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# Mathematicians' views on CAS use in teaching

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## Outline

- Rationale for the study
- Research questions
- Research design and data collection
- Outline of results from Phase-I
- Data collection in Phase-II
- Some results from Phase-II



## The slow integration of technology

- Explosion of technology use in schools was predicted in the 1980s (Steen, 1998; Kaput, 1992)
- At the school level the predicted explosion has not taken place (Cuban, Kilpatrick, & Peck, 2001; Ruthven & Hennessy, 2002)
- Several studies attempted to find the reasons behind the slow integration of technology (Becker et. al, 2001; Ruthven & Hennessy, 2002)



## Importance of teachers' conceptions

Technology integration is greatly influenced by

- access to technology
- teachers' conceptions, beliefs, attitudes, and motivations (of mathematics, mathematics teaching, and technology)
- and social and cultural factors



## University-level research

- Little attention paid on university-level mathematics – mathematicians' beliefs
  - University mathematics teaching considered (non-) problematic
  - Mathematicians are not interested in pedagogical issues
  - Mathematics do not value/respect educational research

**But**

- There are considerable problems
  - Increased student enrollment
  - Declining student preparedness
  - Problems with STEM subjects
  - Emergence of new technologies
- Mathematicians is an important group and can highlight important issues for teachers



## Computer Algebra Systems

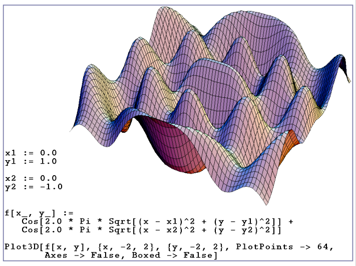
Mathematical software that performs

- Visual
- Computational
- Symbolic

operations.

CAS may run on computer and hand-held devices.

Examples: Derive, Maple, Mathematica, MuPad, Matlab (included), etc.



## Research questions

- **Extent – current use**
  - To what extent and manner are Computer Algebra Systems currently used in university mathematics departments?
- **Mathematicians' conceptions**
  - What mathematical and pedagogic beliefs and conceptions mathematicians hold with regard to CAS including factors influencing their professional use of CAS? Vision?
- **Influence of teaching traditions**
  - To what extent nationally situated teaching traditions, frequently based on unarticulated assumptions, influence mathematicians' conceptions of and motivation for using CAS?

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## Research design

Mixed-method approach (Johnson & Onwuegbuzie, 2004)

- Phase I. – Qualitative – Grounded Theory approach
  - Semi-structured Interviews (22 mathematicians)
  - Class observations
  - Collection of course materials
- Data collection sites at (8) universities in
  - Hungary
  - United Kingdom
  - United States
- Phase II. – Quantitative – Large-scale survey study
  - Web-based questionnaires has been sent to 4500 mathematicians in Hungary, UK, US
  - Received 25% response rate

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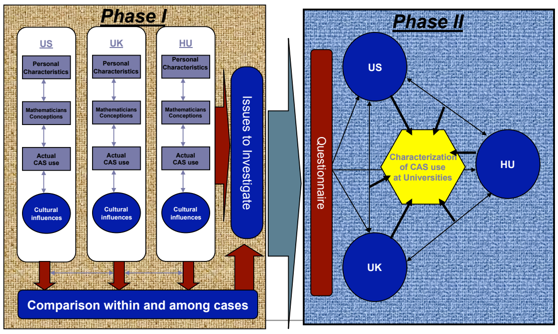
## Research design

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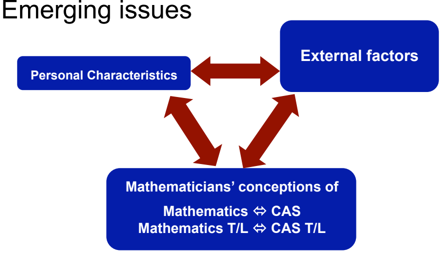
## Results: Phase-I

- Emerging issues

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## Development of the questionnaire

- Incorporate findings from Phase I
- Relate concepts to literature
- Mathematicians' conceptions
  - Decide what aspects of conceptions to investigate
  - Consider equivalences among cultures (Osborn, 2004)

