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From teachers' professional knowledge to teacher education: Research and practice

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Summary

1. Studies on teachers' knowledge
2. Studies on teachers' practice
3. Studies on teachers' identity
4. Teacher education: strategies and issues
5. Questions

1. Teachers' mathematics knowledge

Key idea
- To teach mathematics, it is necessary to know (well) mathematics.

Questions
- What do mathematics teachers know...
  …About numbers and operations, proportion, equations, functions, number theory concepts, geometry, proof?

Empirical research	Authors	Theoretical frameworks
Primitive models	Tirosh, Graeber & Glover, 1986	Mathematics
Concept image/concept definition	Vinner 1986	Cognitive psychology
Conceptual knowledge/ procedural knowledge	Tall & Hershkowitz 1980 Hiebert 1987	

Overriding image: the deficient teacher…

Striking issue: this topic is researched since a long time, with very little progress. Why?

Beliefs and conceptions studies

Key idea
- All mathematics teaching stands on a philosophy of mathematics (Thom, 1973)

Questions
- What are the most important beliefs/conceptions/views/perspectices/images that frame practice?
- How can we change teachers' beliefs/conceptions?

Empirical research	Authors	Theoretical frameworks
Beliefs/Conceptions about: - Mathematics - Education - Students' learning Mathematics teaching	Thompson 1982, 1992 Cooney 1985 Lerman 1983 / Ernest 1989 G. Törner 1995 M. Hannula 1996	Philosophy Epistemology Psychology

Unsolved issues: What is the relationship between beliefs/conceptions and practices? What are the processes that constitute beliefs/conceptions?

Cognitive psychology studies

Key ideas

- The teacher is an expert.
- The teacher can be empowered by knowledge about students thinking

Questions

- What are the teachers' cognitive structures?
- How does the teacher make decisions in the classroom?

Empirical research	Authors	Theoretical frameworks
Squeme, *frame, script,* agenda, routine Knowledge, Goals, Beliefs, Decision Making Students' concepts and cognitive processes in specific areas	Leinhardt 1988, 1991 Borko 1990 Schoenfeld 2007 Carpenter & Fennema 1989 Even & Tirosh 1992 (…)	Cognitive psychology Mathematics education

Unsolved issues: In teachers' thinking and decision making, what is the role of non cognitive elements, such as affective aspects, professional culture, classroom context?

PCK studies (pedagogical content knowledge)

Shulman (1986)

Key idea - "Content" has an essential role in teachers' professional knowledge, but the teacher has a special way of knowing it

Recent development – Breaking MKT into CCK, SCK, HK and breaking PCK into KCT, KCS, KCC

Questions - What are the main elements of *PCK* and how are they learned?

Empirical research	Authors	Theoretical frameworks
Teaching of specific topics or areas of the curriculum (number, algebra, functions…)	Lampert 1990 / Ball 1991 Eisenhardt et al. 1993 Llinares 1993 Even & Tirosh 1995 Ball et al. (2005,6,7,8,9…)	Mathematics education Cognitive psychology

Unsolved issues: What is PCK? What is its nature? How does it develop?

Shulman (2003)

- Lacks emphasis in the level of action
- Does not consider the community of teachers
- Does not consider affective, motivation o passion
- Does not include elements such as students, community, curriculum.

Professional knowledge for teaching mathematics

What is the nature of PK?

- Formal/declarative or intuitive/practical?
- Mostly informed by theory or mostly informed by practice?
- How do theory and practice combine?

What is the content of PK? (hat is "good" PK?)

- Who validates it? The professional community of teachers? Researchers in mathematics teacher education? Social/government institutions external to mathematics teaching and researchers?
- By what processes is PK validated?

How do teachers develop PK?

- What is the role of theory? What is the role of experience? How do they combine?
- What conditions promote its development? Hinder it?

