

Triggering University Students' Mathematical  
Creativity and Intellectual independence by Use of  
Technology : *une implémentation à Brock University*

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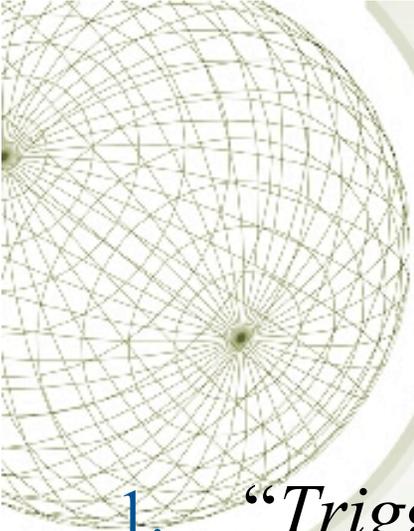
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# Outline

1. *“Triggering students’ mathematical creativity and intellectual independence by use of technology”?*
2. **MICA** program: ***M**athematics **I**ntegrated with **C**omputers and **A**pplications*
3. **MICA** student projects
4. **MICA** courses sustainability challenge: synchronization
5. Discussion: Student Experience in **MICA**



*Mathematics Integrated with  
Computers and Applications*

*since 2001*

## **Two main guiding principles of MICCA:**

- to encourage **creativity** and **intellectual independence**
- to develop mathematical concepts **hand in hand** with **computers and applications**

see **CMS Notes, October 2007**

# *Technology in Brock Mathematics*

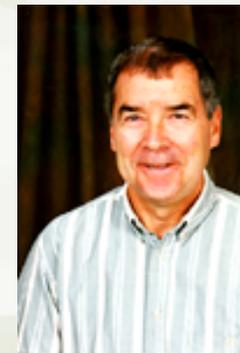
## *Curriculum (2008)*

(in the formal description of the courses)

lectures,  
assignments, projects,  
labs, exams

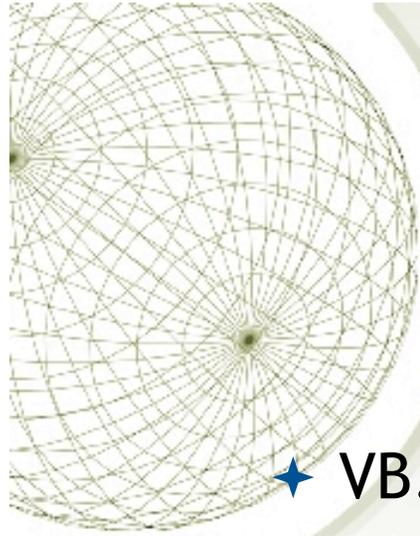
- ★ Calculus I - II - III 1P01 - 1P02 - 2P03
- ★ Linear Algebra I - II 1P12 - 2P12
- ★ Differential Equations I - II 2P08 - 3P08 - 3P09
- ★ (Non)-Euclidean Geometry 2P90
- ★ Statistics & Probability 2P91-2P82  
3P81 - 3P82 - 3P85 - 3P86  
4P81 - 4P82 - 4P84 - 4P85
- ★ MICA I - II - III 1P40 - 2F40 - 3F40
- ★ Calculus I - II - III 1P05 - 1P06 - 1P97 - 2F05
- ★ Applied Statistics I - II 1F92 - 1P98 - 2P98

CAS, SAS, DGS,  
Programming Languages,  
...



Eric Muller

*Service Courses*



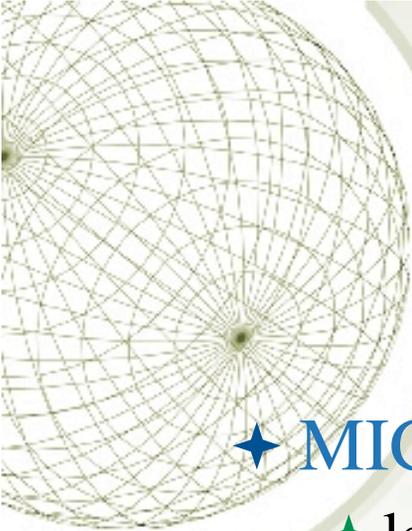
# *Use of Technology in* *(project-based) **MICA** Courses*