Response rate worries

- Keep the questionnaire relatively short
- Develop closed questionnaire items
  - Difficult to obtain responses for open items
- Obtain adequate information from closed items

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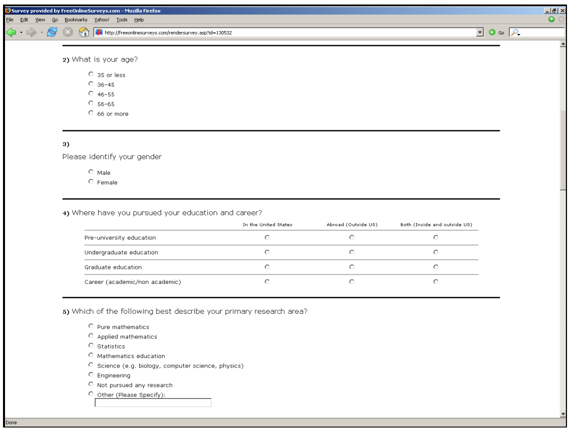

## Questionnaire structure

- Personal characteristics
- Mathematicians' views on the role of CAS in mathematics literacy
- Mathematicians' views on CAS-assisted teaching and learning
- Mathematicians' views on factors hindering CAS integration into teaching learning of mathematics
- Actual use of CAS in mathematics teaching
  - (30 questions, several (8-12) sub-questions)
  - 10-12 minute completion time

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## Received data

**Sent out**
- 4500 questionnaires
- One set of reminder – e-mails

**Received**
- 1103 filled questionnaires
- US (20%), 347 UK (25.2%), and 235 (46.35%)
- Participant characteristics were comparable with the population
- Around 600 e-mails
- 150 pages written responses
- Very positive feedback

**Follow up**
- Thank you notes - research reports
- 297 volunteers for future studies
- Mathematicians are open to collaboration and to teaching issues

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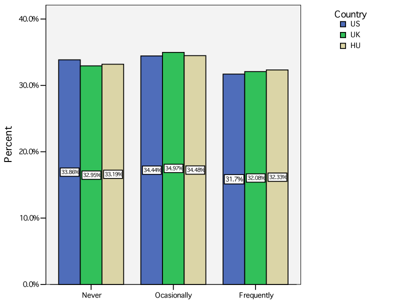
## Findings – Phase II

**CAS in Research**

**67% of all responders use CAS in research**

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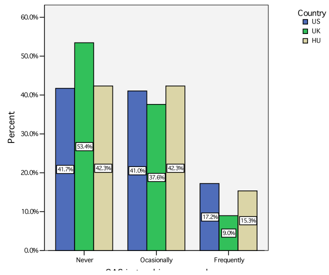
## Findings – Phase II

**CAS in Teaching**

**55% of all responders use CAS in teaching**

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## Findings – Phase II

**Purpose of CAS use**
- Visualization/projection of images
- Experimentation/exploration/discovery
- Realistic/complex/real-world problems
- Homework assignment preparation
- Check solutions
- Assessment (most controversial)
- Group work
- Motivation

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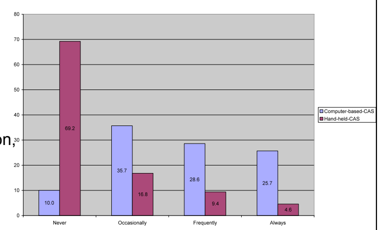
## Platform of CAS use

Computer based CAS use

Some calculator use

Power, visualization, mobility




"Eventually students will have their own laptop computers with CAS." [469, 12, US]

