



Preparing the teachers for an interdisciplinary curriculum: Modelling courses for secondary education in-service teachers

Claus Michelsen

Center for Science and Mathematics Education

University of Southern Denmark

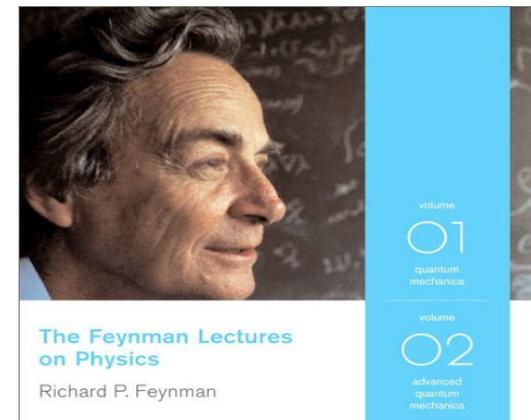
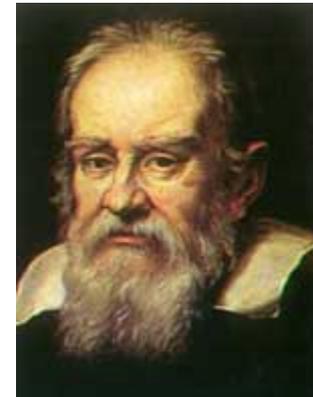
42. Jahrestagung der GDM, Budapest





ScienceMath

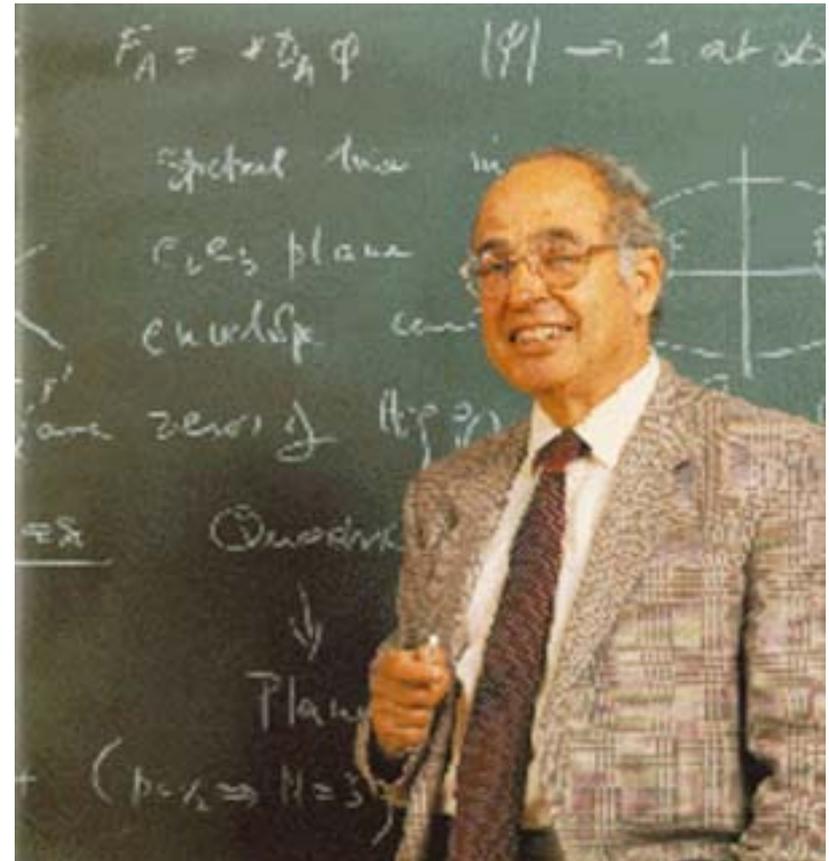
- **Mathematical literacy and cross curricular competencies through interdisciplinarity, mathematising and modelling science.**
- ***Nature is a book written in the language of mathematics. If we cannot understand that language, we will be doomed to wander about as if in a dark labyrinth. Galileo Galilei***
- ***People who wish to analyze nature without using mathematics must settle for a reduced understanding. Richard Feynman***





Michael Atiyah

- For centuries, physics has had a close symbiotic relationship with mathematics, and Witten's forecast is that the 21 century will see this rise to new heights. But what of the future of biology? Many that understanding the brain will be the major challenge of the next century and, while it would be presumptuous of claim that they will solve the problem, it is not unreasonable to think that mathematics may have a useful part to play.





