COMMUNICATION OF MATHEMATICS

EXAMPLES AND METHODOLOGIES IN EUROPE AND BEYOND

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1. **Mathematics education in Europe – Teaching methods, guidelines and practices – EUROPEAN COMMISSION**

In recent years, the issue of competence in mathematics has become increasingly important and has been taken up at the highest policy level. Mathematical competence has been identified as one of the key competences necessary for personal fulfilment, active citizenship, social inclusion and employability in a knowledge society.

This first Eurydice report on mathematics education aims to contribute to European and national debate on how to improve the teaching and learning of mathematics and provide support to European cooperation in the field.

The report highlights the common challenges facing European countries and the national responses to these challenges. It reviews national policies for raising attainment levels, increasing motivation and overcoming barriers to learning in the light of evidence on what constitutes effective mathematics teaching. In doing so, the report identifies successful practices implemented in different education systems and suggests ways to tackle the issue of low achievement.

Source: European Commission
http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/132EN.pdf

2. **"The Klein-Project" – INTERNATIONAL MATHEMATICAL UNION AND THE INTERNATIONAL COMMISSION ON MATHEMATICAL INSTRUCTION**

In 2008, the International Mathematical Union -IMU- and the International Commission on Mathematical Instruction -ICMI- commissioned a project to revisit the intent of Felix Klein when he wrote *Elementary Mathematics from an Advanced Standpoint* one hundred years earlier.

The aim is to produce a **book for upper secondary teachers that communicates the breadth and vitality of the research discipline of mathematics and connects it to the senior secondary school curriculum**. The 300-page book, prepared in more than 10 languages, will inspire teachers to present to their students a more informed picture of the growing and interconnected field represented by the mathematical sciences in today's world.

The international Design Group for the project met first in Paris in May 2009, and again in Auckland in April, 2010. The project is expected to take about four years.

The book cannot be either comprehensive, nor definitive of the field. The text will emphasise links between branches of the field and generic themes (such as the impact of computing). Insights from mathematics education will not be addressed specifically but will be implicit in many places.

The Design Group seeks input from all those working in the mathematical sciences, researchers and educators alike. We welcome written communications, but will also be holding several "Klein conferences" around the world where feedback on draft ideas and material can be given, and original contributions offered. The actual writing will be done by invited authors of proven experience in expert and inspiring authorship.

Source: Prof Magnus Fontes, Head of Centre for Mathematical Sciences, University of Lund, Sweden
International Mathematical Union
http://www.didaktik.mathematik.uni-wuerzburg.de/projekt/klein/project.html
http://wikis.zum.de/dmuw/index.php?title=The_Klein_Project

3. Theatre, Film and Show techniques for Science Education - GERMANY

In this article, we motivate our interest in theatre, film and show techniques for science education and explain our methods with one specific example taken from the DVD-project "QED – Matter, Light and the Void" (www.sciencemotion.de).

Mathematical formulas are like pieces of music. They need to be performed to come alive.Mathematics is a language which is needed to communicate observations and findings in physical research.

How can we teach pupils at high school the simple and beautiful ideas which stand behind the mathematical model without teaching the complicated technicalities of the mathematical model itself?

We approach the problem how the simple and beautiful concepts underlying quantum electrodynamics (QED) can be explained on three levels:

Level I**:** A puppet animation movie about QED. In five chapters, the concepts behind the theory are introduced without mathematical equations. Here, we use the following methods:

(i) Two puppet characters discuss the question what light is and debate different models to explain their experimental observations.
(ii) Visualization of the models and underlying physical concepts using modern computer graphics.
(iii) Performance of experiments, comparison with the models, and once more: discussion of the results.

Level II: 30 short clips (3-4 minutes each) in which the intuitive concepts introduced in the puppet animation movie are related to mathematical equations.

Level III: Further explanations of the models introduced on the DVD are provided through the internet on the webpage"Cinema and Science", (www.cisci.net). This material enables teachers to use parts of the movie in classroom.
The EU-funded project "Cinema and Science"(CISCI, www.cisci.net) combines two media, the internet and the DVD to raise the interest of young people for science.

In classroom, short sequences (3-4 minutes) of the movies can be presented to introduce a topic and to motivate the scientific analysis. From the DVD "QED – Matter, Light and the Void", more than a dozen short clips can be used in classroom to introduce the physical properties of light.