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# Findings – Phase II

### CAS in Mathematics Literacy by country

| Mathematicians' views on the role of CAS in mathematics literacy | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q | Statement | All | | | US | | | UK | | | HU | | | UK-US | UK-HU | HU-US |
| | | N | Mean | SD | N | Mean | SD | N | Mean | SD | N | Mean | SD | | | |
| **CAS part of the curriculum** | | | | | | | | | | | | | | | | |
| Q10h (+) | Science and engineering graduates should have a working knowledge of CAS | 992 | 3.91 | 0.86 | 470 | 3.96 | 0.85 | 315 | 3.79 | 0.78 | 203 | 3.94 | 0.98 | -0.17 | -0.15 | -0.02 |
| Q10a (+) | Knowing how to use CAS is an essential skill for mathematics graduates | 1003 | 3.66 | 1.09 | 475 | 3.61 | 1.14 | 320 | 3.60 | 1.05 | 204 | 3.84 | 1.02 | -0.01 | -0.24 | 0.23 |
| Q10b (+) | Knowing how to use CAS is beneficial for students' science and engineering courses | 1001 | **4.15** | 0.75 | 474 | **4.14** | 0.77 | 317 | **4.03** | 0.71 | 206 | **4.37** | 0.73 | -0.11 | **-0.34** | 0.23 |
| Q10g (+) | Knowing how to use CAS enhances students' future employment prospects | 997 | 3.72 | 0.81 | 471 | 3.79 | 0.83 | 320 | 3.54 | 0.75 | 202 | 3.83 | 0.85 | -0.25 | -0.29 | 0.04 |
| **CAS changes research** | | | | | | | | | | | | | | | | |
| Q10e (+) | CAS is changing the way in which mathematics research is being done | 1002 | 3.60 | 0.95 | 475 | 3.64 | 0.97 | 319 | 3.56 | 0.95 | 204 | 3.58 | 0.93 | -0.08 | -0.01 | -0.06 |
| Q10c (+) | CAS enables mathematicians to work on problems more efficiently | 1001 | 3.91 | 0.87 | 475 | 3.89 | 0.89 | 317 | 3.87 | 0.85 | 205 | 4.00 | 0.87 | -0.02 | -0.14 | 0.12 |
| **CAS changes the curriculum** | | | | | | | | | | | | | | | | |
| Q10d (-) | CAS use does not affect the mathematics that has to be learned by students in universities | 997 | **2.85 (3.15)** | 1.08 | 472 | **2.90 (3.10)** | 1.09 | 318 | **3.12 (2.88)** | 1.01 | 203 | **2.35 (3.65)** | 0.95 | 0.22 | **0.77** | **-0.55** |
| Q10f (+) | CAS use offers the possibility of introducing new topics into undergraduate mathematics | 1001 | 3.71 | 0.88 | 475 | 3.80 | 0.90 | 320 | 3.54 | 0.87 | 202 | 3.76 | 0.81 | -0.26 | -0.22 | -0.04 |
| | **Total Mean** | 999 | **3.73** | 0.91 | 473 | **3.74** | 0.93 | 318 | **3.60** | 0.87 | 203 | **3.87** | 0.89 | | | |
| | Total SD | 3.65 | 0.29 | 0.12 | 2.7 | 0.31 | 0.13 | 1.8 | 0.36 | 0.12 | 1.4 | 0.24 | 0.10 | | | |

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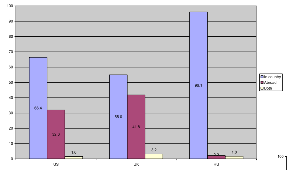
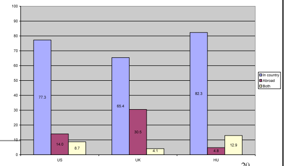
# Influence of education