- ★ VB.net, Maple, C++
- ★ MICA courses use technology for
  - ★ Visualization
  - ★ Realistic/complex/real-world problems (**modelling**)
  - ★ Experimentation/exploration (**conjecturing**)

“[Use of technology] to illustrate & convince that a theorem is true and to formulate conjectures that could lead to a proof”



Henryk Fuks  
(MICA II Instructor)



# *MICA courses*

*(2h lectures+2h labs)*

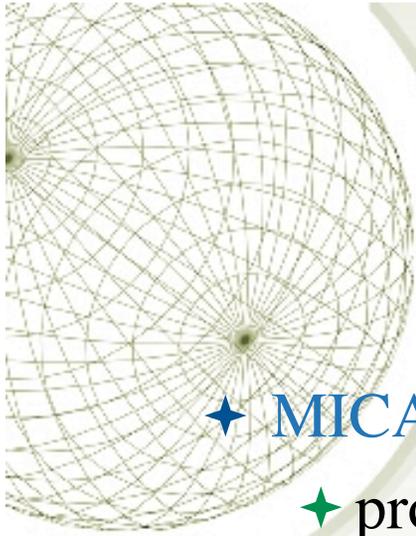
✦ **MICA I** (1/2 credit)

- ✦ lectures: theory (primes, Collatz conjectures, modular arithmetic, RSA-encryption, dynamical systems,...) & conjecturing
- ✦ labs: designing, implementing & using “experimental stations”

✦ **MICA II** (1 credit): **modeling** (dynamical systems, stochastic models, markov chains, empirical models, models based on DE, queuing models, ...)

✦ **MICA III** (1 credit) : investigation of PDEs (heat flow, wave propagation, ...)

**Individual original** final project on a **topic**  
selected by the **students** themselves



# *MICA I Assignment/Lab Projects*

- ★ *MICA I Prime Number Lab (week 3)*
  - ★ programming mathematics
  - ★ assignment - conjecture about prime numbers
- ★ *MICA I RSA-Encryption Assignment (week 6)*
  - ★ programming mathematics
  - ★ dealing with very large numbers
- ★ *MICA I Dynamical System Lab/Assignment (weeks 9-10)*
  - ★ graphical representation
  - ★ exploration and conjecturing



# *MICA Student Original Projects*

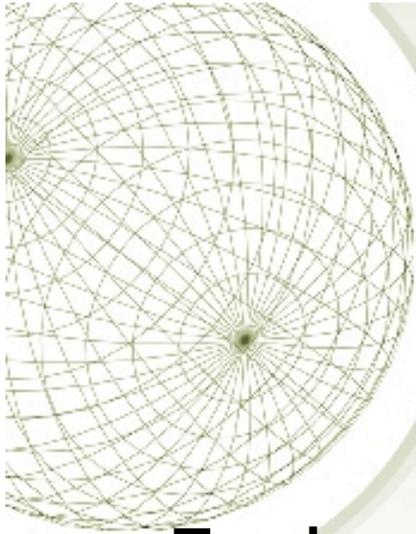
*(“experimental or teaching station” & written report)*

- ★ Exploratory or Applications projects

where students develop a computer environment for the **exploration of a mathematical conjecture** or **simulation of a mathematical application**

- ★ Teaching projects (*Learning Objects*)

where students develop a computer **teaching environment** for the learning of new mathematical concepts



# *Examples of **MICA** Projects*

[www.brocku.ca/mathematics/studentprojects](http://www.brocku.ca/mathematics/studentprojects)

## Exploration or application projects:

- ◆ The Structure of Hailstone Sequences

Colin Phipps, **MICA I**

- ◆ Running in the Rain

Kylie Maheu and Matthew Lillie, **MICA II**

- ◆ Mandelbrot Set

Adam Profetto, **MICA II**

# What is learned?

## *Designing Process*

key component triggering  
students' intellectual independence  
& mathematical creativity

(*exploration or application projects*)

