

# Survey of classroom examples

Peter Harris (NPL, UK)

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MATHMET



## Background

- Classroom examples are an important component of training on MU
- MU is often taught as a generic (and sometimes abstract) concept, and practical examples can help to bring the concept of MU and its evaluation “to life”
- Also, examples that are close to the area of interest for the student can be a powerful teaching aid as well as providing a “template” for bringing MU and its evaluation to the student’s working practices
- At NPL, we have developed a “pathway” of e-Learning courses (of increasing for depth) on the general topic of MU ...
- ... but lately we have focussed more on developing application-specific courses aimed at particular audiences (although not exclusively), e.g.,
  - Uncertainty Analysis for Earth Observation ... for climate scientists
  - Uncertainty Propagation for Quantitative MRI ... for MRI physicists

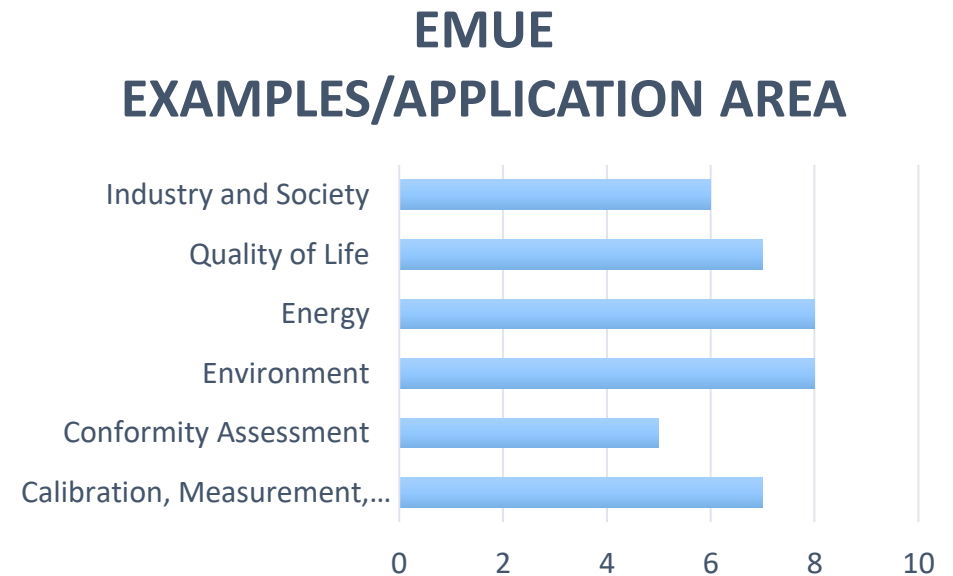
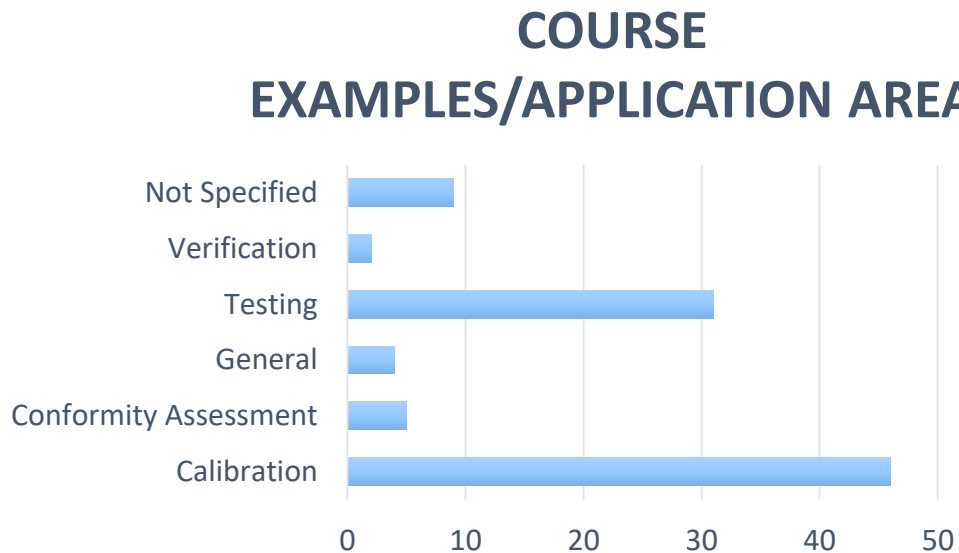


