The consequences of including computer-based mathematics and informatics in the STEM curriculum; results from the CIDREE STEM expert meeting 2016

CIDREE 2018 yearbook congress, Michiel Doorman (Utrecht University) and Jos Tolboom (SLO)

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Goal of our chapter

- To create an international overview of innovations in mathematics education and informatics education, the curricular chances they offer each other mutually and the coherence from the STEM perspective.
- Determine the key conditions to be met in order to design a curriculum in which mathematics and informatics can mutually benefit from each other's perspective, so students can experience their coherence.

Besides that,

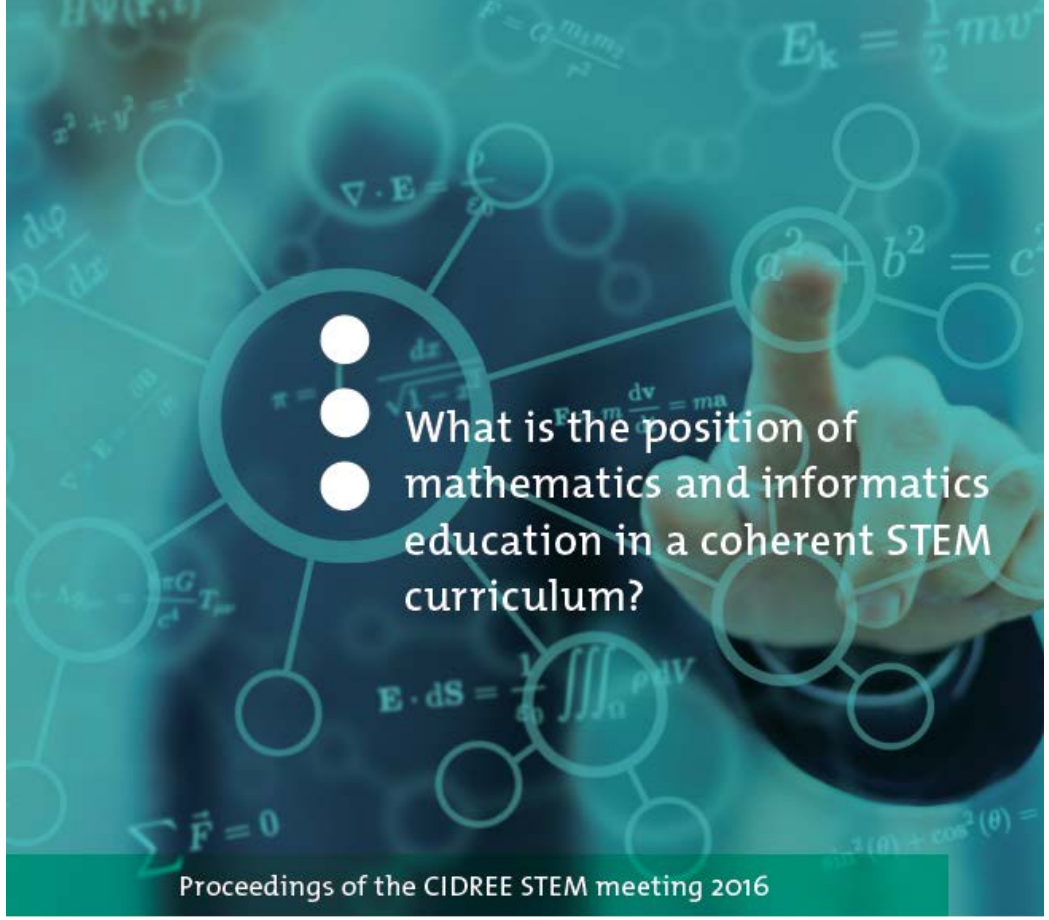
- CIDREE experts on science education were also present, in order to optimize opportunities for coherence.
- At this event, it was not possible for a specialist in informatics education from each country to join us, but this is an objective for following events.

Research questions

What are the influences of mathematics and informatics education on each other in our increasing technology driven society?
Determine the key conditions to be met in order to design a curriculum in which mathematics and informatics can mutually benefit from each other's perspective, so students can experience their coherence.

What are the design principles for a coherent mathematics and informatics curriculum?

Country	Name of presenter(s)	Title of contributions
Belgium, Flanders	Patricia DeGrande, Lotte Milbou	Mathematics and STEM in Flanders
England	Adrian Smith, Alec Titterton	Let's fix maths education
England	Miles Berry, Andrew Csizmadia	The silent C in STEM
Estonia	Ülle Kikas, Terje Hõim	Changing mathematics education in Estonia: Computer-based statistics project
France	Gilles Aldon, Sophie Soury-Lavergne	The new French Curriculum for mathematics and technology
Hungary	Csaba Csapodi	The remaining velocity problem with different solutions : A Case Study
International baccalaureate	Deborah Sutch	Development of a steM course within the IB Diploma Programme
Ireland	Rachel Linney, Anna Walshe	Curriculum reform of applied mathematics in Ireland
The Netherlands	Wouter van Joolingen	Drawing-based modelling to support higher order thinking in mathematics and science (presentation, no paper)
The Netherlands	Nataša Grgurina	Modelling as a New Literacy
Norway	Ellen Marie Bech	Pilot project - Computer programming in lower secondary school
Slovenia	Radovan Krajnc, Mojca Suban	Present status of informatics and its presence/inclusion as an auxiliary tool for learning mathematic in Slovenia
Sweden	Olof Andersson, Helena Karis	Digital competence in Swedish curriculum


