BRIDGING MATH-GAPS WITH THE LEARNING ENVIRONMENT MUMIE

F. Daalderop, J. Daudt, M. Grudzinski, M. Hanke, N. Kurt, A. Rassila, R. Seiler, H. Tiitu

WITH THE SUPPORT OF THE LIFELONG LEARNING PROGRAMME OF THE EUROPEAN UNION
What is MUMIE?

• E-learning platform for math-learning & teaching
• combines theory, demos, visualisations, assignments & feedback in one package
• open but not public source ware for institutes of higher education
• MUMIE courses can be offered to students as
  • regular courses (e.g. blended learning, self-study)
  • bridge courses in preparation to a bachelor or master programme
• MUMIE very appropriate for explorative learning
Experience at the TU Delft

- Pilot in 2009: first year course Linear Algebra for students Aerospace engineering
- Relevant topics of German course were translated and adapted
- Course was offered parallel to regular lectures
- In 2012 an EU LLP proposal was submitted and rewarded to develop bridging courses in the MUMIE environment
value and necessity of bridging courses

- Student mobility for incoming master students from other engineering schools, become more and more important.

- More (international) students with various backgrounds enter master programmes and need bridging courses to (re)master and refresh the necessary knowledge to take advanced master courses.

- Bridging courses are meant to narrow the gap between the knowledge and understanding from students and the demands in the advanced STEM-master courses.

- Using an inclusive e-learning environment makes the bridging course flexible and open to adjustments and extension.

- Teachers can check whether the prerequisite knowledge is present.
Partners in the S3M2 project
(support successful student mobility with MUMIE)

For incoming master students

- TU Delft  Numerical Analysis
- TU Berlin  Probability and Statistics
- KTH Sweden  Matlab/Octave intro course (scientific computing)

For incoming bachelor Engineering students

- Aalto Finland  bridge material Math

- ILC Berlin: company for support
Partners in the OMB+ project
(online mathematics bridge course)

For incoming bachelor students in Germany:
(start: Nov. 3 2014 in German, English version in spring)

• 20+ German Universities under the lead of
  • RWTH Aachen and
  • Technische Universität Braunschweig

• integral-learning GmbH Berlin: company for support
main activities in S3M2

For every course:
• defining subjects and review
• filling the platform with: theory, visualizations and problems

After one year:
• pilot and evaluation with small group of students

Second year:
• extension of subjects etc.
• development diagnostic test
• pilot and evaluation with larger group
Pilot at the Civil Engineering department

- theory non-linear equations & numerical integration
- two exercises for bisection,
- two exercises for fixed point methods
- one exercise for integral approximation.
Some examples in MUMIE
Example 2

To add a point left click while holding the 'c' key.

Two points are at least required to perform the interpolation function(s).

- [ ] Lagrange interpolation
- [ ] Spline interpolation
Example 3

Consider the numerical method:

\[
\begin{align*}
    k_1 &= hf(t_{n}, w_{n}) \\
    k_2 &= hf(t_{n} + \frac{1}{2} h, w_{n} + \frac{1}{2} k_1) \\
    w_{n+1} &= w_{n} + k_2
\end{align*}
\]

a) Is this method implicit or explicit?
- Implicit
- Explicit

b) Determine the amplification factor.
\[
Q(\lambda h) = ? + ? \lambda + ? (\lambda h)^2
\]

c) Consider the differential equation
\[y' = -y + \cos(t)\]
Determine the maximum step size.
\[h \leq ?\]
Results on grades

exam results Numerical Analysis

- Did not participate (134)
- Did participate (100)
### Table Results on Grades 2

<table>
<thead>
<tr>
<th></th>
<th>No MUMIE</th>
<th>Excl. Bonus</th>
<th>Incl. bonus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage passed</td>
<td>67%</td>
<td>86%</td>
<td>90%</td>
</tr>
<tr>
<td>Average exam grade</td>
<td>6.25</td>
<td>7.58</td>
<td>8.02</td>
</tr>
</tbody>
</table>
### Highlights student survey (n=100)