★ Student *individually* selects a  
topic/conjecture/application/problem

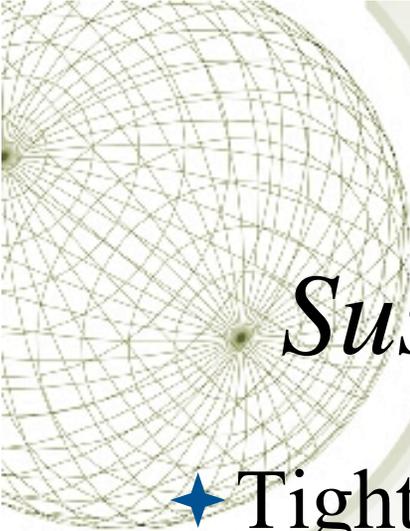
★ researches it

★ designs and implements a computer  
environment (with interface) to simulate or  
explore; and uses it representations

★ communicates results with report and  
computer environment

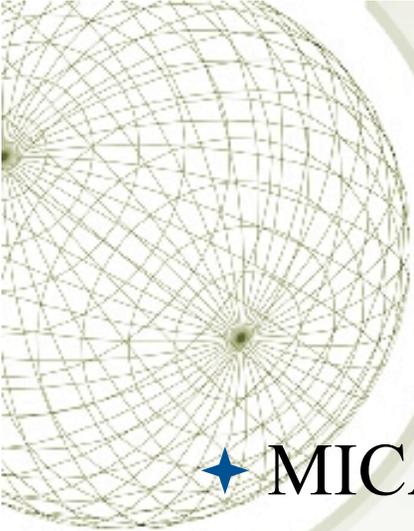
programming mathematics (precision,  
abstraction,  
self assessment)

Muller, Buteau, Ralph, Mgombelo (forthcoming)



## *Challenge of **MICA** Course Sustainability: Synchronization*

- ★ Tight orchestration of integration of technology in MICA program & proactive curriculum committee (**faculty's academic freedom**)
- ★ Exploration in mathematics with technology starting at first term, *Journey through Calculus* in Calculus I course, and continuing with MICA assignments & teaching



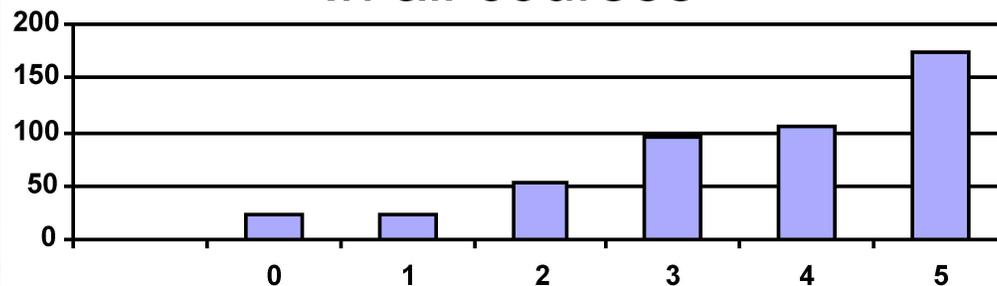
# Challenge of *MICA* Course Sustainability

- ★ MICA courses in the calendar  
(departmental decision)  
*student enrolment tripled since 2001*
- ★ Time investment for faculty (individual guidance & )
- ★ \$\$\$ issue for running MICA labs?  
(Dean's support)
- ★ Good teaching assistants  
(MICA undergraduates)

# *Student Experience - Their Appreciation of Technology*

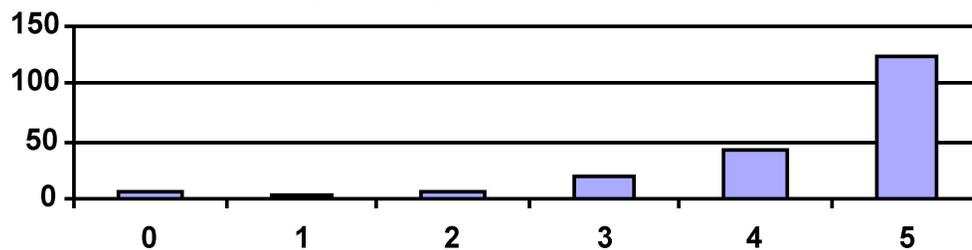
Do you think that the use of computer technology in this course was beneficial?