Mathematics teacher craft knowledge

Shutz, Bourdieu

Academic knowledge

- Formal, declarative
- May be assessed through tests
- **Theoretical**

Common Sense

- Experiential
- Cultural and context-bound
- **Practical**

Craft knowledge refers to the professional knowledge used by the teachers in their day-to-day classroom teaching; action-oriented knowledge which is not generally made explicit by teachers, which they may indeed find difficult to articulate, or which they be unaware of using. **(Ruthven and Goodchild, 2008)**

Professional (craft) knowledge

Schön, Grimmett

- Is performative (knowing in action)
- In part explicit, in part tacit
- Is recognized by the professional group of practitioners (and by outsiders)
- **May integrate theory and practice**

Professional knowledge: Production modes

Pedagogical tradition	Modern tradition	Inquiry tradition
Practice->practice	Theory->practice	Theory<->practice
Observation of models Exercises	Leaning in "school way" (taught courses)	Professional problem solving Projects
No research	Research done outside the profession	Research done inside the profession

2. Studies of teachers' practices

Key idea

- The professional role of teachers is carried out through teachers' practices

Questions

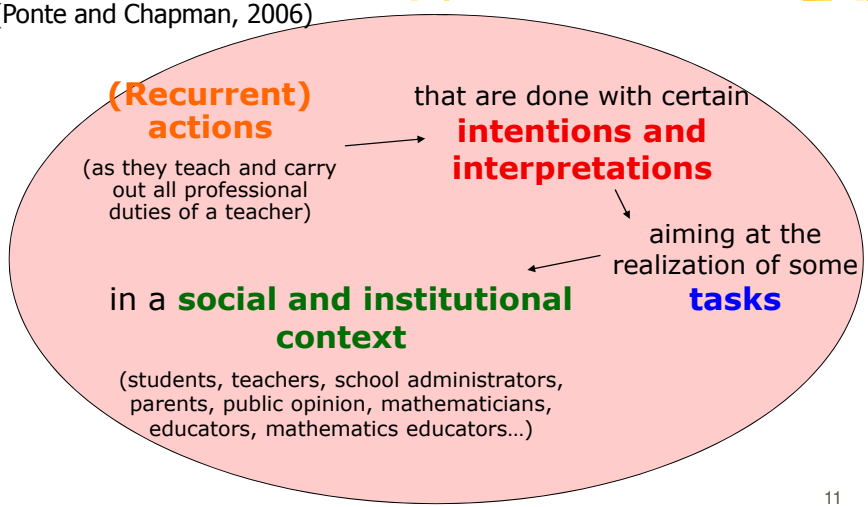
- What are teachers' practices?
- What conditions frame teachers' practices?
- How may teachers' practices develop?

Empirical research	Authors	Theoretical frameworks
Classroom interaction	Wood 1996	Cognitive psychology
Teacher intervention / "scafolding"t	Adler 1995	Sociocultural studies
	Tzur 2002	Communities of practice
Teacher classroom management	Jaworski 1991	Narrative and biography
	Boaler 2003 (…)	Mathematics curriculum and mathematics education

Issues: What are "good" practices? Who decides that?
What is the role of theory?

(Professional) practices

(Ponte and Chapman, 2006)



Mathematics teacher professional practice

Planning

- Curriculum objectives
- Classroom structure (introduction – exploration – discussion)
- Tasks (Adapting/Designing)
- Resources
- Organization of students' work
- Management of time
- Assessment

Doing

- Introduction and negotiation of the work and classroom norms (contract)
- Handling mathematical growth (challenging/supporting/observing)
- Handling classroom communication (questioning/explaining/negotiating meanings/orchestrating discussions)
- Regulating the classroom climate

Reflecting

- The curriculum objectives were met? The students learnt what was sought?
- The tasks and materials were appropriate? The classroom structure and organization of students' work was all right?
- The (unforeseen) classroom events were dealt with properly?

Curriculum change

Students learn from their mathematical experience and their reflection on their experience.

Direct teaching

Tasks
- Standard task: Exercise.
- Situations are artificial.
- For each problem there is a strategy and a correct answer.

Roles
- The teachers shows "examples" so that students learn "how to do".
- Students receive "explanations".
- Teachers and textbooks are the only authorities in the classroom.

Communication
- Teachers pose questions and provide immediate feedback (sequence I-R-F).
- Students pose "clarification" questions.

