DESIGNING, DEVELOPING AND EVALUATING INTEGRATED STEM ACTIVITIES FOR JUNIOR CYCLE

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Structure of Presentation

- Motivation and Context
- Modelling Science and Mathematics Integration
- Methodology
- Design and Development of the Integrated Activities
- Cycles of Formative Evaluation
- Significant Outcomes
- Theoretical Implications

Integrated STEM: Why?

- Integrated STEM education: Preparing students for complexity of life in 21st Century
- Science & Mathematics: **naturally correlated** in the physical world – **separate as school** subjects (Czerniak 2007)
- Science & Mathematics integration can increase student **conceptual understanding, interest and motivation, and transfer of knowledge**
- 'Project Maths'; Review of Junior and Senior Cycle Sciences, STEM Education Review

Orton and Roper 2000; NCCA 2005; Roehrig et al (2012); Breiner et al (2012).

Aim of Study

To design, develop and evaluate a framework to facilitate science and mathematics integration at second-level in Ireland

The ‘Critical Integrated Skills and Activities’ or CISA Model for integrating STEM subjects

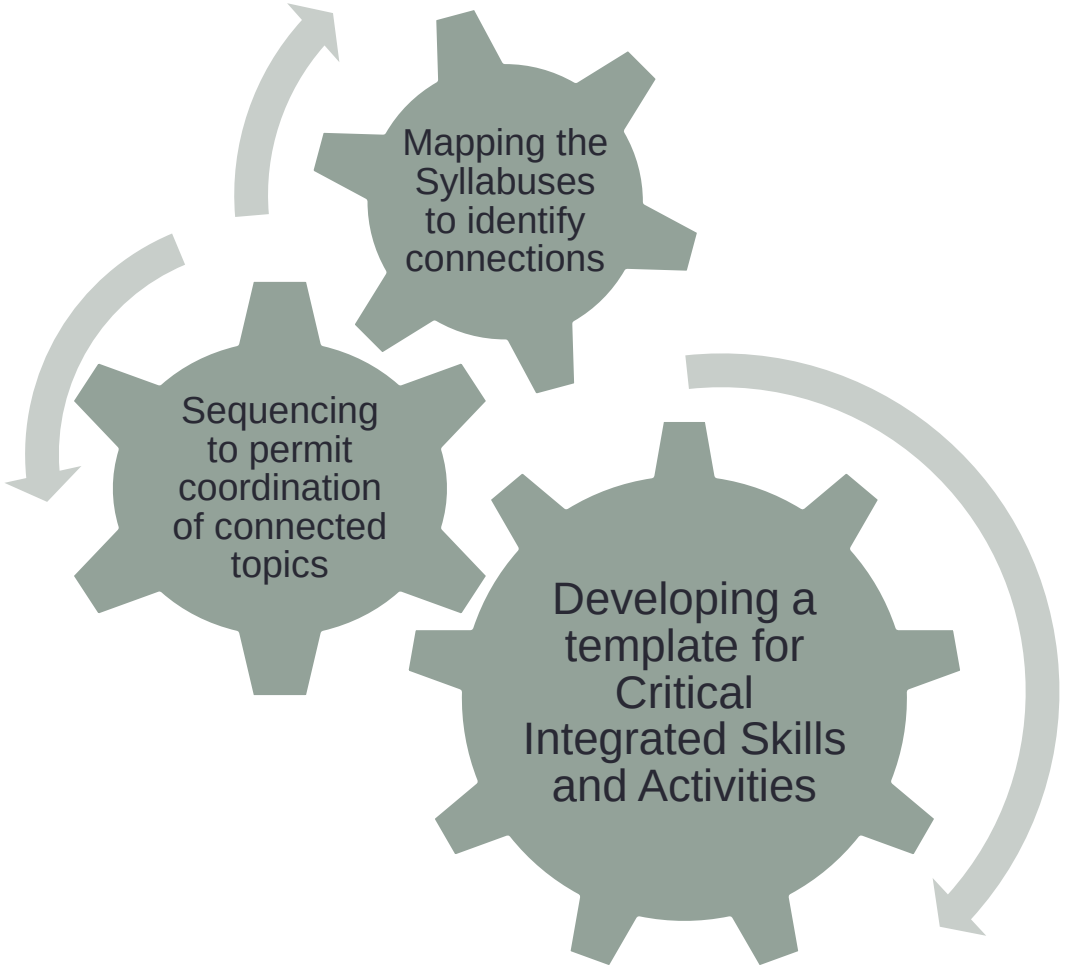
Focus of the CISA Model

Evolve a global integrated framework for teachers in order to devolve local implementation

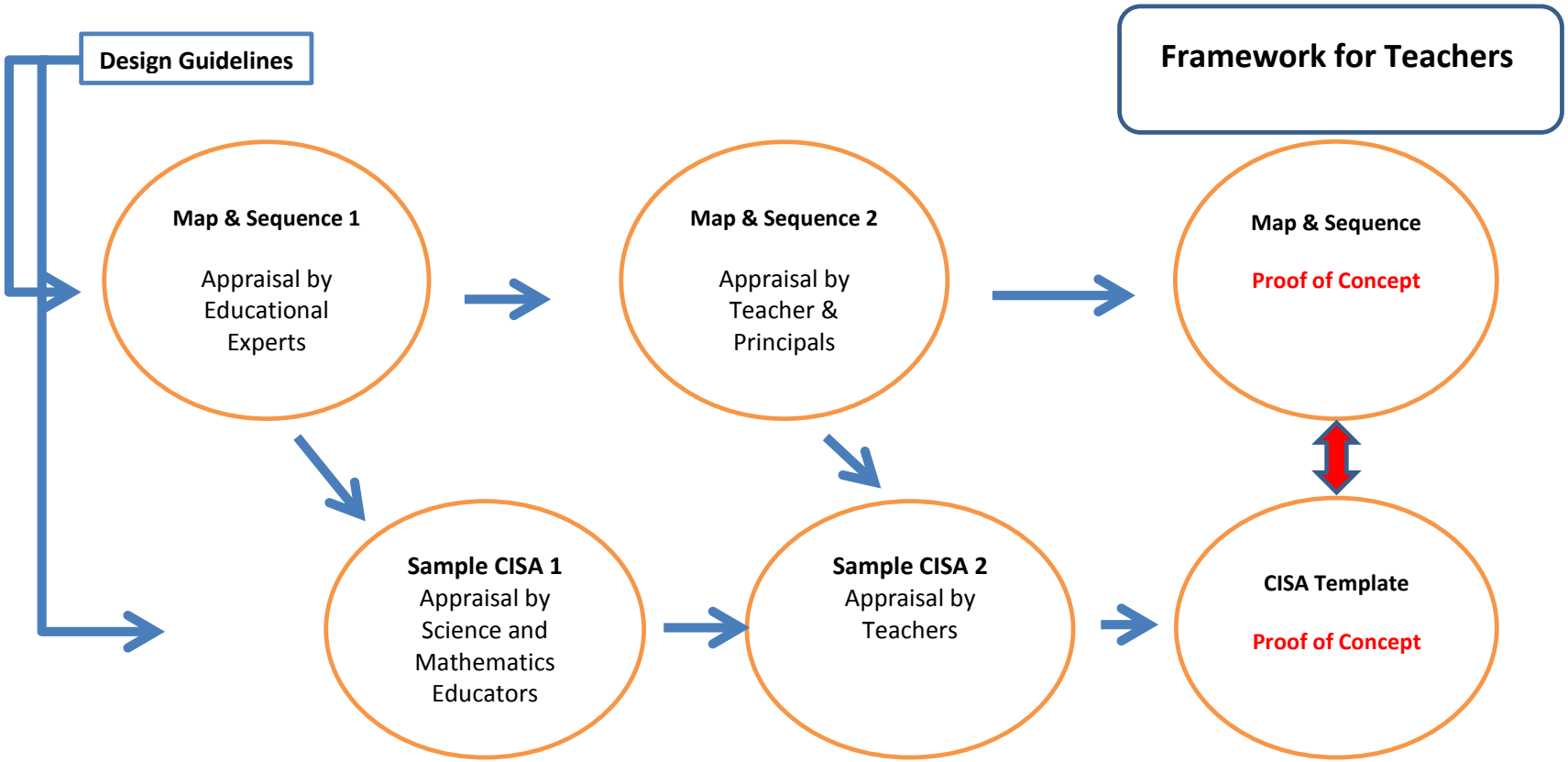
Considerations for Modelling Science & Mathematics Integration

