

FaSMEd

RAISING ACHIEVEMENT THROUGH FORMATIVE ASSESSMENT IN
SCIENCE AND MATHEMATICS EDUCATION

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FP7 research project

Action: Science in Society (Research in the role of teaching methods and assessment methods in addressing low achievement in the field of Mathematics, Science and Technology) Collaborative Project

Purpose: To research the use of technology in formative assessment classroom practices that allow teachers to respond to the emerging needs of learners in mathematics and science.

Timescale 3 years

The project FaSMEd has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 612337

Partners

University of Newcastle upon Tyne, UK (Coordinator)

The University of Nottingham, UK

Ecole Normale Supérieure De Lyon, France

National University Of Ireland Maynooth

University Of Duisburg-Essen, Germany

University Of Turin, Italy

Freudenthal Institute, University Of Utrecht, The Netherlands

African Institute For Mathematical Sciences Schools Enrichment Centre , South Africa (Stellenbosch)

University College Of Trondheim, Norway

Objectives:

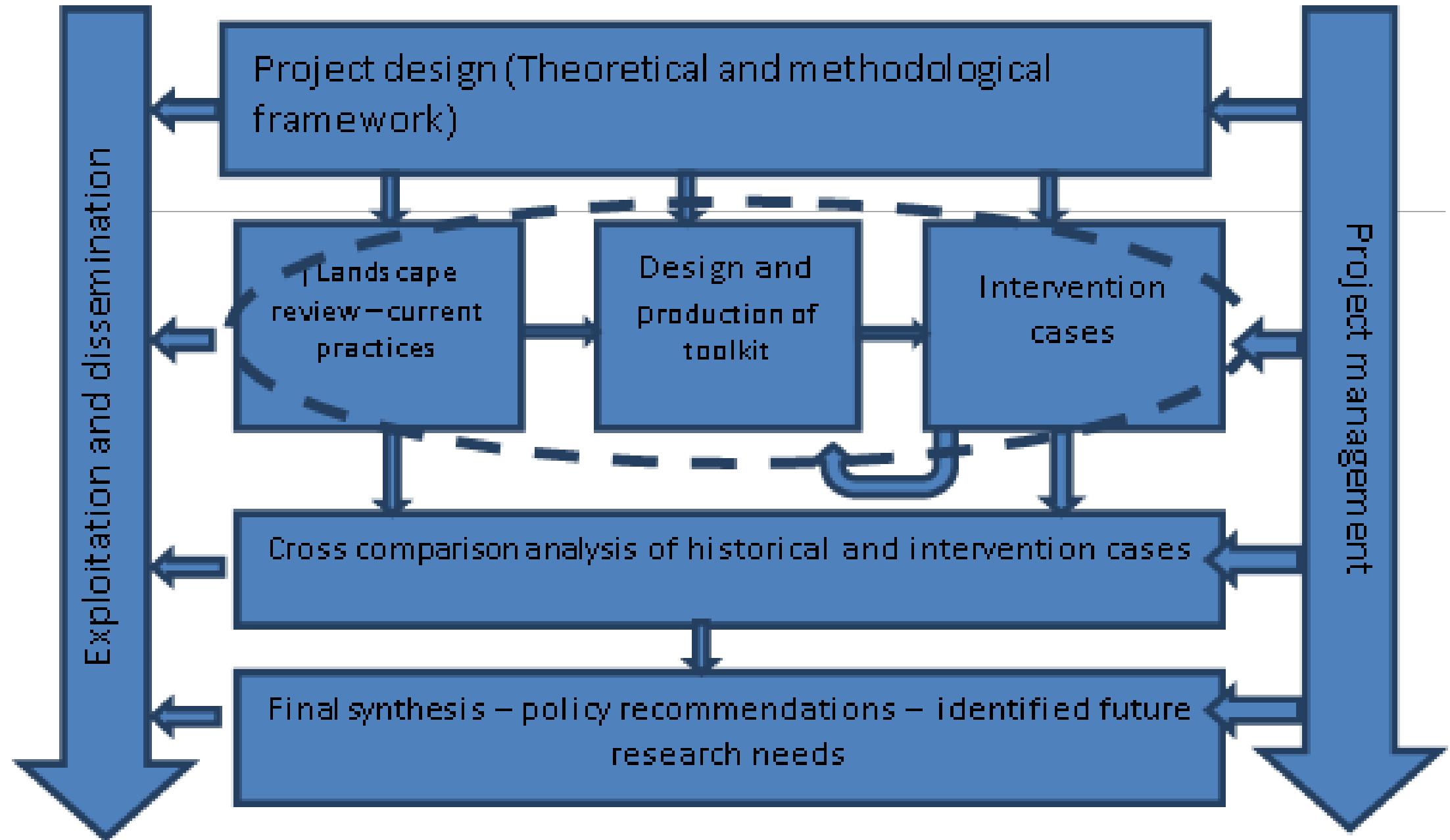
A design research project

To adapt and develop existing research-informed pedagogical interventions (developed by the partners), suited to implementation at scale, through:

- fostering high quality interactions in classrooms that are instrumental in raising achievement;
- Expanding our knowledge of technologically enhanced teaching and assessment methods addressing achievement in mathematics and science

Deliverables:

1. Offer approaches for the use of new technologies to support formative assessment.
2. Develop sustainable teaching practices that improve achievement in Mathematics and Science.
3. Produce a toolkit for teachers to support the development of practice and a professional development resource to support it.
4. Disseminate the outcomes.