## Aim and approach

- Aim was to categorize available classroom examples
  - to help students to identify training courses suitable for their needs
  - to help training providers to ensure good coverage of their training products and target them at student needs
- Analysed two sources of classroom examples:
  - Survey of existing courses from Mathmet MU Training Activity (69 examples)
  - Compendium of examples from EMPIR project EMUE “Examples of Measurement Uncertainty Evaluation” (41 examples over 6 broad application areas)
- Considered four characteristics: Application area; Metrology area; Technical approach taken to MU evaluation; Level of difficulty
- Results summarised in a spreadsheet available on the Mathmet web site and in an article published in ACTA-IMEKO

# Application area

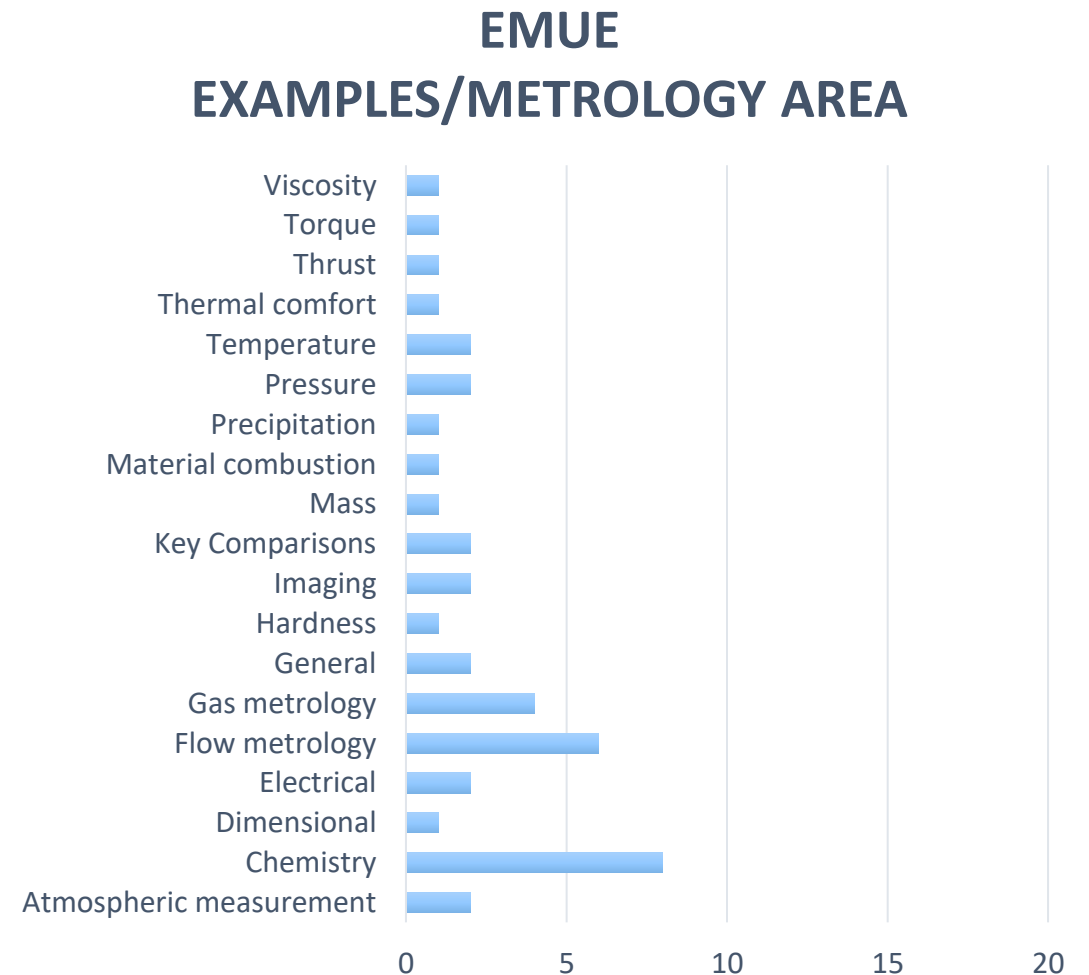
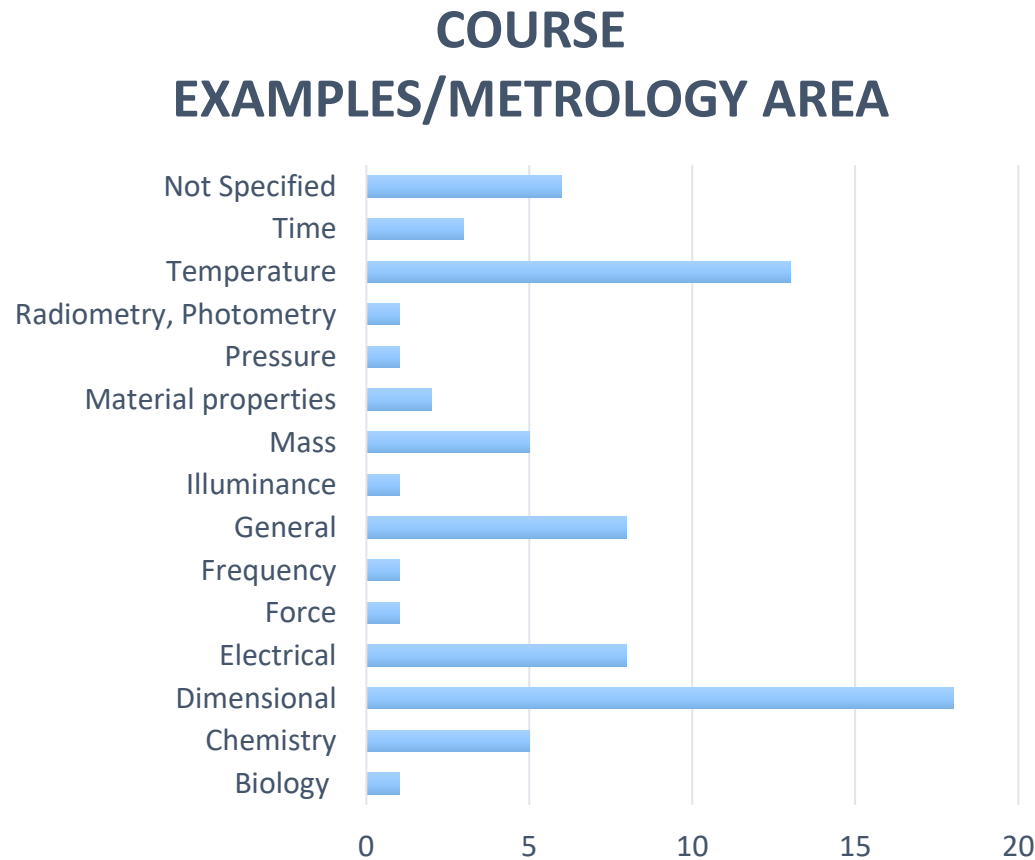
- For the course examples
  - more than one application area was sometimes identified
  - the top two are “calibration” (46/97) and “testing” (31/97), but for some (9/97) no specific application area is identified
- For the EMUE examples, the six application areas (or “strategic areas”) were fixed in advance and the distribution across those was uniform, largely by design ... in hindsight we might have used these strategic areas as options within the survey of course examples