- International models vary considerably (Pang and Good 2000)
- Should be suitable for educational context and purpose (Venville et al 2008)
- Teachers rarely experience integration and have limited knowledge of what it entails and how to implement it (Czerniak 2007)
- Students often meet the maths at the wrong time to support the science and/or meet it in different form (Orton and Roper 2000)

Evolving a Framework for STEM Integration



Methodology: Educational Design Research



Plomp (2008)

Designing and Developing the CISA Lessons

Exemplar CISA lesson Packs:

- To illustrate how mathematical knowledge, processes, skills can be integrated into Junior Science
- Coordinated with stage of learning in both subjects
- To provide examples of integrated instructional materials, that could be adapted for a range of science topics
- To support student transfer of knowledge across disciplinary boundaries

CISA Topics

New First Years:

- CISA 1: Introduction to Simple Statistical Inquiries in Junior Science Investigations (eg, food labels, pulse/breathing rates)

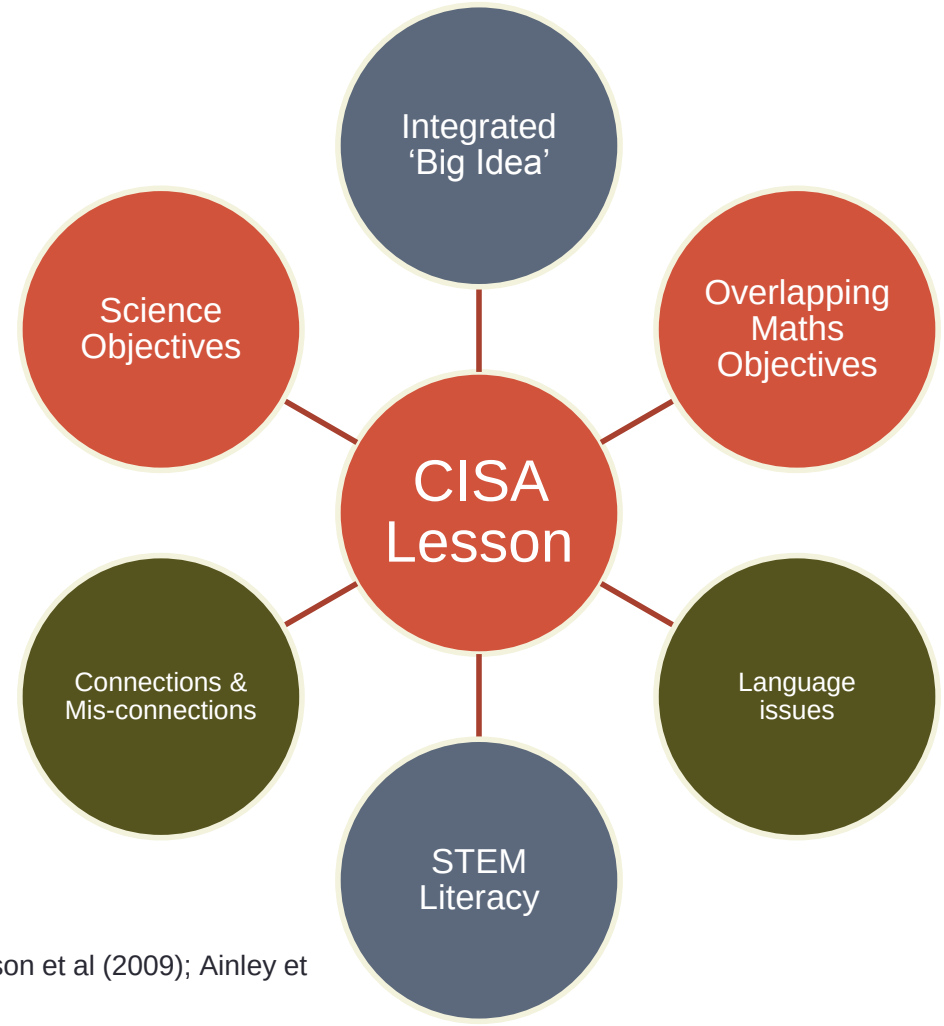
Mid First Years

- CISA 2: Investigating Relationships Between Two Variables in Science (solubility curves, temperature-time)

Second Years

- CISA 3: Investigating Linear Relationships between Variables in Junior Science (extension of a spring, distance-time)

The CISA Lesson Template



Offer and Mireles (2009) Stinson et al (2009); Ainley et al 2011

Evaluation of Version 1

- **4 Subject Matter Experts**

- Third-level Science educator (Primary Science)
- Second-Level teacher and professional developer for Science
- Two third-level Mathematics educators

Convergent-Participation Process

- Individual review of materials: Feedback via written commentaries & questionnaire - six open questions
- Researcher amalgamated feedback and prepared agenda
- Panel Discussion - audio-recorded interview (1 hr)

Evaluation of Version 2

End-user Expert Evaluation
Initially 18 teachers
Data from 15

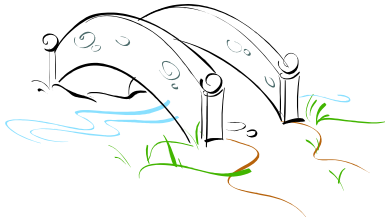
1. Review of Lesson Packs
All teachers read one or more of the packs
Feedback via Questionnaire & Interview
15 Questionnaires returned (33 items; 3 open questions)
9 Interviews (from 20 minutes to 1.5 hours)

2. Lesson Try-out