The challenge of boundary crossing: opportunities for learning through dialogue

Our boundaries:

- Geographical/cultural - Science/Mathematics - Cognitive/affective - Researcher/teacher-School/home

Boundary crossing offers opportunities for learning through dialogue in relation to issues of:

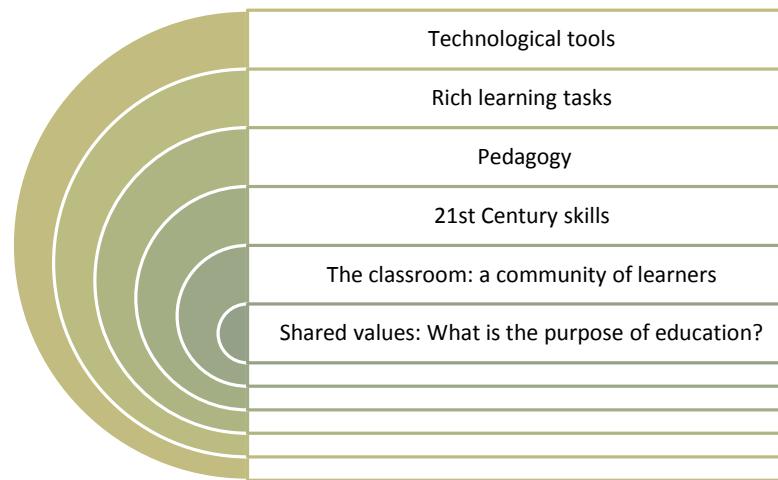
- Identity
- Coordination
- Reflection
- Transformation

(Akkerman & Bakker (2011))

The purpose of education: what are our values?

- The project is embedded in a context with a clear political dimension of Social renewal and Social Justice:
- International statistics (PISA, TIMSS etc) demonstrate that across many (most) education systems, the membership of certain groups eg: Gender, class or ethnicity implies differential educational outcomes in science and mathematics.
- It is not just a technical issue of finding better ways of teaching and learning science and mathematics – it is about empowering our students.
- Mathematical and scientific literacy: ‘Reading and writing the world with science and mathematics’ (Freire (1970), Gutstein (2006))
- ‘Reading the world’ = Using science and mathematics to understand society and the world.
- ‘Writing the world’ = Developing a sense of individual and social agency through science and mathematics.

The context for technology in education



Fullan (2013)

Formative assessment - a process not a product – ‘Making learning visible’

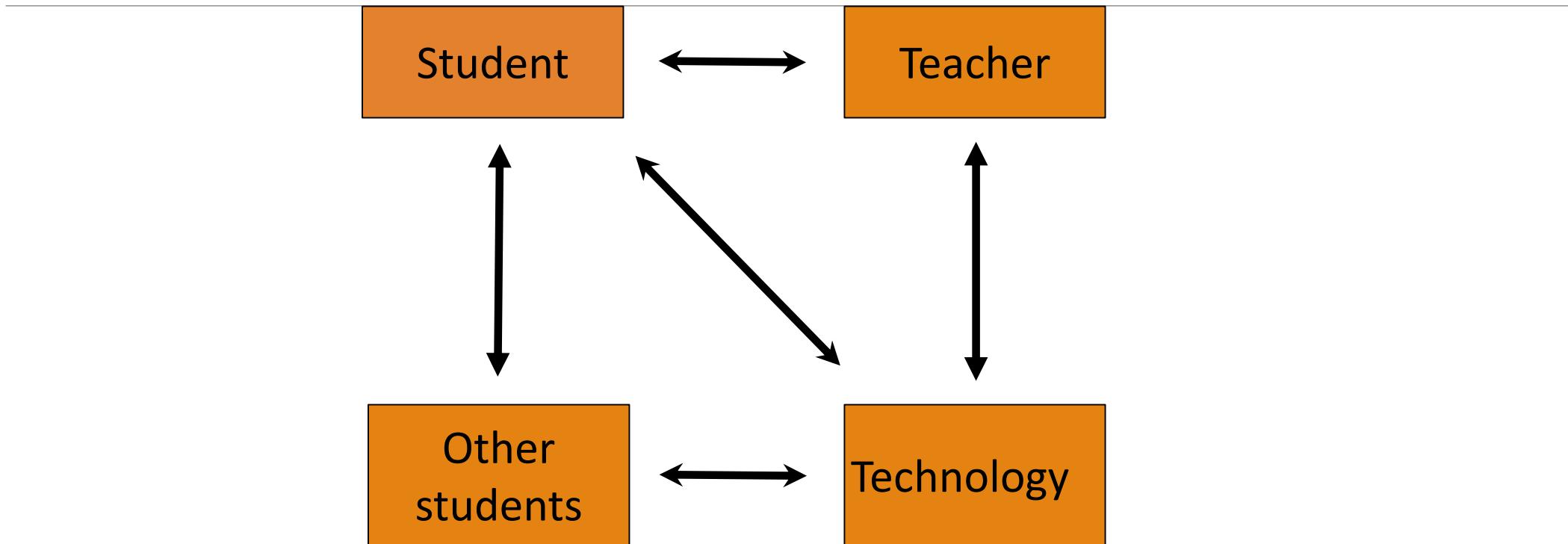
“Students and teachers using evidence of learning to **adapt teaching and learning** to meet immediate needs minute-to-minute and day-by-day”.