Exploratory learning

Tasks
- Variety: Explorations, Investigations, Problems, Projects, Exercises…
- Situations are realistic.
- There are several strategies to tackle a problem.

Roles
- Students receive tasks to discover strategies to solve them.
- The teacher asks the student to explain and justify his/her reasoning.
- The student is an authority.

Communication
- Students are encouraged to work and discuss with their mates (groups or pairs).
- Frequent classroom discussion (addressing significant work).
- Meanings are negotiated in the class.

3.

Studies of teachers' identities

Key idea
- Identity connects cognitive, affective, and social issues and offers a new perspective to consider teachers' knowledge, practices, and development.

Questions
- How does a teacher identity develop from pre-service, to beginning, to experienced teachers?

Empirical research	Authors	Theoretical frameworks
Teachers' professional knowledge	Walshaw 2004	Cognitive perspective
(Political and institutional) constitution of teachers' identity	Goos 2005	Artistic perspective
Pedagogical practices and beliefs	Oliveira 2004	Sociocultural studies
	(…)	Narrative and biography
		Mathematics education

Issue: Is there a teachers' identity? Or many identities (primary, secondary mathematics, university...)?

Professional identity

Link among the individual, the social, and the professional

Individual identity
Images of the profession / Images of self
Ways of assuming the professional roles
Values about education and teaching
Relationship with mathematics
Relationship with students and colleagues
Reflexivity
Professional agency

Group identity (social)
Professional culture
Norms and values
Knowledge specific of the profession
Processes of induction

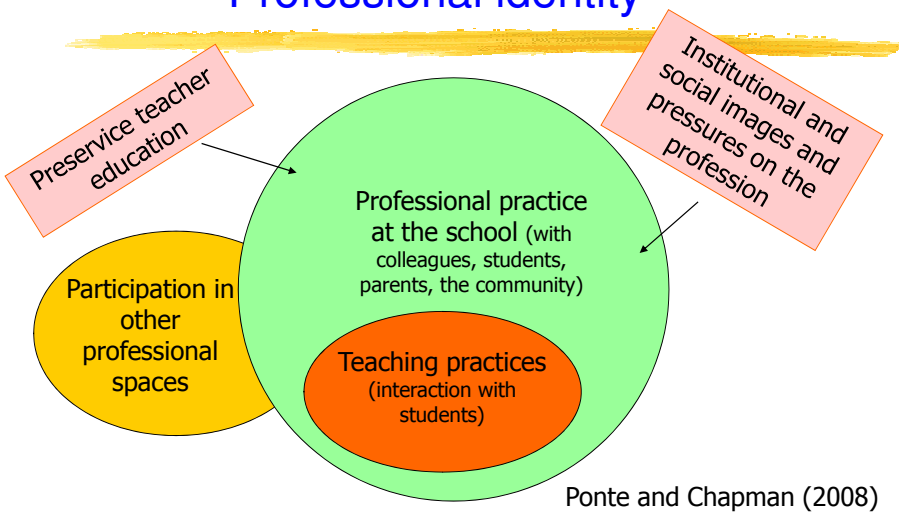
Professional practices
Teaching
Institutional
Associative
Professional development