Interdisciplinary curriculum

- **Reform wave in Denmark: Interdisciplinary curriculum in mathematics and science**
- **August 2005 - Reform of Upper Secondary Education (Gymnasium):**
 - Emphasis on an interaction between subjects
 - A short common introductory period for all students before the final choice of a subject package – mathematics and subjects of the natural sciences form a coherent program
- **February 2008 - *Action plan for mathematics and science education* from the Ministry of Education:**
 - Development of a new and innovative content and new forms of instruction at primary and secondary education
 - Common learning goals for mathematics, science and technology
 - Innovation-focused training for teacher students and in-service teachers



Reform: Focus on the teachers

■ Teachers and reforms

- A reform movement is enacted on various levels, and a large variety of agents are involved: teachers, teacher trainers, researchers, administrators, and so on. In the end, however, it will be **the teachers who will have to make the innovation come through**. It will be the teachers who have to establish the reformed practice in their classrooms.

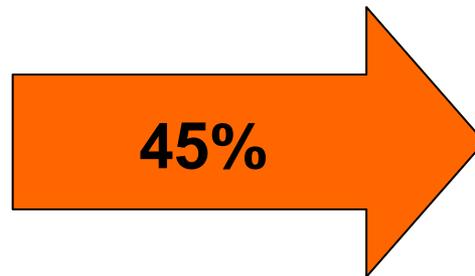
■ Need for

- didactical models for interdisciplinary activities
- in-service teacher training
- prototypes of meaningful interdisciplinary teaching sequences



The Danish Educational System

**Basic School
(Folkeskolen)
Grade 0 – 9/10
Teachers are
educated at
university
colleges**



**High school
(Gymnasium)
Grade 10 – 12
Teachers are
educated at
universities**





Courses for in-service teachers

- **The challenge is to replace the current monodisciplinary approach with an interdisciplinary approach, where mathematics, biology, chemistry, physics and technology are woven continuous together.**
- **The course program for in-service teachers from the Danish lower and upper secondary school at University of Southern Denmark.**
 - A didactical model for interplay between the subjects of mathematics, biology, chemistry, physics and technology
 - Instructional design in teacher education
 - The modelling course (upper secondary education)
 - The science teachers of the future project (lower secondary school)



Theoretical framework

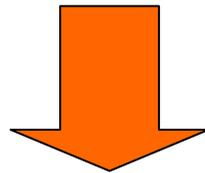
Mathematics education:

Freudenthal: Horizontal mathematization- vertical mathematization.

