Analytical chemistry education activities at University of Tartu
Ivo Leito
Ivo.leito@ut.ee
EcoBalt 2018
Vilnius

Contents

• Validation of LC-MS methods
  – State of the art
  – Tutorial papers
  – The online course
• Estimation of Measurement uncertainty in chemical analysis
• Usage modes of the online materials
• International master programmes
• Eurachem 2018 Workshop
LC-MS as technique

- Liquid chromatography mass spectrometry
- The most powerful technique for determination of low levels of organics in difficult matrices
- LC-MS: many adjustable parameters
  - In LC
  - In MS

Checking that the method performs as required is not trivial!

Validation is BIG in LC-MS!
Validation Guidelines?

Validation guidelines

• Generally very useful, but ...

  – Often inconsistent terminology
    • e.g. accuracy vs trueness, ...
  
  – Often very general
    • Choosing concentrations? How many replicates? Spiking levels? How many days? ...
  
  – Sometimes conflicting recommendations
  
  – Usually LC-MS is not addressed
    • Except e.g. 2002/657/EC

sisu.ut.ee/lcms_method_validation/
Our aims were:

1. Give a **critical overview** of the state of the art of LC-MS method validation
   - Including comparisons of the relevant guidance materials

2. Draw attention to the **LC-MS specific aspects**
   - e.g., ionization suppression by matrix effects

3. Give **recommendations on problematic issues** in validation of LC-MS methods

Outcome:


Features

- **Specific LC-MS issues**
  - Ionization, matrix effects, MS^n selectivity, ...

- **Main validation guidelines are reviewed and compared**
  - With every performance parameter

- **Recommendations** are given how to determine performance parameters
  - Synthesis from guidelines and our experience

- **General workflow** of LC-MS method validation is presented

sisu.ut.ee/lcms_method_validation/
**Tutorial review on estimating LoD on the example of LC-MS**

Hanno Evard

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Online LC-MS Validation course

- Validation: General
- Performance parameters
  - Selectivity, Identity
    - Incl specifics of LC/MS
  - Linearity, linear range, sensitivity
  - Precision, Trueness, Accuracy
    - Including matrix effects
  - Stability
  - LoD, LoQ, CCₐ, CC₈
    - Including specifics of LC/MS
  - Ruggedness, Robustness
- Glossary
- Literature
**Course contents**

- **Theoretical** basis as well as **practical** skills
- **Detailed** and **example**-based treatment
- More than **50** short **video lectures** by **6 teachers**
  
  - Excel videos demonstrating calculations
- **Numerous** **tests** and **calculation exercises**
  - Understanding of main concepts
  - Calculation exercises from **real life** situations
  - **Feedback** is given
- **On-line software** (some functionality)

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**Videos ...**

- Using slides:

  ... or ...

- **Pen and whiteboard:**

  sisu.ut.ee/lcms_method_validation/
Discussion dialogues

• Two professionals discuss a problematic situations: one asks for help and the other one gives suggestions

Lab videos

sisu.ut.ee/lcms_method_validation/
Excel videos explaining calculations

• Initial calculation files can be downloaded

Worked examples
Self-tests

sisu.ut.ee/lcms_method_validation/

Online validation software
MOOC: Autumn 2017 edition
424 registered participants from 71 countries

Overall completion rate: 37%
Completion rate of those who started: 67%

Interested?
• Without registration: the materials are freely available 24/7:
  sisu.ut.ee/lcms_method_validation/
• Registered participation:
  – Forums
  – Graded tests
  – Free of charge (digital certificate)

LC/MS Validation MOOC – third edition:
Nov 27, 2018 – Feb 08, 2019
Registration is open at:
sisu.ut.ee/lcms_method_validation/
On-line course: Estimation of measurement uncertainty in chemical analysis

Our goal

- Web-based teaching material for
  - Independent learning to estimate measurement uncertainty in real-life situations
  - On-line reference point of explanations of concepts and approaches
  - Support for auditorial teaching of metrology in chemistry at UT, summer schools, etc
  - Offering as MOOC

- Required previous knowledge
  - General analytical chemistry knowledge
Course contents

- **Theoretical** basis as well as **practical** skills
- **Detailed** and **example**-based treatment
  - Modeling (ISO GUM)
  - Within-lab validation (Nordtest)
- Close to **50** short **video lectures**
  - Supplemented by textual explanations and downloadable slides and calculation files
- **Numerous** **tests** and **calculation exercises**
  - Understanding of main concepts
  - Calculation exercises from **real life** situations
  - Feedback is given

sisu.ut.ee/measurement
Uncertainty course completion rates up to now

<table>
<thead>
<tr>
<th>Year</th>
<th>Registered participants</th>
<th>Successfully completed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Overall</td>
</tr>
<tr>
<td>2014</td>
<td>270</td>
<td>52%</td>
</tr>
<tr>
<td>2015</td>
<td>489</td>
<td>34%</td>
</tr>
<tr>
<td>2016</td>
<td>757</td>
<td>40%</td>
</tr>
<tr>
<td>2017</td>
<td>363</td>
<td>41%</td>
</tr>
<tr>
<td>2018</td>
<td>521</td>
<td>42%</td>
</tr>
</tbody>
</table>

- The uncertainty course will again be offered in spring 2018
MOOCs vs „traditional“ teaching