(Thompson and Wiliam, 2007)

“... all those activities undertaken by teachers, and by their students in assessing themselves, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged. **Such assessment becomes ‘formative assessment’ when the evidence is actually used to adapt the teaching work to meet the needs.”**

(Black & Wiliam, 1998, para, 91)

Improving the flow (and quality) of information



Design or “Engineering” Research

Design-based research **is a formative approach** in which a product or process (or ‘tool’) is envisaged, designed, developed and refined through cycles of enactment, observation, analysis and redesign, with systematic feedback from end-users.

Educational theory is used to inform the design and refinement of the tools, and is itself refined during the research process.

Its goals are to create **innovative tools for others to use**, to describe and explain how these tools function, account for the range of implementations that occur and develop principles and theories that may guide future designs.

Ultimately, **the goal is transformative**; we seek to create new teaching and learning possibilities and study their impact on end-users.

Issues and challenges

The status of theory.

- What works? How does it function?

The importance of context.

- Social and cultural context. E.g. pressures, constraints.

The role of the researcher.

- From interventionist to ‘hands off’.

Design mutation

- Explain how and why things evolve.

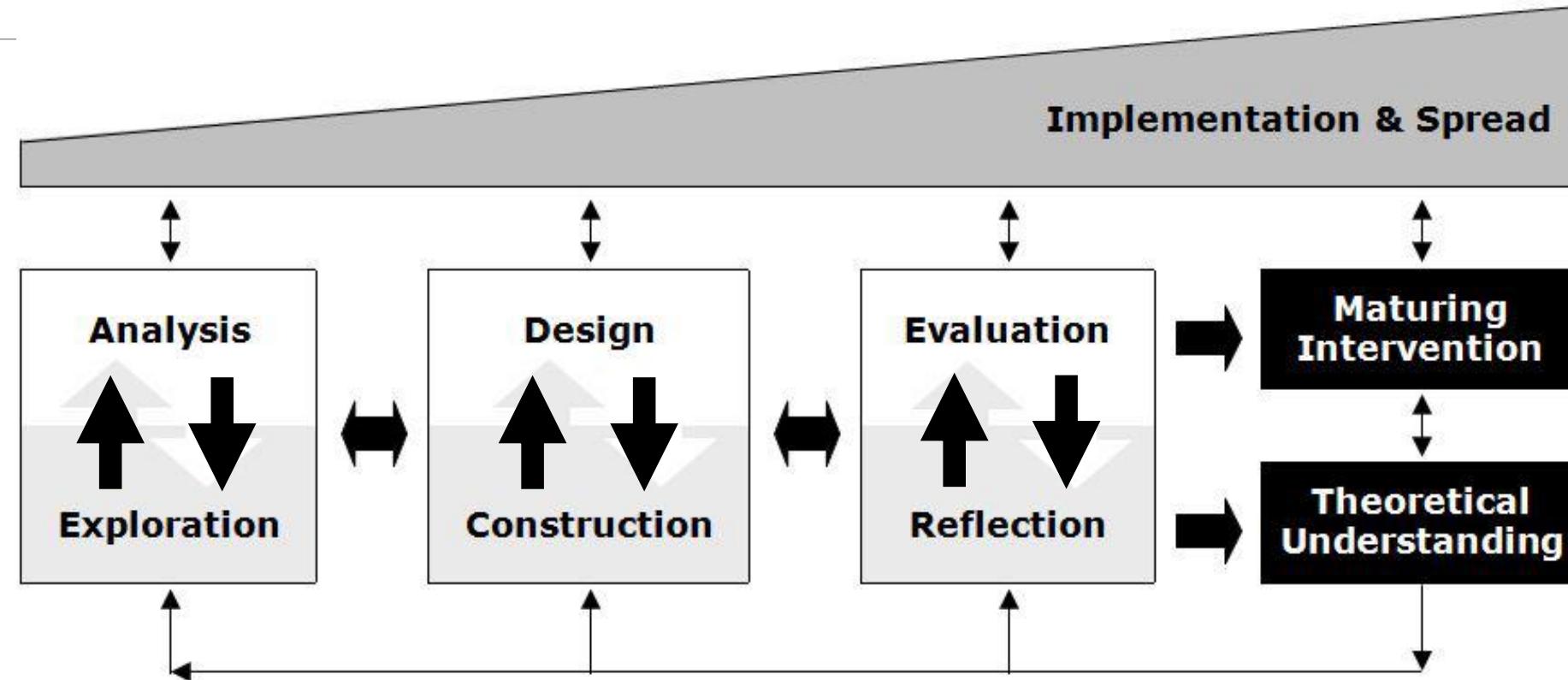
Grain size and selection of teachers

- Small, close observations *moving towards*
Larger more representative trials

The richness of the data

- range and evolution of implementation; learning gains, attitude changes. “I had no room to store all the data, let alone time to score it.’ (Brown, 1992)

The generic process



McKenney and Reeves (2012)

Analyze the context. Describe transformation envisioned

Analyze the context

Curriculum materials context

- 11-14, low attainers
- Existing technology use extremely varied
- Exemplar lessons v extended units of work

Professional development context

- Teachers experienced with technology?
- One-off workshops?
- Extended courses mediated by an outsider?
- Communities of teachers within a school using online resources.
- Communities of teachers across schools + outsiders. (e.g. “Japanese Lesson study”)
- Individual teachers working alone

What transformations are we seeking?