What is the position of mathematics and informatics education in a coherent STEM curriculum?
Proceedings of the CIDREE STEM meeting 2016

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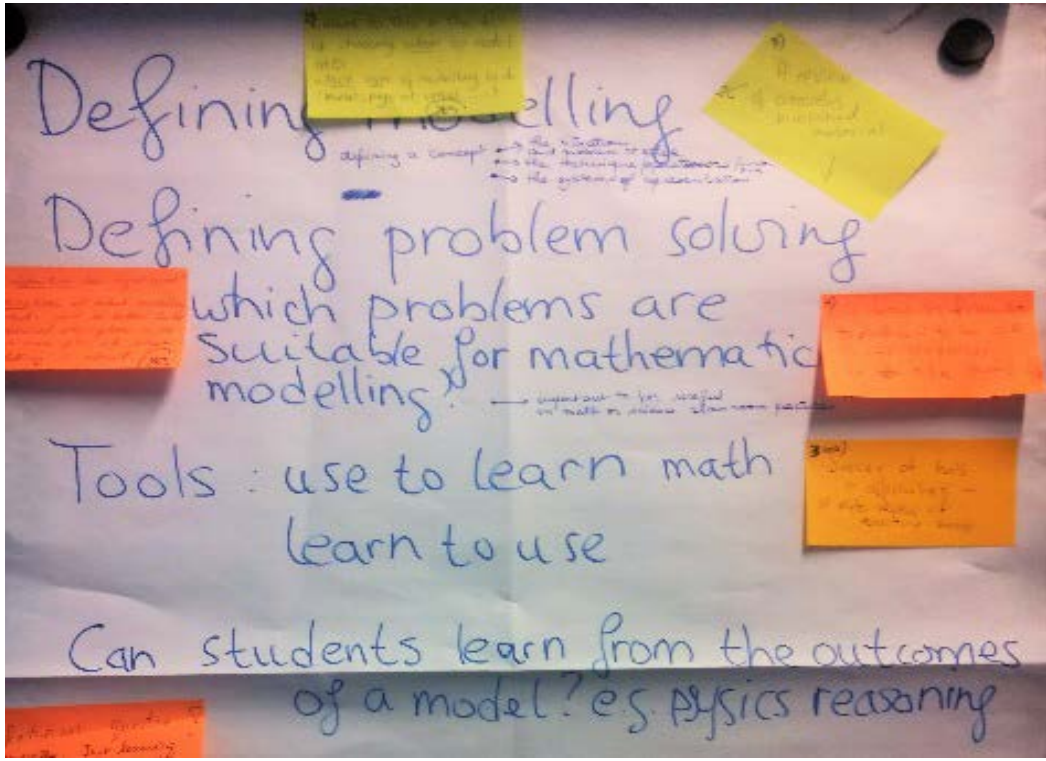
Groups to prepare posters

The participants were placed in five small, heterogeneous (i.e. internationally mixed) groups with the assignment to identify core themes in the body of presentations. Their findings were communicated through a poster. Each group presented their poster the next day.



Poster analysis 1

1. The first poster tried to capture the relationship between modelling, computational thinking and mathematical reasoning. Their drawing attempting to bring these perspectives together in one model.
2. The second poster emphasized the importance of computer science without computers and highlighted the need for a better understanding of what progression looks like in informatics education and to what extent that parallels progression in mathematics education. As an example, they suggested to become more explicit about problem solving techniques in the mathematics curriculum and to connect this with problems in (functional) programming.
3. The third poster addressed modelling, the need for good definitions of modelling and problem-solving competences, and the position of (computer) tools in education. A central question on the poster is: Can students learn (e.g. physical reasoning) from the outcomes of a (computer) model?

Poster analysis 2

4. The fourth poster also highlighted the need for clear definitions and a consensus on terminology and vocabulary (programming, coding, computational skills, informatics, algorithms, problem solving, modelling, simulating, technology, computer science, …). In addition, it asked for a better understanding of didactics of programming in relation with STEM education. Finally, they pleaded for the inclusion of Arts as a creative discipline in the discussion: from STEM towards STEAM.
5. The fifth poster also addressed the need for definitions and a joint platform. Furthermore, this poster added the issue of assessment to the discussion. Can we assess progress in problem solving skills (with technology)? This poster also highlighted another issue of implementation related to the needed professional development of teachers (who, how, learning communities?).