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Conventional university course</th>
<th>Practitioner training (short) course</th>
<th>MOOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction between students and teachers</td>
<td>Direct</td>
<td>Direct</td>
<td>Remote</td>
</tr>
<tr>
<td>Possibility to deliver the course</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Possibility to deliver the course simultaneously to many participants</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Level of self-discipline needed from</td>
<td>Average</td>
<td>Average</td>
<td>High</td>
</tr>
<tr>
<td>participants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time constraints, time to “digest” the</td>
<td>Not a problem</td>
<td>Serious time constraints</td>
<td>Not a</td>
</tr>
<tr>
<td>knowledge</td>
<td></td>
<td></td>
<td>problem</td>
</tr>
<tr>
<td>Possibility of independent homework</td>
<td>Possible</td>
<td>Usually impossible</td>
<td>Possible</td>
</tr>
<tr>
<td>Possibility of hands-on problem-solving</td>
<td>Possible</td>
<td>Possible (within the time constraints)</td>
<td>Possible</td>
</tr>
<tr>
<td>Possibility of teamwork</td>
<td>Possible</td>
<td>Possible (within the time constraints)</td>
<td>Not easy</td>
</tr>
<tr>
<td>Possibility of experimental work</td>
<td>Easy</td>
<td>Possible, but not easy</td>
<td>Not</td>
</tr>
<tr>
<td>Possibility of experimental work</td>
<td>Easy</td>
<td>Possible, but not easy</td>
<td>Not</td>
</tr>
<tr>
<td>Possibility of working with participants</td>
<td>Difficult but doable</td>
<td>Difficult</td>
<td>Possible</td>
</tr>
<tr>
<td>of uneven level or preparation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possibilities of meaningful assessment of</td>
<td>Wide possibilities</td>
<td>Difficult</td>
<td>Possible</td>
</tr>
<tr>
<td>obtained knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danger of cheating during knowledge assessment</td>
<td>Can be made low</td>
<td>Can be made low</td>
<td>Can be</td>
</tr>
<tr>
<td>assessment</td>
<td></td>
<td></td>
<td>high</td>
</tr>
<tr>
<td>Costs of setting up the course</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Costs of running the course</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Travel and accommodation costs</td>
<td>Can be high</td>
<td>Can be high</td>
<td>None</td>
</tr>
</tbody>
</table>

I. Leito, I. Helm, L. Jalukse
Anal Bioanal Chem. 2015, 407, 1277–1281
Applied Measurement Science

Master’s Programme

ams.ut.ee

AMS Outline

• Interdisciplinary 3+2 master's degree programme
• Cross-sectorial
  – Physical measurements
  – Chemical measurements (chemical analyses)
  – Metrology
  – Quality systems
  – Economic and legal aspects of measurements
• Tuition in english

The education that students will get is of very broad applicability
Programme structure

**Obligatory Module (45 ECTS)**

**Courses:** Measuring and Instrumentation, Measurement Data Processing, Lab of Physical Measurements, Practical Chemical Analysis Methods, Lab of Chemical Analysis Methods, Fundamentals of Metrology, Metrology in Chemistry, Seminar in Measurement Science, Quality management

**Elective Module (30 ECTS, courses can be chosen from the list)**

**Courses:** Atomic Spectroscopy, Materials Characterization and Testing, Measurements in Biochemistry, Measurements and the Law, Economic Aspects of Measurements, Signal Processing, Chemometrics, Environment and Measurement, Electrochemical Measurement and Analysis Methods, Nanometrology, Quality Systems etc

**Optional Subjects**

(6 ECTS, any courses can be chosen university-wide)

**Practical speciality training**

(9 ECTS, internship placement in industry or analysis or calibration laboratories)

**Master’s thesis**

(30 ECTS, reasearch project with a topic related to measurement science)

26.10.2018

www.ut.ee/ams

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**Measurement Science in Chemistry**

- International consortium
- 9 countries
  - Estonia, Slovenia, Bulgaria, France, Portugal, Poland, Finland, Belgium, Ireland
- 11 universities
- 9 Summer schools during 2008-2016

26.10.2018

www.msc-euromaster.eu
Excellence in Analytical Chemistry
Erasmus Mundus

• Four European universities excelling in different fields:
  - Fundamentals of analytical chemistry, metrology in chemistry, quality assurance, socio-economic aspects
  - Organic and bioorganic analysis, advanced separation methods, mass spectrometry
  - Industrial analysis, process control and monitoring
  - Advanced analytical devices, sensors, miniaturization, electrochemistry
Excellence in Analytical Chemistry

- Full-fledged contemporary analytical master degree programme (120 ECTS)
- Tuned to the job market needs
  - Metrology topics
  - Socio-economic aspects
  - Practical placement

EACH Programme structure:

Year 1: Fundamentals + Placement  60 ECTS

University of Tartu
Fundamentals of analytical chemistry, metrology in chemistry, quality assurance, socio-economic aspects

Uppsala University
Organic and bioorganic analysis, advanced separation methods, mass spectrometry

University of Lyon
Industrial analysis, process control and monitoring

Åbo Akademi
Advanced analytical devices, sensors, miniaturization, electrochemistry

Year 2: Specialisation + Master’s thesis  60 ECTS
Validation of targeted and non-targeted methods of analysis

Examples of issues addressed:
- Validation of targeted methods: where are we?
- Validation of non-targeted methods – differences from targeted methods
- Detection of a multitude of (unknown) components in complex samples, criteria for identification
- Managing the huge amounts of complex data from non-targeted methods
- Software solutions for validation
Many thanks to the team!

Course development:

Lauri Jalukse  Irja Helm  Hanno Evard
Anneli Kruve  Koit Herodes  Maarja-Liisa Oldekop  Riin Rebane  Karin Kipper  Anu Teearu

Video, web design, admin:

Enno Kaasik  Triin Marandi  Lehti Pilt  Esta Pilt  Toomas Petersell  Juho Jalviste

26.10.2018

Thank you for your attention!

LC/MS Validation MOOC – third edition:
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Registration is open at:
sisu.ut.ee/lcms_method_validation/

Slides and links:
www.akki.ee

Questions, requests:
ivoleito@ut.ee

26.10.2018