School level Education




Postgraduate Education

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# Findings – Phase II

### CAS in Mathematics Literacy by users and non-users of CAS

| Mathematicians' views on the role of CAS in mathematics literacy | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Q | Statement | Non-Users | | | Users | | | Non Users - Users |
| | | N | Mean | | N | Mean | SD | |
| **CAS part of the curriculum** | | | | | | | | |
| Q10h (+) | Science and engineering graduates should have a working knowledge of CAS | 401 | 3.61 | 0.89 | 498 | **4.17** | 0.76 | **0.56** |
| Q10a (+) | Knowing how to use CAS is an essential skill for mathematics graduates | 405 | 3.22 | 1.08 | 502 | **4.06** | 0.94 | **0.84** |
| Q10b (+) | Knowing how to use CAS is beneficial for students' science and engineering courses | 403 | 3.84 | 0.78 | 501 | **4.44** | 0.61 | **0.60** |
| Q10g (+) | Knowing how to use CAS enhances students' future employment prospects | 404 | 3.50 | 0.8 | 499 | 3.91 | 0.79 | **0.41** |
| **CAS changes research** | | | | | | | | |
| Q10e (+) | CAS is changing the way in which mathematics research is being done | 406 | 3.35 | 0.99 | 502 | 3.83 | 0.87 | **0.48** |
| Q10c (+) | CAS enables mathematicians to work on problems more efficiently | 404 | 3.62 | 0.88 | 502 | **4.18** | 0.76 | **0.56** |
| **CAS changes the curriculum** | | | | | | | | |
| Q10d (-) | CAS use does not affect the mathematics that has to be learned by students in universities | 401 | 3.04 (2.96) | 1.02 | 501 | 2.71 (3.29) | 1.11 | **0.34** |
| Q10f (+) | CAS use offers the possibility of introducing new topics into undergraduate mathematics | 405 | 3.43 | 0.9 | 501 | 3.95 | 0.8 | **0.52** |
| | **Total Mean** | 404 | **3.44** | 0.92 | 501 | **3.98** | 0.83 | **0.54** |
| | Total SD | 1.85 | 0.27 | 0.11 | 1.49 | 0.34 | 0.15 | 0.15 |

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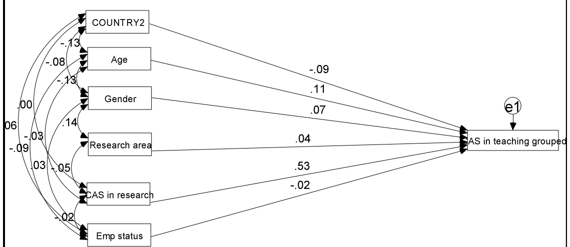
# Findings – Phase II

### SEM Models - Observed variables' effect on CAS in teaching




**CFI**=0.977, RMSEA=0.045

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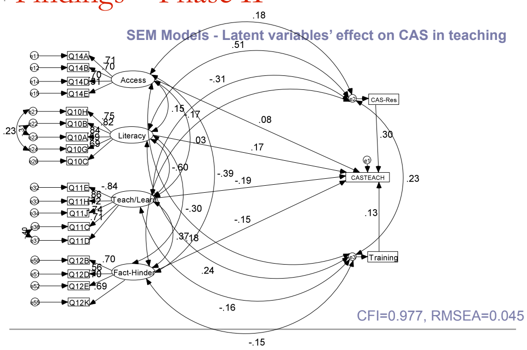
# Findings – Phase II

### SEM Models - Latent variables' effect on CAS in teaching




CFI=0.977, RMSEA=0.045

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# Findings – Phase II

- Mathematicians use technology for teaching more extensively than (at least as much as) school teachers
- Overall mathematicians positively view the role of technology in the mathematics curriculum and literacy
- Most CAS use takes place in science and engineering courses
- Numerous mathematicians are open to enhance their teaching practices with technology and experiment with innovations in mathematics teaching

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## Findings – Phase II

- Mathematicians have a vast knowledge in using mathematical software and they have already developed astonishing innovations which can be also utilized elsewhere
- Educational researchers should pay more attention to the technology-related teaching practices of mathematicians to better understand and enhance innovations in mathematics teaching at all levels
- Working/collaborating with mathematicians would be beneficial in improving our knowledge in educational technology
- Educational researchers could also contribute to the work of mathematicians

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## Findings – Phase II

- However, departments and policies should value the time contributed/required to curriculum development and research on teaching/innovations
- Universities and departments should offer support for technology integration
- Mathematicians and mathematics educators should be open to collaboration and learn from each other
- Mathematicians together with teachers should be more involved in developing successful integration of technology into mathematics education

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## Future research plans

- Analyse the data with more advanced statistics techniques
- Work together with mathematicians to examine and develop CAS-assisted teaching practices
- Identify mathematicians and institutions for research projects
- Close examination of curricula/practices of particular departments (successful, transition, no-CAS)
- Develop a diagnostic instrument for enhancing technology integration for departments
- Focus on transition issues (secondary to university)
- There is an interest to repeat this study in **Canada**, South Africa, Australia

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**Thank you!**

**Questions? Comments?**

**Project website:**

**http://cus.cam.ac.uk/~zl221/CAS.htm**

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