Better motivation

“The project aims to research the use of technology in formative assessment classroom practices in ways that allow teachers to respond to the emerging needs of low achieving learners in mathematics and science so that they **are better motivated** in their learning of these important subjects.”

Higher quality interactions among students

“that are instrumental in

- raising achievement for low achievers which support teachers in enabling low attaining students to:
 - Learn more mathematics and science
 - Get better at learning mathematics and science
 - Feel better about themselves as mathematics and science students.”

Analyze the context. Describe transformation envisioned



Develop theories and principles to guide the design

Principles from theory

Learning occurs through

- active participation in and reflection on social practices,
- internalisation and reorganisation of experience.

Activate pre-existing concepts and ideas.

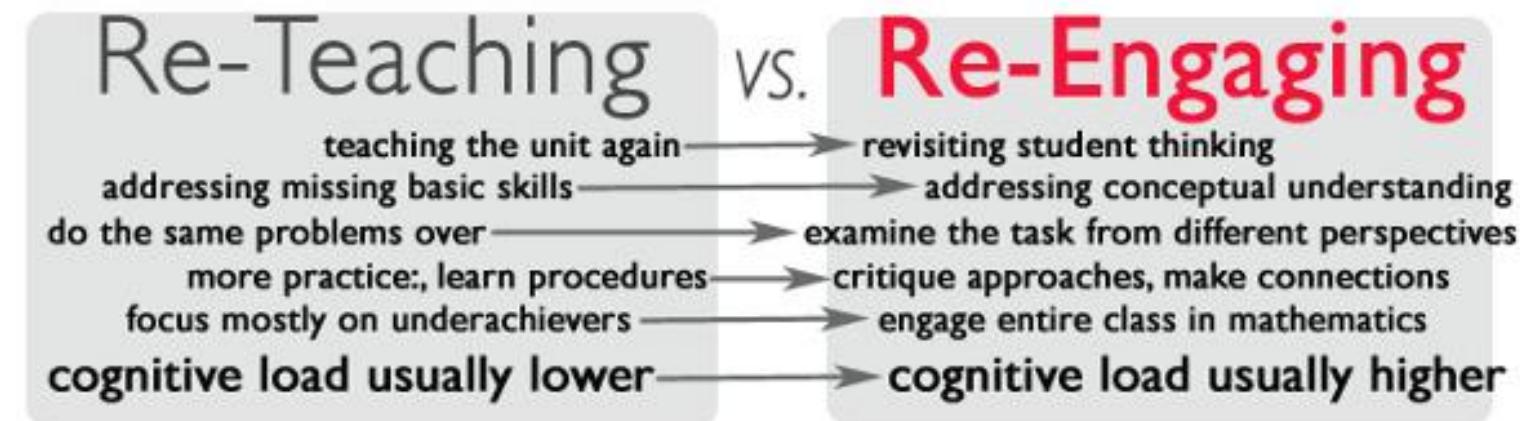
Stimulate ‘conflict’ or ‘challenge’ to promote re-interpretation, reformulation and accommodation.

Devolve problems to learners. Learners articulate their own interpretations and create their own connections.

‘Productivity’ must give way to reflective periods for examining alternative meanings and methods.

This applies to teachers and students equally.

Pedagogy: Re-Engaging learners.



[Inside mathematics, Re-engaging learners](#)

Professional development (Wiliam, 2011)

Looking at the wrong knowledge...

The most powerful teacher knowledge is not explicit

- That's why telling teachers what to do doesn't work
- What we know is more than we can say
- And that is why most professional development has been relatively ineffective