5 (of the 15) teachers also tried out lessons with their students
Feedback via questionnaire, lesson logs & interview

Focus on practicality & expected effectiveness of CISA Model

Responses transcribed & coded via NVivo

Significant Outcomes



- Readability changes, eg,
  - Remove some content from plans
  - Additional clarity in some of the materials
  - Overestimation of students' vocabulary in some activities
- Practicality Issues, eg:
  - Examination constraints
  - Time constraints

Teacher and Student Knowledge Issues:

  - Lack of mathematical knowledge
  - Coordination with Maths teacher

Crossing the Subject Boundary?

- ‘I have never taught maths. The intro made it very clear what maths students do in primary and makes it clear how to differentiate depending on what they’ve done in secondary education.’ (Science teacher)

- ‘As a JC Maths teacher, it was wonderful to see the cross-curricular approach and the marrying of the Project Maths topics, eg, Data analysis, probability, Data representation, etc’ (Science and Mathematics teacher)

- ‘I like the idea of the integration of the two subjects but I feel the science course is long enough…without adding the maths parts that are not relevant. I would definitely add those parts that are transferable. Maybe I just need to embrace it and decide to make it more relevant!’ (Science teacher)

Feedback into CISA Framework

- Initially conceived CISA Framework as a material process
- Improvement of artifacts possible and desirable up to a point
- Repackage for adaptation to local circumstance
- Science teachers have multiple identities; science teachers and mathematics teachers vs science teachers
- Multiple communities of practice

Theoretical Implications for the CISA Framework

- Teachers' 'crucial' role as translators across disciplinary systems (Nikitina 2006)
- A group of science teachers who cannot make these translations from mathematics into science
- Repositioning the CISA Framework as a Boundary Object that mediates and translates across two partially distinct communities of practice (Star and Griesemer 1989; Hulten 2013)
- CISA Framework is a good basis on which to start interdisciplinary dialogue: 'photocopier conversations'

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