Attitudes

Social and institutional context

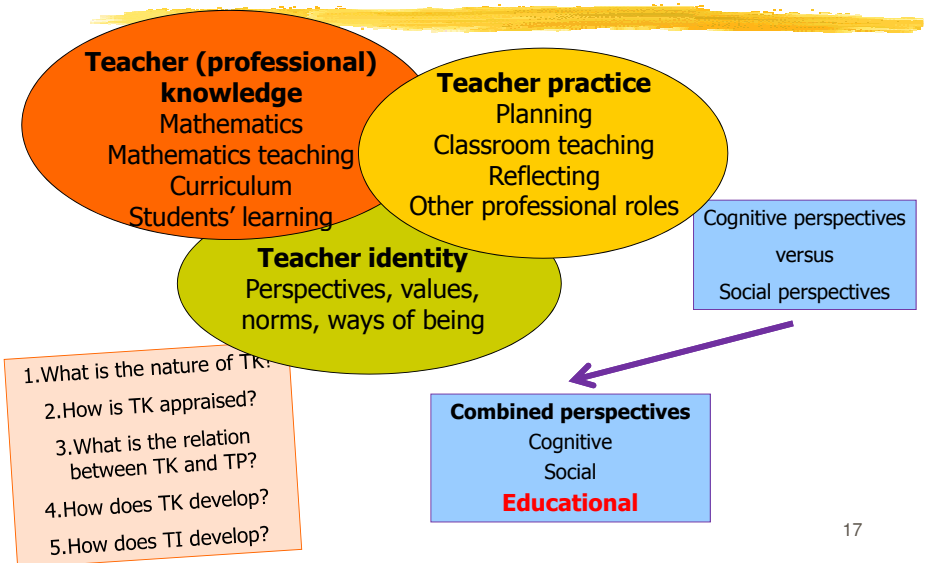
Constitution of a

Professional identity

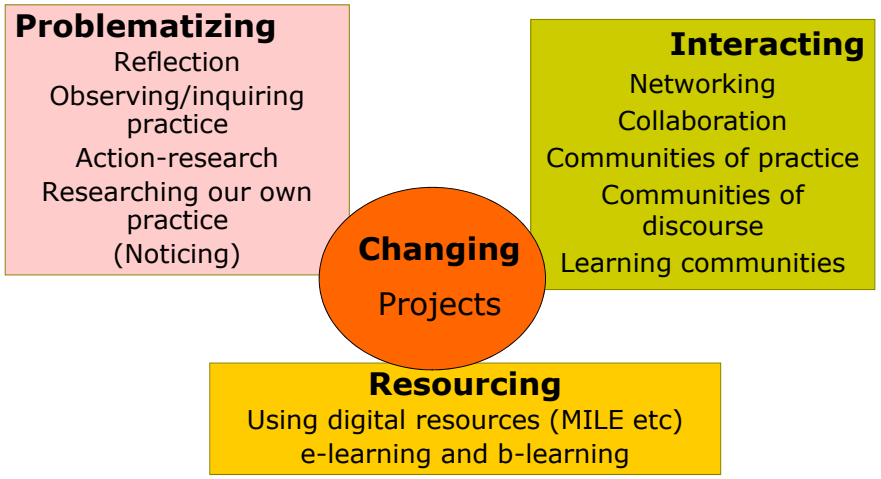


Ponte and Chapman (2008)

Theoretical perspectives about the mathematics teacher

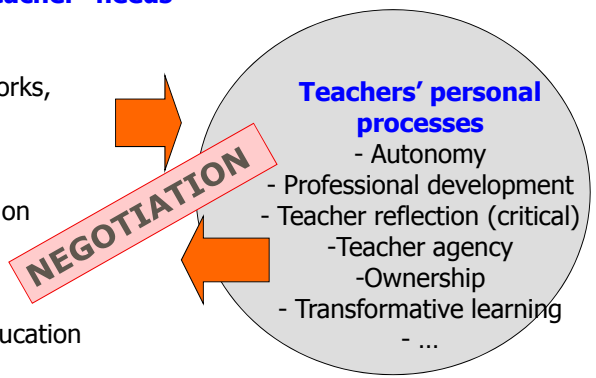


4. Strategies for teacher education



The fundamental dilemma in teacher education

Knowledge that the teacher "needs"
- Mathematics
- Children's learning
- The curriculum frameworks, aims, connections
- Instructional materials
- ICT
- Classroom communication
- Assessment
- Multicultural settings
- Ethno mathematics
- Critical mathematics education
- Inclusive education
- Students with special needs
- History and epistemology of mathematics
- …



What is the nature of this transaction?

Design of teacher education (TE) programs

Role of the context
- Provide conditions for teacher education / Value teacher education

Needs and interests	Negotiation of the TE proposal	Activities and their relation to practice	End of the course / new challenges

Direct role of the teacher educator /TE setting
-Challenge / New ideas / Resources / Support in doing in practice
-Presence / Empathy / Emotional support

Core of the design of the teacher education process
Perspective about how the teacher learns and develops professionally - the role of practice, reflection, collaboration, professional projects, etc.

