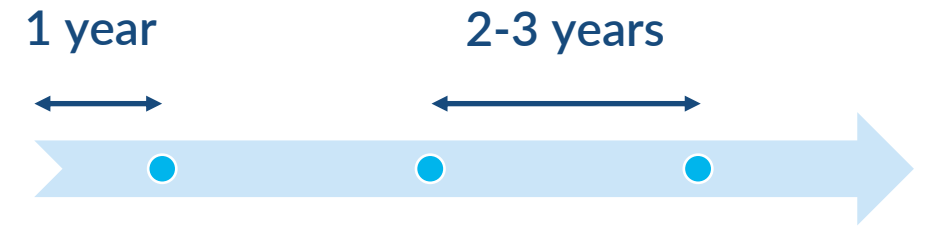


- Follow a red wire, but break the monotony
- Real examples, real pictures, real ...
  - Even more relevant to the audience (ask them !)
- Illustrations, pictures, animations of mathematical concepts (esp. for non-literates in math)



# When ?

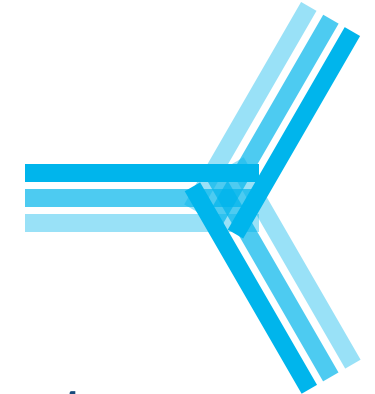
- After some practice, say 1 year of experience
  - fit-for-purpose with current job
  - Better identification of own needs
  - Better introspective against the teaching
- Refresh course needed
  - Every 2-3 years
  - ISO/IEC 17025 implies/enforces periodicity
- Flipped classroom and blended approach need a specific schedule



# (Short) conclusions



- Concept of uncertainty is much more than its computation
- Proper use of uncertainty : certificate, decision making
- Basic level is of interest for most of trainees
- Keep interacting/adapting at any stage !
- Fit the needs and purposes of your trainees (and their indirect user community)
  
- E-learning is a possibility but it deserves a full design on its own  
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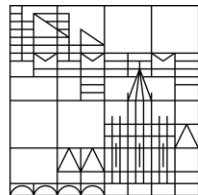
Questions ?  
Remarks ?  
Suggestions ?

Thank you for your attention !

# Real authors of this presentation



Universität  
Konstanz





# Next steps not to miss

- Raising awareness videos
- Analysis of survey in accreditation labs, bodies and assessors
- Have a look at the courses/ lab NMI training offers

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# Bloom's taxonomy



Assimilation of the training material