**Civil Engineering students**

<table>
<thead>
<tr>
<th>results</th>
<th>N=100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home work assignments were too easy in MUMIE</td>
<td>70%</td>
</tr>
<tr>
<td>applets in MUMIE helped them understand the course material and motivated them to learn the course</td>
<td>70%</td>
</tr>
<tr>
<td>I recommend other students to use MUMIE for the Numerical Analysis course</td>
<td>68%</td>
</tr>
<tr>
<td>Problems with JAVA</td>
<td>15%</td>
</tr>
</tbody>
</table>
Conclusions student results

• MUMIE benefits the student in getting a higher grade for the exam.

• Students participating in MUMIE are stimulated to frequently spend time studying the material and not wait until last moment.

• Students using MUMIE might have gained extra insight in the mathematical concept from using the interactive visualizations in MUMIE.

• Students who participate in MUMIE are willing to put extra effort in the course in order to pass the exam.
Conclusions developers/teachers

- Use of LaTeX files in MUMIE
- Open/not public software; support has to be paid
- Advantage to have money from LLP to experiment and test this e-learning environment
- To develop visualisations in JAVA is not easy (generic framework makes visualizations accessible to non-programmers)
- Summer course for students to make visualisations very useful
- Especially for bridging courses MUMIE is an interesting e-learning platform where incoming (master) students can refresh and master missing theory and practice
Pilot Scientific Computing with Matlab/Octave

how to
- simulate problems and
- solve numerical problems with Matlab/Octave

- octave is integrated into MUMIE
- homework problems: Matlab code is automatically corrected
Pilot Scientific Computing

Octave output

Your answer:

```matlab
function out = count_char(a, txt)
    out == sum(a == txt);
end
```

Sample solution:

```matlab
function out = count_char(a, txt)
    out = sum(a == txt);
end
```

Octave output

```
error: 'out' undefined near line 2 column 3
error: called from:
error: /srv/webapps/s3m2/WEB-INF/correction/1410714682316-5/count_char.m at line 2, column 7
```

Explanation:
Your code caused a runtime error
Pilot Statistics and Probability

- 9 lectures about the fundamentals of statistics and probability
- many exercises with full solutions (incremental visibility)
- interactive visualizations
Binomial Distribution

Choose: \( p = 0.3 \in [0, 1] \) and \( N = 20 \in \mathbb{N} \)

\[
p_k = \binom{N}{k} p^k (1-p)^{N-k}
\]

<table>
<thead>
<tr>
<th>( k )</th>
<th>( p_k )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7.979227E-4</td>
</tr>
<tr>
<td>1</td>
<td>0.006839337100000005</td>
</tr>
<tr>
<td>2</td>
<td>0.0278458725</td>
</tr>
<tr>
<td>3</td>
<td>0.0716036722</td>
</tr>
<tr>
<td>4</td>
<td>0.1304209744</td>
</tr>
<tr>
<td>5</td>
<td>0.17886305060000002</td>
</tr>
</tbody>
</table>
OMB+
(online mathematics bridge course)

- For incoming bachelor students in Germany

- syllabus follows Cosh standard (widely accepted in Germany)
  - numbers & fractions
  - linear and quadratic equations
  - elementary functions
  - differential and integral calculus

- pedagogical concept follows to a large extent the highly successful Swedish online mathematical bridge course by a group of Swedish universities under the lead of KTH.
  - virtual tutorium
  - call center
Example for an interactive visualization with adaptive explanation

2 Circles intersect in 2 points
Eine Möglichkeit besteht darin, \( x^2 + y^2 = (1)^2 \) von
\[
(x-(1))^2 + ((-1)+y)^2 = (\frac{1}{2})^2
\]
zu subtrahieren. Sie erhalten dann
\[
(x-(1))^2 + ((-1)+y)^2 - x^2 - y^2 = (\frac{1}{2})^2 - (1)^2
\]
und durch Ausmultiplizieren sowie Vereinfachen die lineare Gleichung
\[
(1 \cdot x) + (1 \cdot y) = \frac{11}{8}.
\]