Improving practice involves changing habits, not adding knowledge

- That's why it's hard

And the hardest bit is not getting new ideas into people's heads

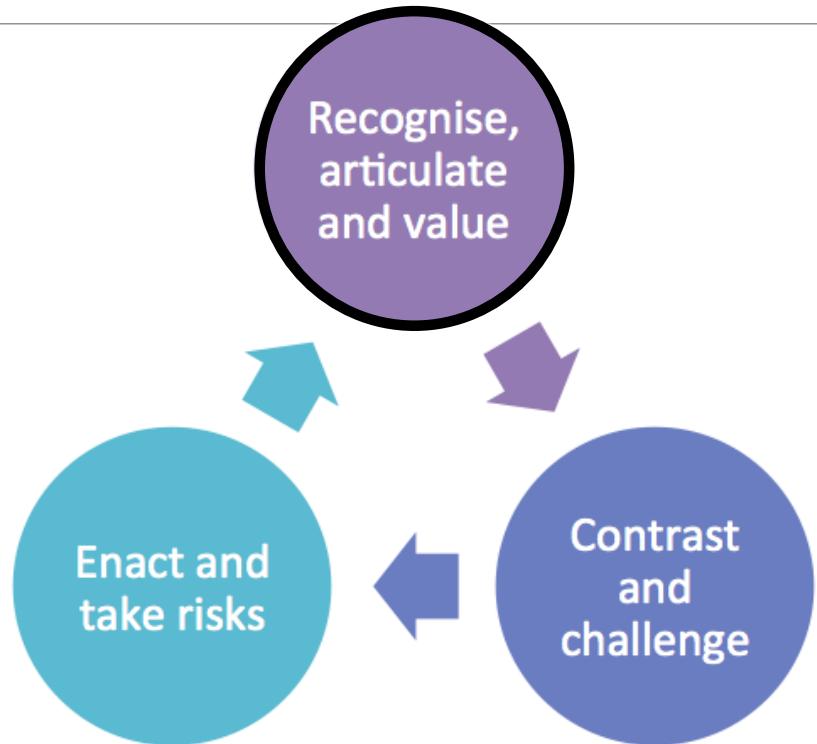
It's getting the old ones out

- That's why it takes time

But it doesn't happen naturally

- If it did, the most experienced teachers would be the most productive, and that's not true (Hanushek, 2005)

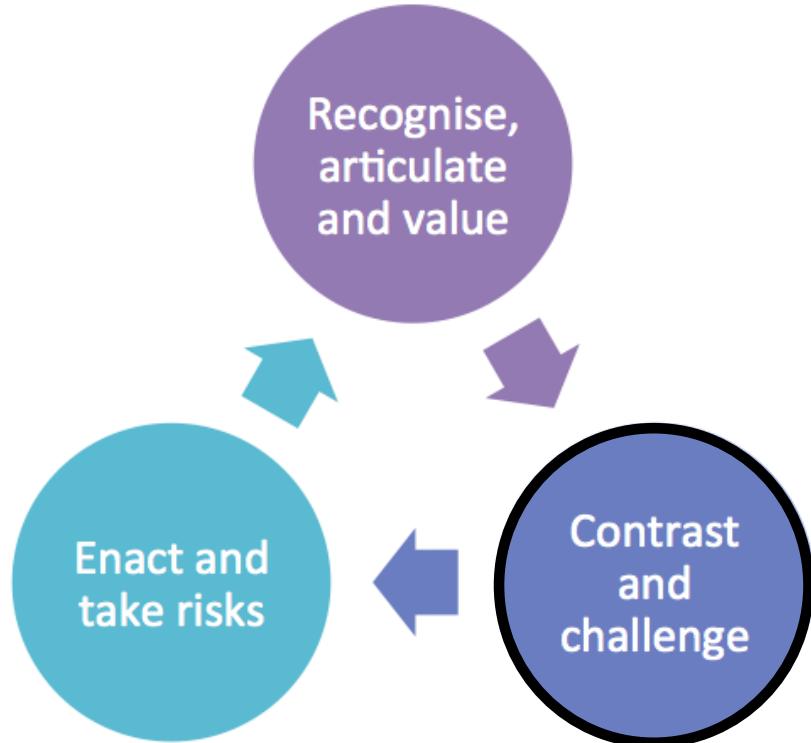
Phases of Professional Development



Recognise, articulate and value

Reflect on the contexts in which teachers work and make explicit existing values, beliefs and practices.

Phases of Professional Development



Contrast and challenge

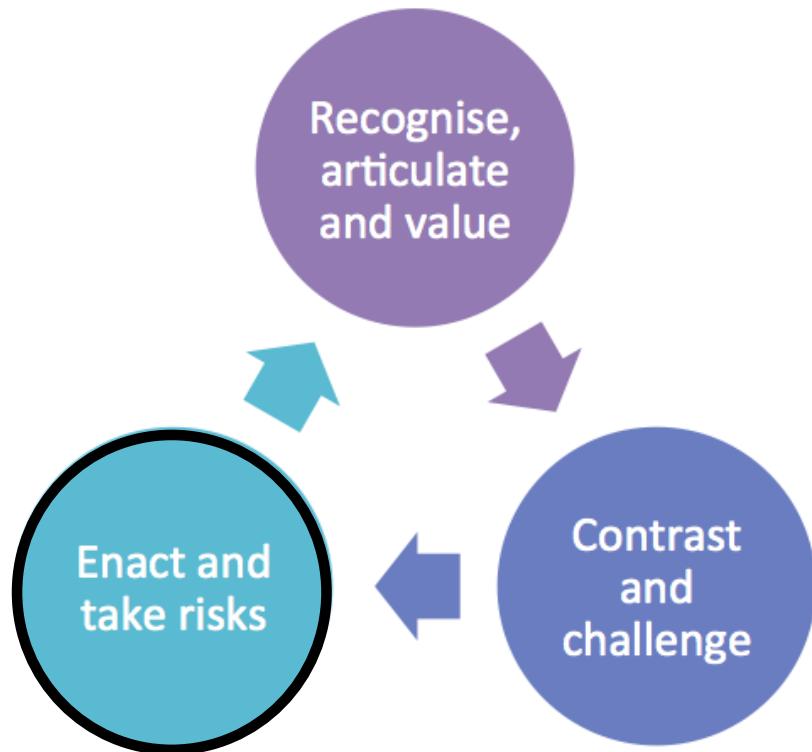
Illustrate vivid, contrasting practices.

Work on task genres.
Analyse videos.

Discuss theories, pedagogies, and context.