Gravemeijer: Model of – model for

Confrey: Grounded activity - systematic inquiry

Sfard: Operational - structural



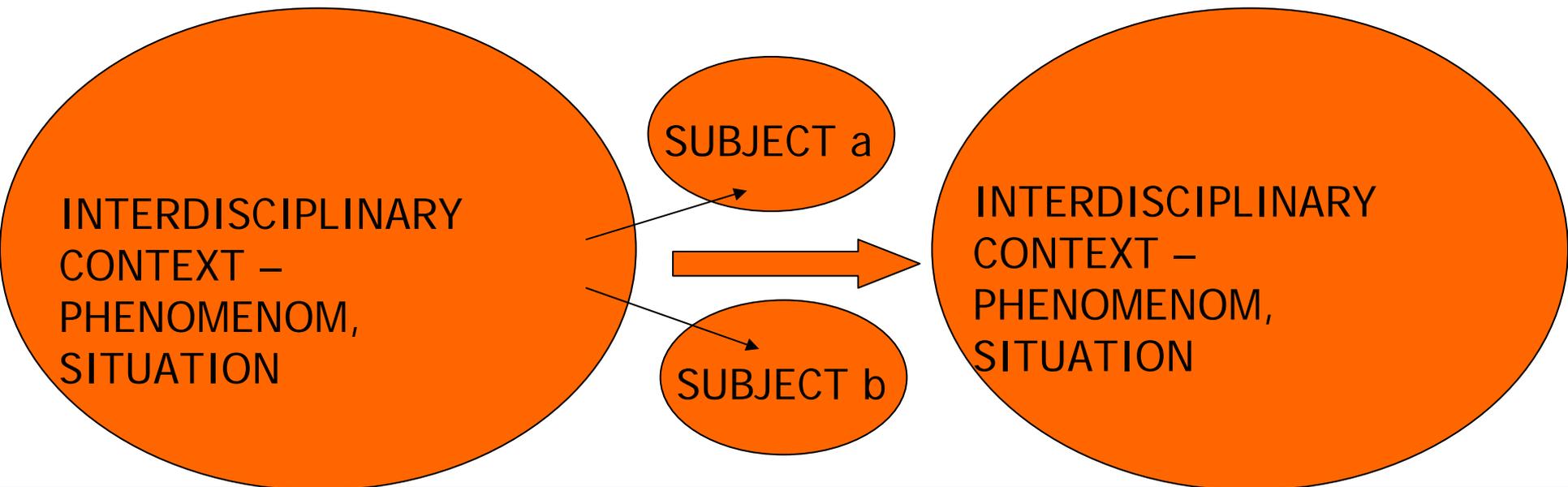
Science and mathematics education

Michelsen: Horizontal linking – structural embedding in subjects



The 2 cycle iterative didactical model

- **Horizontal linking** - the process of modelling across mathematics and subjects of the natural sciences
- **Vertical structuring** – the process of conceptual anchoring in the relevant subjects





Instructional design in teacher education

- **Improvement of teacher-learning process requires teachers' experiences are acknowledged and build upon.**
- **Science education research as a basis for the design and development of warranted practices with which the teachers may experiment in their classroom.**
- **Teachers encounter situations where they get access to knowledge about innovation of mathematics and science teaching and in partnership with researchers use, share and develop this knowledge in design projects.**



The modelling course for in-service teachers

- **Developed and implemented by a team of science and educational researchers from University of Southern Denmark and teachers from upper secondary school**
- **Pilot study funded by the Danish Ministry of Education**
- **Based on the experiences from the pilot study the first version of the course was developed. The course's objectives:**
 - To develop prototypes of interdisciplinary instructional units centred on modelling and including at least two subjects.
 - To encourage the creation of communication between the subjects of biology, chemistry, mathematics and physics.
 - To introduce the teachers to the System Dynamics approach to modelling in an interdisciplinary context.



Course structure

- 1. workshop (3 days) – introduction to the didactical model and System Dynamics modelling, creating interdisciplinary teams
- 1. intervening period (1 month) - design a scenario for an interdisciplinary instructional unit
- 2. workshop, (2-days) - preliminary report and comments from the other teams.
- 2. intervening period (1½ month) - Report and implementation their ideas in the classroom
- Open seminar at University of Southern Denmark - presentation of the interdisciplinary instructional units





The open seminar: Presentation of interdisciplinary projects

Project:

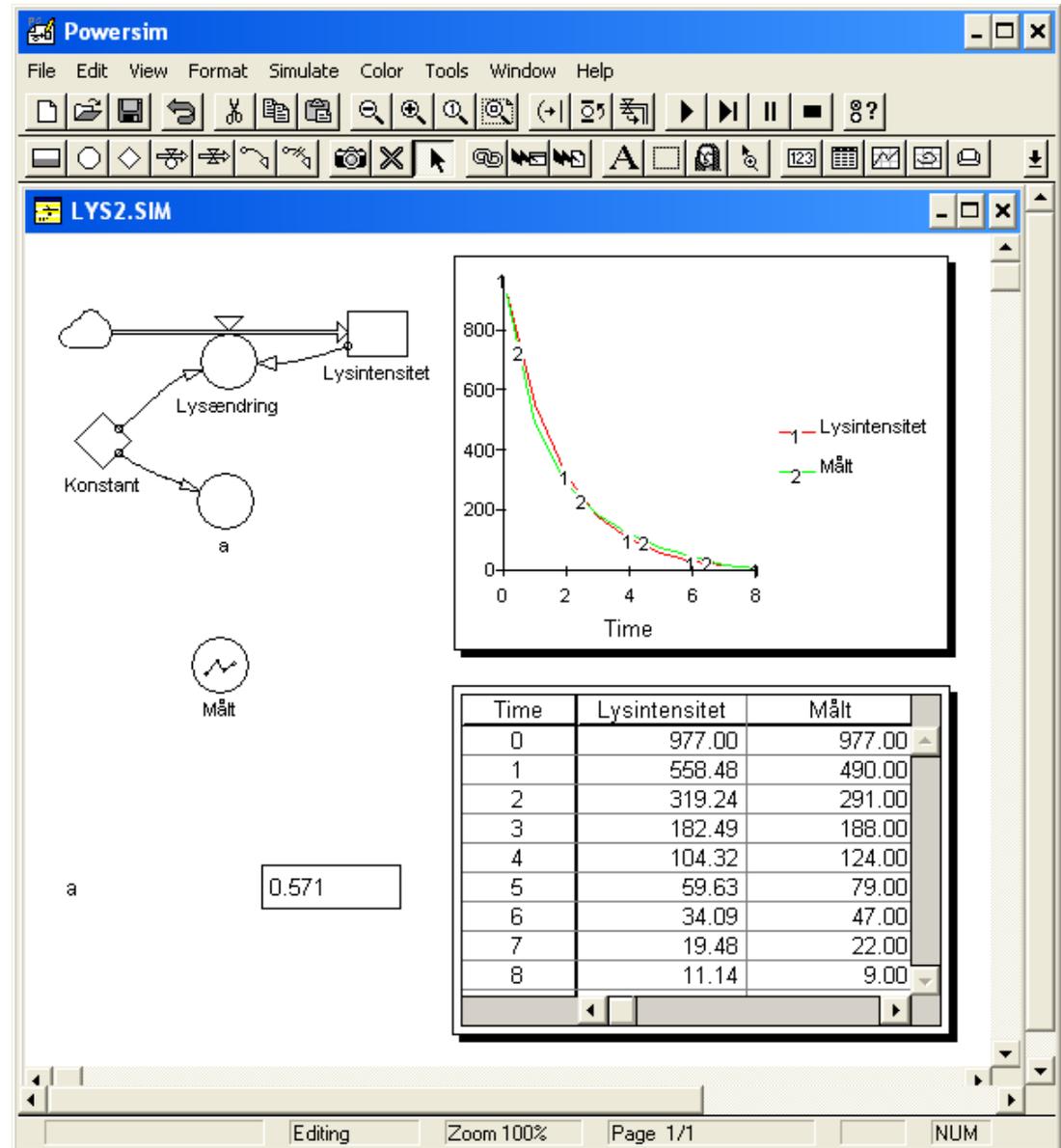
- Mathematical modeling with Powersim
- Models – interplay between reality and simulation
- Data sampling and modeling
- Modelling an inclined throw
- Traffic and kinematics
- Mathematical modeling and enzyme kinematics
- Modelling with dynamic diagrams

Subjects involved:

- Maths and biology
- Maths and physics
- Maths, chemistry and biology
- Maths and physics
- Maths and physics
- Maths, biology and chemistry
- Maths and physics



- The main law survival of the useful law that determines the continuing existence of innovative programs and curriculum materials (Lesh & Sriraman 2005)





Experiences

- **Modelling provides a generic methodology that can serve as a common denominator for learning disciplines, such as physics, biology, chemistry, and mathematics**
- **The System Dynamics approach was according to the teachers a new way to enhance students' understanding of complex systems and formal thinking. But the integration of System Dynamics into teaching is also challenging and time consuming**
- **The workshops and the open seminar made it possible for the teachers to share their ideas and experiences with their colleagues and having contacts with academic experts in the fields of modeling and educational research**