Source: University of Münster, Germany
http://www.pantaneto.co.uk/issue32/heusler.htm

4. Making Mathematics more Attractive - AUSTRIA

The **Austrian Government** installed a project "Innovations in Mathematics, Science and Technology Teaching". In these projects new technologies should be integrated into math and science course fostering the interdisciplinary working and reasoning. The ministry of education is also planning a platform for math and natural sciences in order to make these subjects more attractive for pupils and to encourage them to study natural sciences.

Source:
http://archives.math.utk.edu/ICTCM/VOL16/S024/paper.pdf

5. Creativity and the Arts in the Primary School - IRERLAND

The arts are an integral part of a complete, successful and high-quality education. Study of the arts enhances young people's intellectual, personal and social development. Develops pupils' abilities to think, reason and understand the world and its cultures.

It offers pupils opportunities to respond, perform, and create in the arts. The arts instil in our pupils the habits of mind that last a lifetime: analytical skills, the ability to solve problems, perseverance and a drive for excellence.

Creative learning is a natural human process that occurs when people become curious and excited. Children prefer to learn in creative ways rather than just memorizing information provided by teachers or parents.

Source: Irish National Teachers' Organisation
http://www.into.ie/ROI/Publications/CreativityArtsinthePS.pdf

6. Teacher-pupil dialogue in mathematics lessons - UK

This paper reports the findings of a systematic review of the literature looking at what characterises effective teacher-initiated teacher-pupil dialogue to promote conceptual understanding in mathematics lessons in Key Stages 2 to 4. The review was based on an in-depth analysis of 15 studies. Eight key characteristics were identified: going beyond IRF (Initiation-Response-Feedback); focusing attention on mathematics rather than performativity; working collaboratively with pupils; transformative listening; scaffolding; enhancing pupils' self-knowledge concerning how to make use of teacher-pupil dialogue as a learning experience; encouraging high quality pupil dialogue; and inclusive teaching.

Source: University of York, Department of Educational Studies
https://www.ncetm.org.uk/public/files/3287630/Chris+Kyriacou.pdf

7. Mathematics at the theater: possibilities instructional use - GREECE

Mathematics in various ways is present in all kinds of literary works (novels, poetry, theater, etc.). Noteworthy is the presence of mathematics in theatrical texts and dramatic dialogues. Whether plays are based on contemporary classical repertoire whether they are written on specially adapted for use in schools, their didactic utilization offers an alternative approach to mathematics.

This approach could help in the development of the dynamic interaction among students, the teacher and the mathematical knowledge taught.

Plays could be used by the school system as a means of familiarizing students with mathematics.

Plays written for didactic purposes based on mathematics are among others:

- *Dialogues on Mathematics,1967, A.Renyi*
- *Life of Galileo, 1937-1939, B.Brecht*
- *Hypathie, 1900, G. Trarieux*
- *The Number Devil, 1997, H.M Enzenserger*
- *The Parrot's Theorem, (1998), D. Guedj*
- *The Man Who Counted, (1938), Malba Tahan*
- *Flatland (1884), E. Abbott.*
- *Alice's Adventures in Wonderland (1865), L.Carrol*

Source: Christos Milionis, Mathematician
http://karydis.ionio.gr/hdml.gr/pdfs/conferences/222.pdf

8. "Teatro y Matemática" Project – URUGAY

The project "Teatro y Matemática" is funded by the ANII (National Agency for Research and Innovation) of Urugay, under the Popularization of Science, Technology and Innovation scheme.

The project is developed by the School of Engineering of the University of the Republic - Urugay.

Students of this course will expand their ways of thinking, their speaking, written and gestural skills and develop their sensitivity and skills for group work. Over approximately fifteen performing arts workshops and a workshop for writing popular science articles, the students will incorporate expressive resources that will help them to communicate scientific concepts related to mathematics, in a seductive and efficient way.

For students of the Faculty of Engineering the course is equivalent to 6 credits in the field of integrating activities.