This provides 'challenge' or 'conflict'.

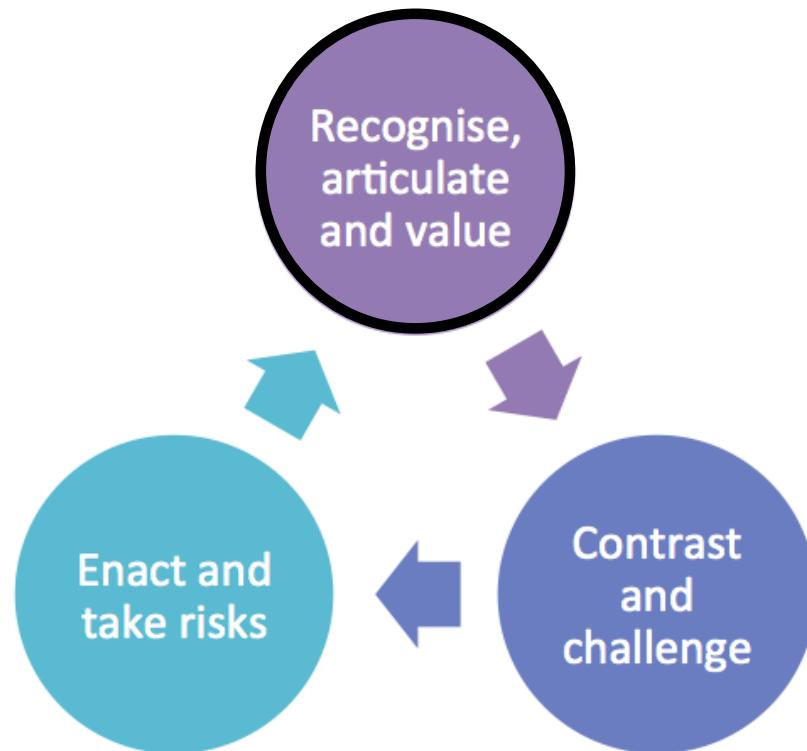
Phases of Professional Development



Enact and take risks

Ask teachers to 'suspend' disbelief and act in new ways, 'as if they believed differently'. Offer mentor and a network of support as they do this.

Phases of Professional Development



Recognise, articulate and value

Encourage teachers to meet together and reflect on their new experiences and the implications that these offer. Ask teachers to reflect on and recognise the growth of new beliefs.

Analyze the context. Describe transformation envisioned



Develop theories and principles to guide the design



Select research sites

Select research sites

Clusters of 3 schools, but which?

- Schools where technology use is strong?
- Schools where formative assessment is strong?
- Schools where neither technology nor formative assessment is embedded?

Analyze the context. Describe transformation envisioned



Develop theories and principles to guide the design



Select research sites



Create a design. Describe how it is intended to function

Create research instruments:

How is the design used/ what is its impact?

The toolkit

“The expression ‘toolkit’ refers to a set of curriculum materials and methods for pedagogical intervention” (proposal)

Curriculum materials:

- Assessment tasks that make teachers more aware of learning obstacles.
- ‘Diagnostic’ tasks that make students more aware of learning obstacles
- Sample lesson plans that show how FA may be embedded to help overcome these obstacles. (e.g. MAP lessons)

Processes for pedagogical intervention:

- PD modules
- Ways of using the PD modules

Key strategies for formative assessment – the framework for the toolkit

	Where the learner is going	Where the learner is right now	How to get there
Teacher	Clarifying learning intentions and sharing and criteria for success (1)	Engineering effective classroom discussions, activities and tasks that elicit evidence of learning (2)	Providing feedback that moves learners forward (3)
Peer	Understanding and sharing learning intentions and criteria for success (1)	Activating students as instructional resources for one another (4)	
Learner	Understanding learning intentions and criteria for success (1)	Activating students as the owners of their own learning (5)	

Wiliam & Thompson, 2007

Research instruments

What are we seeking to learn?

- **Summative**
 - **Better motivation among students?**
(e.g. Teacher/student questionnaires & interviews, lesson observations)
 - **Higher quality interactions among students?**
(e.g. Lesson observations, sample video analysis)
- **Formative (for further development of toolkit)**
 - **What are the easier/ more difficult formative assessment principles to adopt?**
 - **What are the affordances / obstacles with technology?**
 - **What are the most effective models for FA; for PD?**



MAP Home

- ▶ Project goals
- ▶ Products
- ▶ The Team
- ▶ What's on this site?
- ▶ Who can use the MAP materials?



Do I need to log in?

Probably not. Most of our materials are now publicly available from this site without logging in, and the rest will be available within a few weeks.

The Mathematics Assessment Project

"And I'm calling on our nation's governors and state education chiefs to develop standards and assessments that don't simply measure whether students can fill in a bubble on a test, but whether they possess 21st Century skills like problem solving and critical thinking and entrepreneurship and creativity."

President Obama, 1 March 2009.



New lessons: We've been steadily adding new 'Classroom Challenge' lessons for grades 6-8 over the last few months, and in a few weeks all of the planned 20 lessons for each grade from 6 to 10 will be available.

New – TRU Math: *Teaching for Robust Understanding of Mathematics* is a suite of tools for professional development and research - the alpha versions of these documents are available [here](#).