# Metrology area

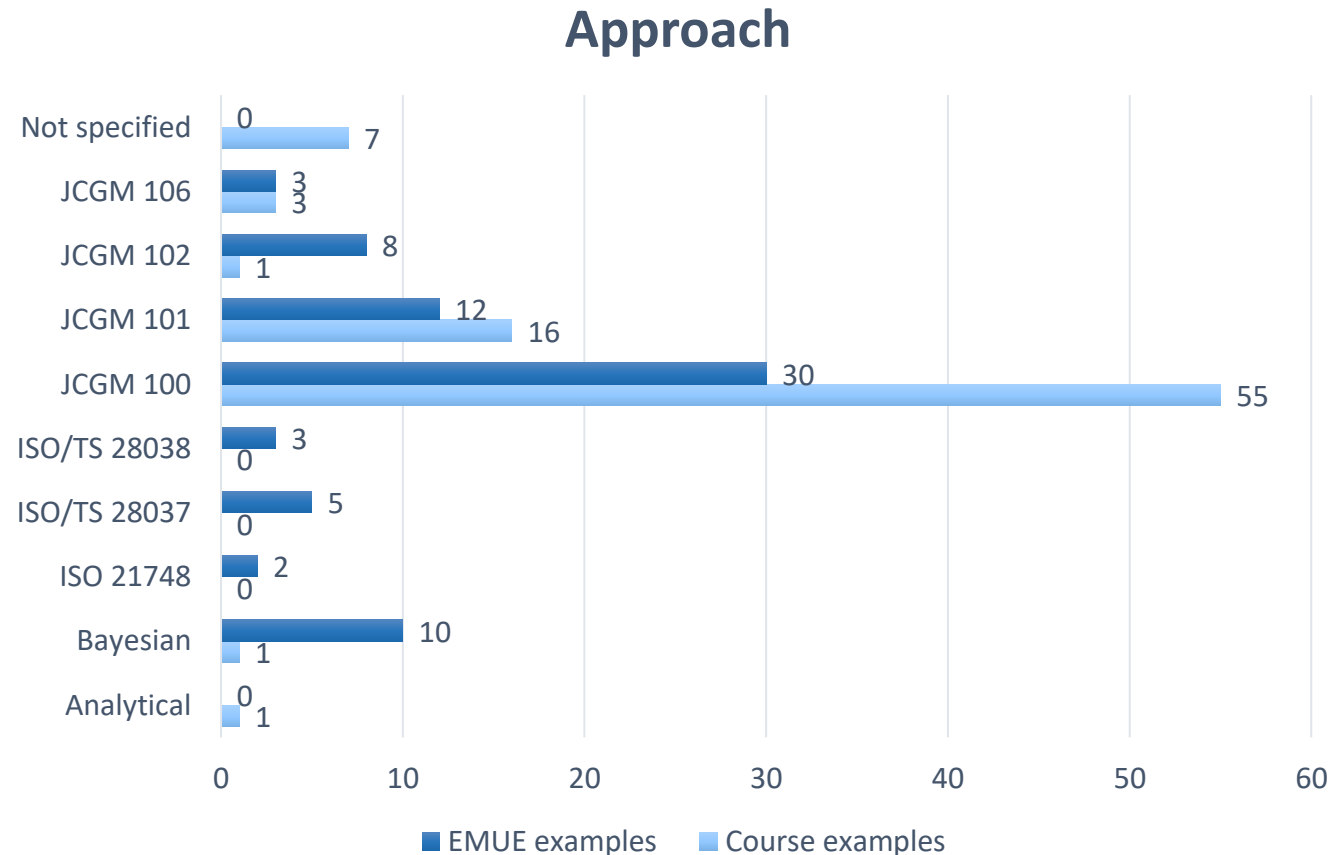
- For the course examples, there are 15 areas and the top two are “dimensional” (18/74) and “temperature” (13/74)
- For the EMUE examples, there are 19 areas, with a more uniform distribution across them and the top two are “chemistry” (8/41) and “flow metrology” (6/41)