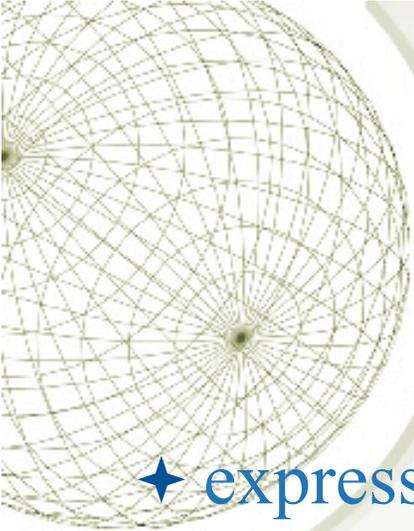
In all courses *(survey winter 2006)*



0 = not beneficial  
5=very beneficial

In MICA courses

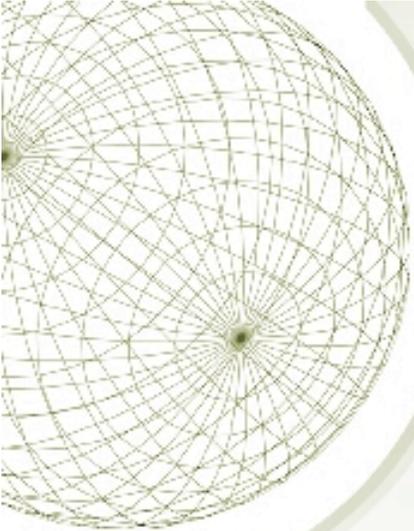




## *Student Experience - Original **MICA** Projects*

- ✦ express their mathematical ideas in an exact way
- ✦ mathematics self-assessment
- ✦ instantiate their creativity in mathematics and in communicating their understanding of mathematics
- ✦ develop their independence in mathematical thinking
- ✦ personalized original mathematics work
- ✦ dedication, pride and ownership
- ✦ to identify with their future profession

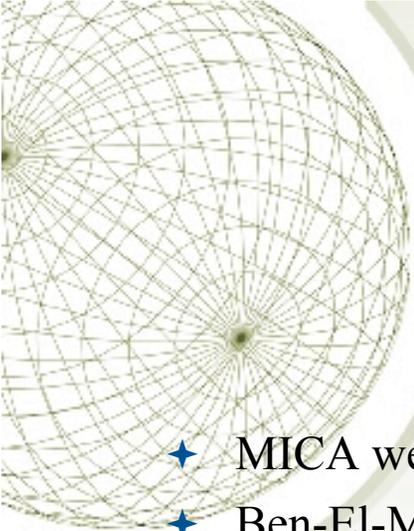
Buteau, Mgombelo, Muller, Ralph (submitted)



## *Student Experience - MICA Courses*

We have found that the approaches, activities, and experiences in the MICA courses are able **to harness the students' motivations** thereby **empowering them** to become their own mediators in the development of their mathematical knowledge and understanding.

*(Buteau & Muller, ICMI Study 17, 2006)*



# References

- ★ MICA website, URL: <http://www.brocku.ca/mathematics/studentprojects>
- ★ Ben-El-Mechaiekh, Buteau & Ralph, (2007) 'MICA: A Novel Direction in Undergraduate Mathematics Teaching', *Canadian Mathematics Society Notes*
- ★ Brock Teaching (2001), URL: [http://www.brocku.ca/ctl/pdf/Brock\\_Teaching\\_1.pdf](http://www.brocku.ca/ctl/pdf/Brock_Teaching_1.pdf)
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- ★ Pead, Ralph & Muller (2007) 'Uses of Technologies in Learning Mathematics through Modeling', *ICMI Study 14 (modeling) Book*
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- ★ Muller et al. (1982) 'Motivating non-mathematics majors through discipline-oriented problems and individualized data for each student', *IJMEST - ICMI Study 1 (technology) Proc.*