Concluding survey 1

Do you agree that a conclusion of the conference is that **modelling is a key student skill** for success in a coherent STEM curriculum, when informatics (computer science) is included in STEM and mathematics has a substantial computer-based component?
These were the respondents' answers:

Yes	**18**	**94.7%**
No	**1**	**5.3%**

This indicates that respondents significantly ($p = 0{,}00000191 < 0{,}05$) consider modelling to be a key student skill, when informatics is included in STEM, while mathematics has a substantial computer-based component.

Concluding survey 2

Do you agree that a conclusion of the conference is that **computational thinking is a key student skill** for success in a coherent STEM curriculum, when informatics (computer science) is included in STEM and mathematics has a substantial computer-based component?
These were the respondents' answers:

Yes	18	90%
No	2	10%

This indicates that respondents significantly ($p = 0{,}00002003 < 0{,}05$) consider computational thinking to be a key student skill, when informatics is included in STEM, while mathematics has a substantial computer-based component.

Concluding survey

Are you at forehand interested in conducting **a curriculum experiment** in your home country with respect to modelling and computational thinking, in the context of a STEM curriculum, informatics included and mathematics having a substantial computer-based component?
These were the respondents' answers:

Yes	18	90%
No	2	10%

We conclude that member countries are significantly ($p = 0{,}00002003 < 0{,}05$) interested in a curriculum experiment regarding modelling and computational thinking.

Conclusions

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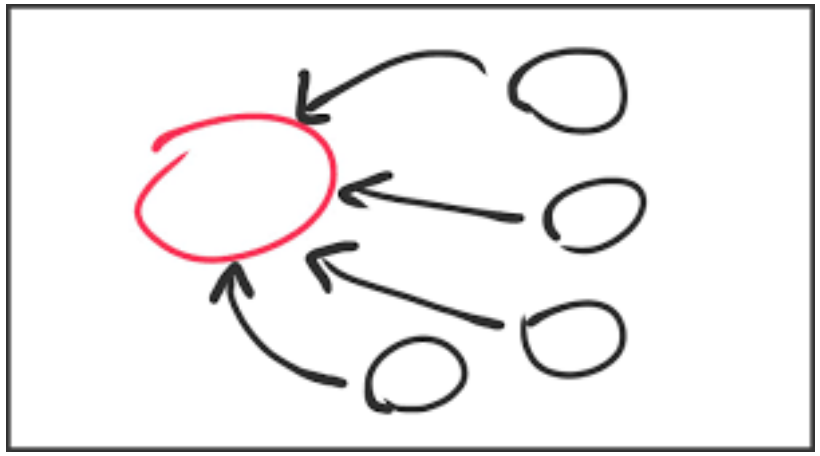
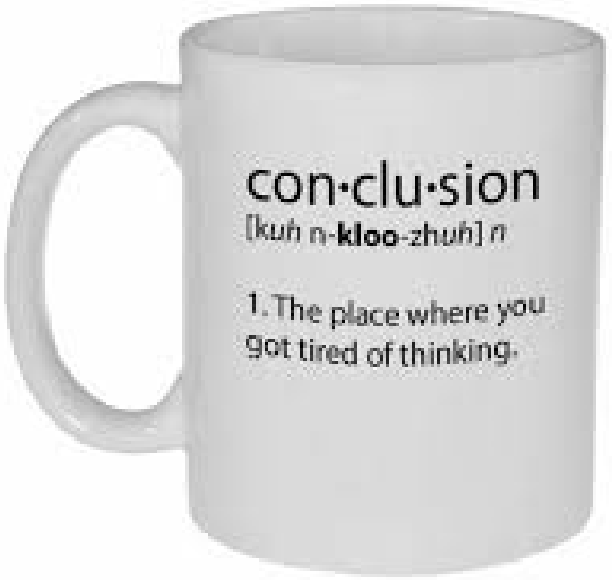
As a result of this two-day expert meeting, we conclude that the attendants consider **both modelling as well as computational thinking to be key student skills** for success in a coherent STEM curriculum, when informatics (computer science) is included in STEM and mathematics has a substantial computer-based component. However, a shared precondition is to create consensus on what we mean by concepts like modelling and computational thinking.



Conclusions

What are the influences of mathematics and informatics education on each other in our increasing technology driven society?

Informatics meets mathematics as both disciplines include modelling, algorithmic thinking and problem solving. In addition, the two disciplines meet when considering the 21st century skills such as creative and critical thinking and the extensive list of digital skills. However, both informatics and mathematics also have an existing right on their own.



Conclusions

What are the design principles for a coherent mathematics and informatics curriculum?
Modelling, computational thinking and the use of simulations seem to be important levers for the mathematics and informatics curriculum. Through the process of modelling, students need to use their knowledge, and can develop and show their understanding of real-world situations. Through simulations, students are invited and motivated to ask 'What if...' questions. Computer simulations enable explorations by offering tools to manipulate system parameters or to alter data and to systematically investigate the consequences of these manipulations.

Questions & discussion!

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To be continued!

This afternoon, November 22nd
From 4:30 - 5:15 PM
In the Lycée Robert-Schuman