The project is working to design and develop well-engineered assessment tools to support US schools in implementing the

Products

Tools for formative and summative assessment that make knowledge and reasoning visible, and help teachers to guide students in how to improve, and monitor their progress. These tools comprise:

- **Classroom Challenges:** lessons for formative assessment, some focused on developing math concepts, others on non-routine problem solving. A [Brief Guide for teachers and administrators \(PDF\)](#) is now available, and is recommended for anybody using the MAP Classroom Challenges for the first time.
- **Professional Development Modules:** to help teachers with the new pedagogical challenges that formative assessment presents.
- **Summative Assessment Task Collection:** to illustrate the range of performance goals required by CCSSM.
- **Prototype Summative Tests:** designed to help teachers and students monitor their progress, these tests provide a model for examinations that may replace or complement current US tests.

The team also contributes to some system capacity building activities within the wider collaboration that the Gates Foundation has assembled, including states and school systems across the US.

For MAP lessons

“The expression ‘toolkit’ refers to a set of curriculum materials and methods for pedagogical intervention” (proposal)

Curriculum materials:

- Formative Assessment Lessons
- Summative Assessment Task Collection
- Prototype Summative Tests

Processes for pedagogical intervention:

- Professional development modules
- Ways of using the PD modules
- TRU Math suite of tools that describe the characteristics of productive classrooms.



MAP Professional Development Modules

- Supporting 21st Century Math Teaching
- 1: Formative Assessment
- 2: Concept Development Lessons
- 3: Problem Solving Lessons
- 4: Improving Learning Through Questioning
- 5: Students Working Collaboratively

Download modules for offline use:

- [Module 1 \(ZIP 500MB\)](#)
- [Module 2 \(ZIP 106MB\)](#)
- [Module 3 \(ZIP 270MB\)](#)
- [Module 4 \(ZIP 180MB\)](#)
- [Module 5 \(ZIP 75MB\)](#)
- [All modules \(ZIP ~1GB\)](#)

Supporting 21st Century Math Teaching



To truly meet the demands of the Common Core State Standards it is not sufficient to simply revise the list of mathematical content covered in the curriculum. The Standards' emphasis on *Mathematical Practices* require students to be able to *think* mathematically, and apply the techniques they have learned to rich problems in diverse contexts. Achieving this requires changes in the way mathematics is taught and assessed in most schools.

The Mathematics Assessment Project has developed the *Classroom Challenges* to exemplify the types of activities needed to supplement traditional classroom practice and support the Standards. The Professional Development Modules are designed to help teachers with the practical and pedagogical challenges presented by these lessons.

[Module 1](#) introduces the model of *formative assessment* used in the lessons, its theoretical background and practical implementation. [Modules 2 & 3](#) look at the two types of *Classroom Challenges* in detail. [Modules 4 & 5](#) explore two

A Professional development resource

Modules covering the main pedagogical challenges:

Each is a three part “sandwich”:

- **Introductory session:**

Teachers work on problems, discuss pedagogical challenges they present, watch video of other teachers using these problems and plan lessons.

- **Into the classroom:**

Teacher teach the planned lessons.

- **Follow-up session:**

Teachers describe and reflect on what happened, discuss video extracts, and plan strategies for future lessons.

Analyze the context. Describe transformation envisioned



Develop theories and principles to guide the design



Select research sites



Create a design. Describe how it is intended to function

Create research instruments:

How is the design used/ what is its impact?



Conduct a trial of the design

Analyze the context. Describe transformation envisioned



Develop theories and principles to guide the design



Select research sites



Create a design. Describe how it is intended to function

Create research instruments:

How is the design used/ what is its impact?



Conduct a trial of the design



Analyze the ways design was used and its impact.

Develop and refine theory. Revise the design.

Analyze the context. Describe transformation envisioned

Develop theories and principles to guide the design

Select research sites

Create a design. Describe how it is intended to function
Create research instruments:
How is the design used/ what is its impact?

Conduct a trial of the design

Analyze the ways design was used and its impact.
Develop and refine theory. Revise the design.

Iterate,
expand
sample
size

Successive Trials

Level	Variables	Typical research and development foci
Learning studies	Student Task	R: Conceptual difficulties, Practical IT issues D: Classroom activities, data capture
Enthusiastic teachers	Instruction Student Task	R: Teaching tactics and strategies, student learning D: Classroom materials OK for some.
Representative teachers	Teacher Instruction Student Task	R: Performance of typical teachers with realistic support. Basic studies of teacher knowledge and competency D: Classroom materials that work for most teachers
System change	System School Teacher Instruction Student Task	R: System and cultural variables D: Tools for change - materials for assessment, professional development, community relations.