Auflösen nach \( x \) ergibt
\[
x = \frac{((1 \cdot y) + \frac{11}{8})}{1} = (-1 \cdot y) + \frac{11}{8}.
\]

Einsetzen von \( x \) in \( x^2 + y^2 = (1)^2 \) führt zu der quadratischen Gleichung
\[
\left((-1 \cdot y) + \frac{11}{8}\right)^2 + y^2 = (1)^2.
\]

Sie hat die beiden Lösungen
\[
y_1 = 0.52 \quad y_2 = 0.85.
\]

Somit erhalten Sie durch Einsetzen von \( y_1 \) bzw. \( y_2 \) in \( (1 \cdot x) + (1 \cdot y) = \frac{11}{8} \)
\[
x_1 = 0.85 \quad x_2 = 0.52.
\]

Daraus ergeben sich die beiden Schnittpunkte
\[
S_1 = < 0.85, 0.52 > \quad \text{und} \quad S_2 = < 0.52, 0.85 >.
\]

(Lösungen mit mehr als zwei Nachkommastellen werden auf zwei Stellen gerundet.)
Example of interactive visualization with adaptive explanation

2 Circles do not intersect

\[ K_1 := \left\{ (x, y) \in \mathbb{R}^2 \mid x^2 + y^2 = (1)^2 \right\} \]

and a second circle \( K_2 \) with center \( \left( \frac{1}{2}, \frac{1}{4} \right) \) and radius \( r_2 = \frac{1}{2} > 0 \)

\[ K_2 := \left\{ (x, y) \in \mathbb{R}^2 \mid (x - \left( \frac{1}{4} \right))^2 + (y - \left( \frac{1}{4} \right))^2 = \left( \frac{1}{2} \right)^2 \right\} \]

Determine their intersection points (if they exist).
Eine Möglichkeit besteht darin, \( x^2 + y^2 = \left( 1 \right)^2 \) von
\[
(x - \left( \frac{1}{4} \right))^2 + \left( \left( \frac{1}{4} \right) + y \right)^2 = \left( \frac{1}{2} \right)^2
\]
zu subtrahieren. Sie erhalten dann
\[
(x - \left( \frac{1}{4} \right))^2 + (-14+y)^2 - x^2 - y^2 = \left( \frac{1}{2} \right)^2 - (1)^2
\]
und durch Ausmultiplizieren sowie Vereinfachen die lineare Gleichung
\[
(14*x) + (14*y) = \frac{7}{16}.
\]

Auflösen nach \( x \) ergibt
\[
x = \frac{\left( \frac{1}{4} \cdot 16 \right) + \left( \frac{7}{16} \right)}{14} = -1 \cdot y + \frac{7}{4}
\]

Einsetzen von \( x \) in \( x^2 + y^2 = (1)^2 \) führt auf die quadratische Gleichung
\[
\left( -1 \cdot y + \left( \frac{7}{4} \right) \right)^2 + y^2 = (1)^2.
\]
Diese Gleichung hat keine reelle Lösung, d.h. es gibt keine Schnittpunkte.

Geometrisch: der Abstand der Mittelpunkte ist kleiner als der Unterschied der Radien:
\[
\text{Abstand} \quad \sqrt{\left( \frac{1}{4} \right)^2 + \left( \frac{1}{4} \right)^2} < \left| 1 - \frac{1}{2} \right|.
\]
Wish to try the bridging courses?

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Interested in S3M2 courses? Go to:
http://www.s3m2.eu/

Interested in OMB+ ? Go to:
http://www.ombplus.de (starting Nov. 3 2014)

Really interested contact:
http://www.integral-learning.de/ to discuss the possibilities

THANK YOU!