Source: information provided by Prof Magnus Fontes, Head of Centre for Mathematical Sciences, University of Lund, Sweden
School of Engineering of the University of the Republic – Urugay
Coordinator of the project: **Omar Gil**, omargil@fing.edu.uy
http://www.fing.edu.uy/~omargil/extension/difusion_curso_tm.html
http://teatroymatematica.blogspot.se/2011_04_01_archive.html

9. Communication in a Mathematic Class (Methodology for teachers – examples) - CANADA

Mathematical communication is an essential process for learning mathematics because **through communication, students reflect upon, clarify and expand their ideas and understanding of mathematical relationships and mathematical arguments.**

Through listening, talking and writing about mathematics, students are prompted to organize, re-organize and consolidate their mathematical thinking and understanding, as well as analyze, evaluate and build on the mathematical thinking and strategies of others.

Source: Ontario Ministry of Education
http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/CBS_Communication_Mathematics.pdf

10. The Integration of Mathematics and Music in the Primary School Classroom - AUSTRALIA

(Case study (June 2004)which refers to teachers)
This paper presents the results of a case study that was designed to explore the knowledge, beliefs and practices of primary school teachers who integrate mathematics and music.

A result of the strong connections between mathematics and music is the many activities written to help teachers integrate mathematics and music in the classroom.

According to Shilling (2002), embedding music activities naturally into children's engagements with mathematics and movement provides a way for children to simultaneously develop their logical/mathematical and musical/rhythmic intelligences.

Teaching via an integrated approach is considered to benefit students because concepts and facts are generally presented in context, usually thematically.

The original research focused on the integration of mathematics and music in the classroom through two major components. The first component consisted of interviews with four primary school teachers who described themselves as practitioners of integration involving mathematics and music. Results

from this component revealed that this group of teachers held specific subject knowledge and an explicit set of beliefs about how children learn. For example, each teacher had an extensive background in music as revealed by their abilities to play several instruments, their attainment of formal qualifications in the subject outside of normal schooling and their involvement in public performances via membership of a band or choir.

Only one teacher identified himself as having a strong background in mathematics and this was characterised by the level of mathematics studied in formal schooling and his self-reported level of confidence in the subject rather then extra qualifications gained in the area.

Source: University of Sidney
http://www.merga.net.au/documents/RP822005.pdf

11. The importance of communication in mathematics

What teachers should be aware of when they teach maths - methodologies for making maths more approachable to students.

Pros:
Communication is a crucial part of mathematics:

- It is a way of sharing ideas and clarifying understanding.
- Through communication, ideas become objects of reflection, refinement, discussion, and amendment. The communication process also helps build meaning and permanence for ideas and makes them public.
- When students are challenged to think and reason about mathematics and to communicate the results of their thinking to others orally or in writing, they learn to be clear and convincing. Listening to others' thoughts and explanation about their reasoning gives students the opportunity to develop their own understandings.
- Conversations between peers and teachers will foster deeper understanding of the knowledge of mathematical concepts.
- When children think, respond, discuss, elaborate, write, read, listen, and inquire about mathematical concepts, they reap dual benefits: they communicate to learn mathematics, and they learn to communicate mathematically

The communication in math encompasses both oral and written communication. If students talk about their thinking as they solve problems, the teacher can tailor the lesson to suit the student's way of thinking. "Teachers' knowledge of students' thinking is an important guide in planning effective lessons"

Cons:

- Traditionalist educators are reluctant to accept the method of communications in mathematics. When traditionalists see students engaged and talking with one another, asking questions, thinking about the mathematics and mathematical relationships, they view these behaviors and infer that the basics and other important mathematics are not being taught
- They believe learning takes place when the basics and fundamental mathematical concepts are taught in the classroom.
- They claim students should be engaged in text-book inquires, not inquiring within the teacher and other students. Students do not learn "naturally" by reading, writing, discussing, elaborating, thinking, and inquiring mathematics.
- Teachers believe independent practice rather than cooperation with groups will help students learn the mathematical concepts.
- When asking students questions, most teachers seek one "right" answer to the math problem and will explain why the answer is correct.
- They also argue that math class is a time to learn mathematical concepts and not writing, reading, or discussing.

Why Communication is Important

- Students should have the opportunity to construct their own knowledge when learning about mathematical concepts.
- To view students as thinkers with emerging theories about the world.
- Students should be able to work cooperatively in groups and independently to make the necessary mental constructions about a particular math concept.

Source:
The Importance of Communications in the Mathematics Classrooms
http://www-users.math.umd.edu/~dac/650/huangpaper.html