Science Teachers of the Future

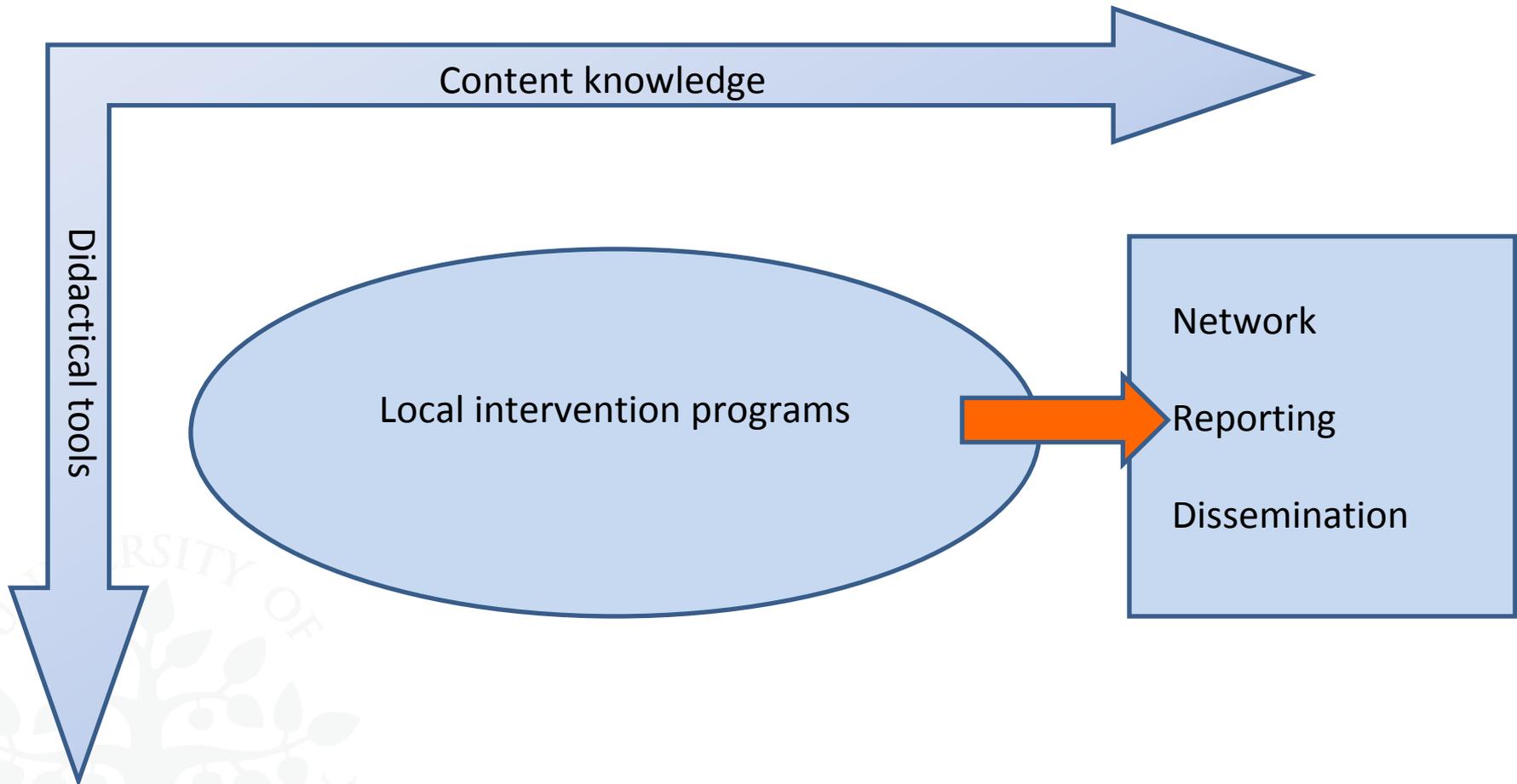
- Applied the European Social Fund in 2005
- Pilot project for developing Master in Science Education for lower secondary in-service mathematics and science teachers
- 24 mathematics and science teachers from lower secondary school started up
- 4 municipalities cooperated
- 2 University Colleges (teacher education) were involved in the development of the project
- Cooperation with the science park Danfoss Universe