Proposal implies two iterations: Prototype & Final

By Month 10:

- 3.1 Develop a prototype toolkit for teachers to support their use of formative assessment in the classroom including advice and support in using technology
- 3.4 Develop prototype PD package for teachers

By Month 25

- 3.2 Evaluation of toolkit
- 3.5 Evaluation of PD package

By Month 36

- 3.3 Develop final toolkit
- 3.6 Develop final PD package

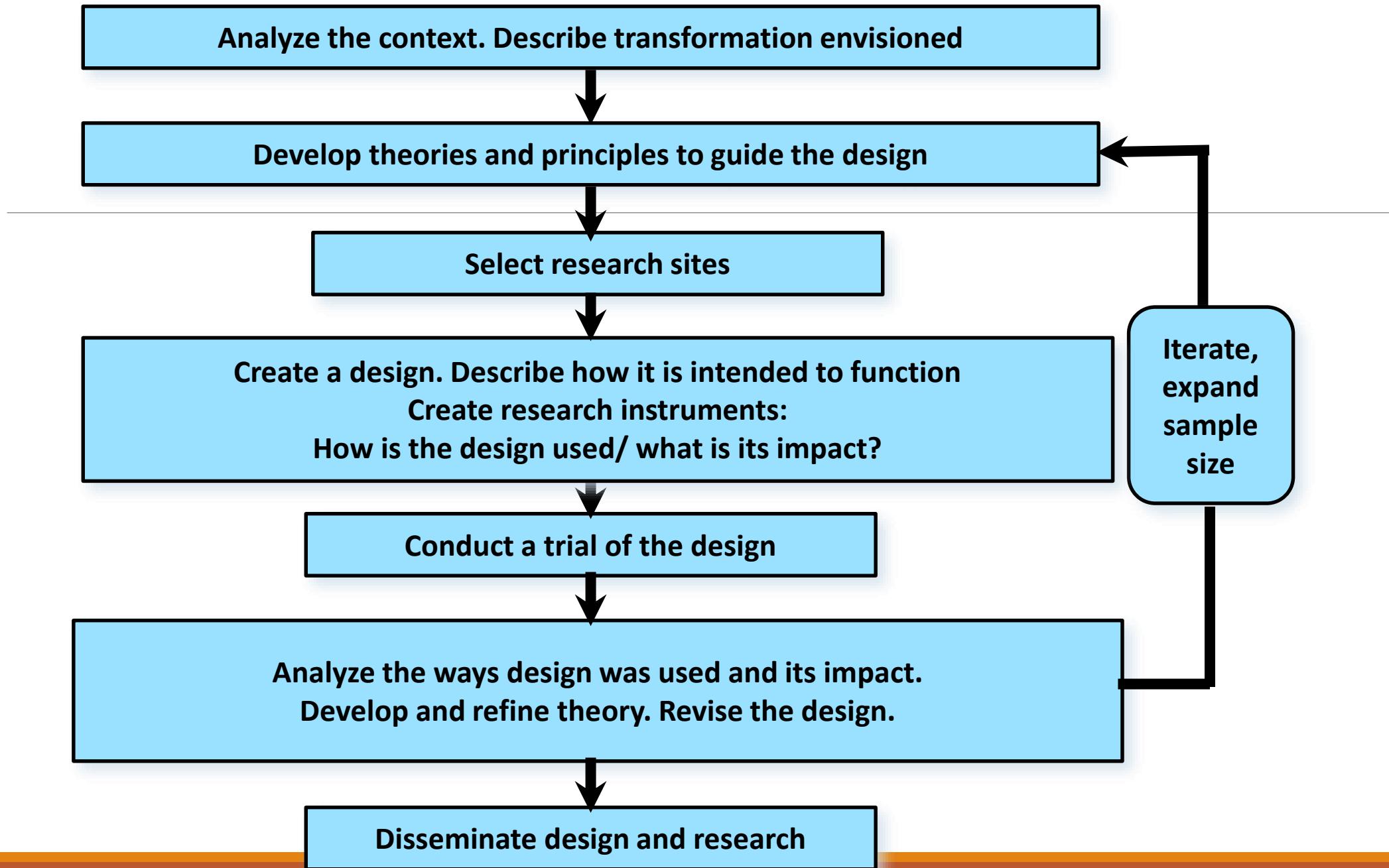
Case studies produced in second iteration

Clusters

“All partners will have a cluster of about three schools to implement each of the approaches”

What is the grain size of a “case study”?

- **Student experience**
- **Teacher experience**
- **Whole school issues**
- **Cluster of schools**



Websites

<http://research.ncl.ac.uk/fasmed/>

<https://toolkitfasmed.wordpress.com/>

<http://map.mathshell.org/>

References

Akkerman, S & Bakker, A, 2011. Boundary Crossing and Boundary Objects *Review of Educational Research* 81: 132-169,

Freire, P, 1970. *Pedagogy of the oppressed*. [New York]: Herder and Herder,.

Fullan, M, 2013. *Stratosphere: Integrating Technology, Pedagogy, and Change Knowledge*. Toronto: Pearson,.

Gutstein, E, 2006. *Reading and Writing the World with Mathematics: Toward a Pedagogy for Social Justice*. London: Routledge,.

Rivkin, S., Hanushek, E., Kain, J., 2005. Teachers, Schools, and Academic Achievement, *Econometrica*, 73(2), pp. 417-458

Swan, M, 2014. Design Research in Mathematics Education. In: Lerman, S, ed., *Encyclopedia of Mathematics Education* Springer.

Wiliam, D, 2005 etc. <http://www.dylanwiliam.org/>

Wiliam, D., & Thompson, M. (2007). Integrating assessment with instruction: what will it take to make it work? In C. A. Dwyer (Ed.), *The future of assessment: shaping teaching and learning* (pp. 53-82). Mahwah, NJ: Lawrence Erlbaum Associates.