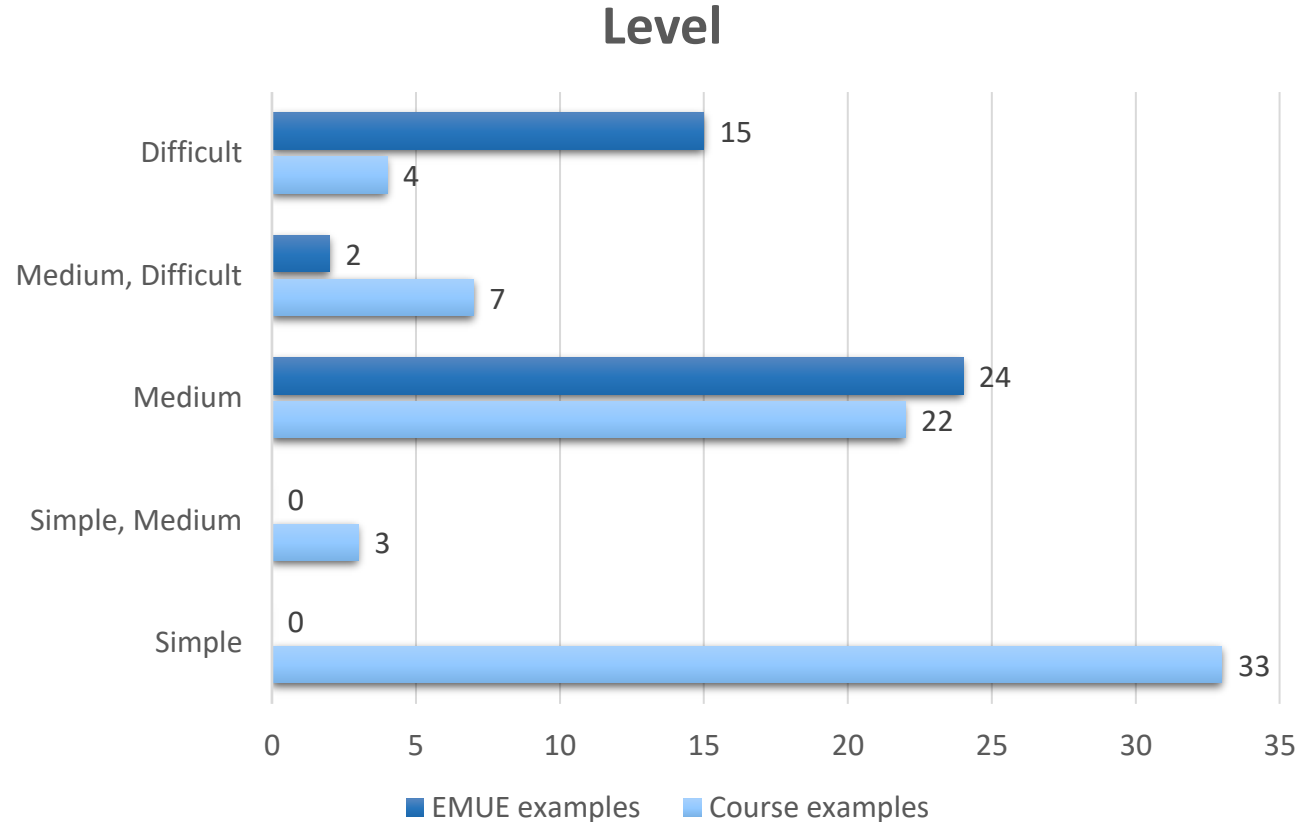
# Approach to MU evaluation

- Examples can consider more than one approach to MU evaluation
- For the course examples, top two are “JCGM 100” (55/84) and “JCGM 101” (16/84)
- For the EMUE examples, top two are again “JCGM 100” (30/73) and “JCGM 101” (12/73), but the Bayesian approach and approaches related to regression problems (“ISO/TS 28037”, “ISO/TS 28038”) are also considered



## Level of difficulty

- For the course examples, selected by owner: most are simple to medium (58/69)
- For the EMUE examples, my own subjective judgement regarding how a “non-expert” might perceive the example: all are medium to difficult (41/41)





## Summary

- Examples taken from the two sources are complementary in terms of:
  - Metrology area
  - Level of difficulty
- Examples from EMUE compendium offer a wider range of approaches covering
  - Bayesian, regression, “top-down” (ISO 21748), ...
- This overview:
  - Supports the identification of gaps in existing training courses
  - Identifies interesting cases to be further developed in the form of classroom examples
  - Facilitates the exchange of knowledge between people teaching MU



## Acknowledgments

- The partners in the Mathmet MU Training activity who completed the survey about existing training courses
- The authors of the compendium of examples from EMPIR project EMUE “Examples of Measurement Uncertainty Evaluation”

**Thank you!**