Science Teachers of the Future





Educational design and in-service teacher training

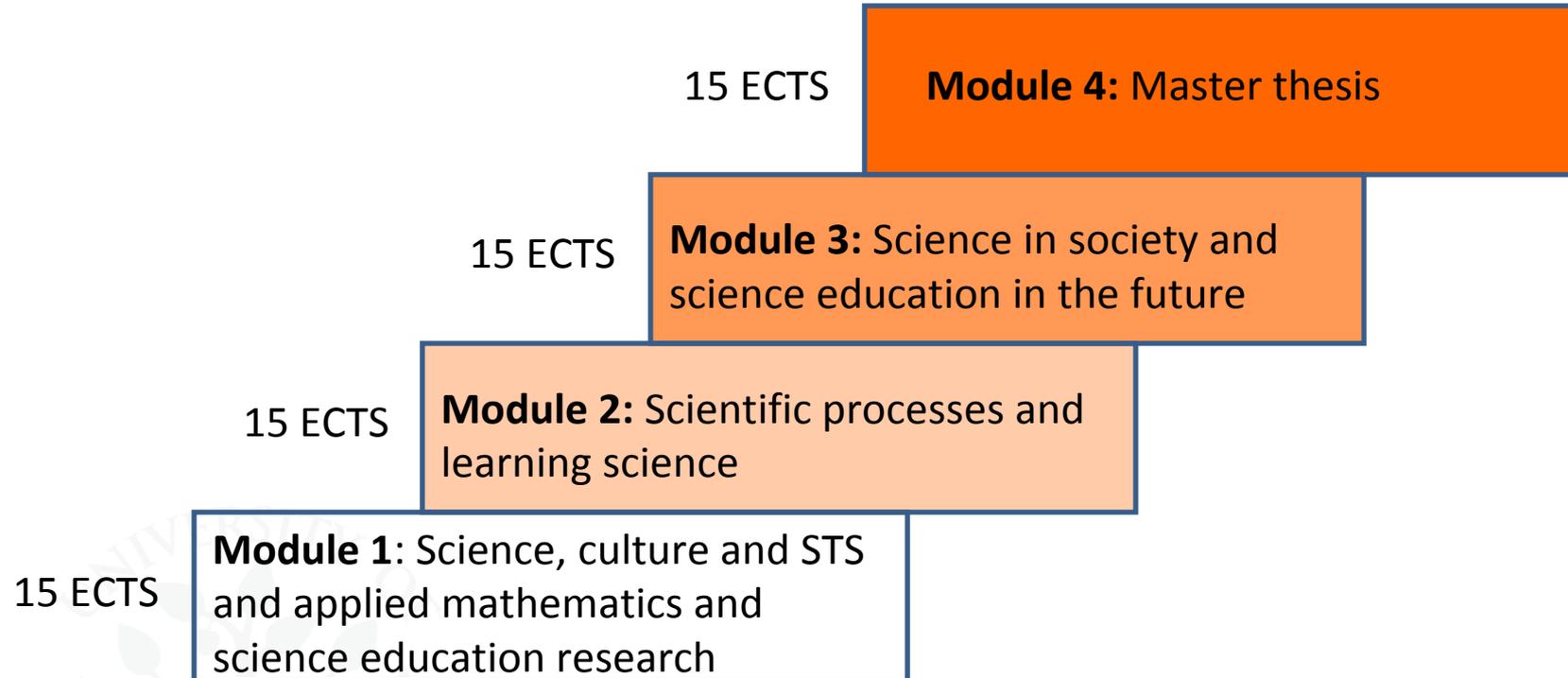


Science Teachers of the Future





Master in Science Education - Structure



Science Teachers of the Future





Response from the teachers

“This is a highly qualifying professional development. If there were one of us on every school it would definitely improve the science education”

Female student at “Science teachers of the future”

“This is the best teaching I have ever received. And the scientists are not from another galaxy like the prejudice says. They are really up on the beat.”

Male student at “Science teachers of the future”

“It has given me a more clear identity as a science teacher. I can now face my colleagues in the teacher’s room with my head held high.”

Female student at “Science teachers of the future”

Science Teachers of the Future





Challenges

- Research on the constraints and possibilities for the integration of mathematics and physics. Studies in real classroom settings
- A more up-to-date interdisciplinary content including technological, health and socio-scientific issues
- Thanks for your attention