Four critical elements in the design of teacher education settings

Example

The calculator module

(Célia Mercê)

4 out of 15 sessions x 3 hours

Underlying principles

- Teachers' classroom practices as a starting point,
- Attention to the practical needs of teachers in relation to their curriculum practices,
- Strong emphasis on collaborative work among teachers.

Collective session format

- 1. Reflection on the tasks previously implemented in the classroom,
- 2. Working on tasks and discussing (deepening teachers' mathematics and mathematics teaching knowledge),
- 3. Discussion of the tasks to propose in the classroom.

Classroom supervision

- The teachers could put into practice the tasks collectively planned, keeping the responsibility of organizing and coordinating the classroom work,
- Analysis and reflection by the teacher and the supervisor after each class.

Session contents

- Exploring student errors in solving problems; Exploring different representations of rational numbers; Operations with rational numbers….

Example

The calculator module

(Célia Mercê)

Task -In a clothing store there are t-shirts that cost 44.50€ and are now with a deduction of 20%. Ana decided to buy two t-shirts and found, after doing some calculations that it would pay 53.40€. When he reached the box the wizard asked for 71.20€. Ana was very confused. So, who is right?

Maria - *I think that Ana is right because a t-shirt has a 20% discount, so:*
44.50 x 2 =89
20+20=40%
89 x 0.40=35.60
89-35.60=53,40

Francisco - *None is right because:* 89-40%= 49€

Miguel - *The wizard is correct because:*
44.50 x 0,20=8.90€
8.90+8,90=17.80€
89€ - 17.80€=71.20€

Marta - *The wizard is correct because:* 89-20% = 71.20€

Example

The calculator module

(Célia Mercê)

Sónia: No, she [Marta] has nothing to do with Francisco (…) She did not indicate correctly the problem, so, if she got 71.20, it is because she had to do 20% of 89.

Anabela: But is not what is here.

Sónia: Okay, this is what I am saying. She put not the correct indication.

[Lot of talking]

Teacher Educator (TE): But how does she do 89-20% and get 71.20?

Sónia: She did with the machine.

[Lot of talking. Sónia takes a calculator and does computations]

Sónia: Oh! The machine was roguish. If she put this here on the machine she gets 71.20 right away.

Anabela: Oh, yeah. [Confirms in the calculator]

Sónia: I, by chance, was not sure if this would work.

Monica: What?

Sónia: If we put 89-20%...

Marta: But, that… She stopped using the percent technique.

[Confusion among teachers. Some seeming outraged by what the student did]

Key idea 1 - Teacher education based in professional practice

Teacher education based on practice **(Smith, 2001)**

- Teacher education seeks to recognize the existing problems in the practical situation that the teacher experiences and frame their solution in the light of theory.

Teacher education situated "in practice"

- The materials that represent the teaching activity (students' work, mathematical/statistical tasks, classroom episodes) are used as opportunities for critique and investigation.
- Teachers develop knowledge analyzing real situations.

Teacher education based on teachers' own practice

- Teachers collect data from their practice and reflect about them with support of the teacher education setting (teacher educator, other teachers).

Key idea 2 - Teacher education based at the school and the professional group

Diagnostic of students real difficulties

- The starting point of teacher education process is not "what is new" that one must know, but the real struggles of students.

Intervention/Professional development projects

- Establishing verifiable objectives,
- Working in a project and collaborative mode.

Auto-learning in the group

- When it is not possible to solve a problem within the group, one seeks external help.

Organization

- Joint planning and exchange of experiences,
- The classroom and the subject group (or its formal subgroups) are essential acting spaces.

Key idea 3 – Challenge / support

Provide examples and reflect good teaching practice

- Using worthwhile tasks, improving classroom discourse…
- Encouraging students' reasoning, expecting teachers to assume intellectual risks.

Create disequilibrium in teachers

- Challenging conceptions about mathematics, mathematics learning and who can do it,
- Involving necessary moments of discomfort...

Encourage teachers' collaboration

- Defining common goals and combining with individual objectives…
- Negotiating ways of working together...

Take into account the teachers' contexts

- Students, teachers and their current practices and resources available,
- Regulations, educational system guidelines, school calendar, school administration.

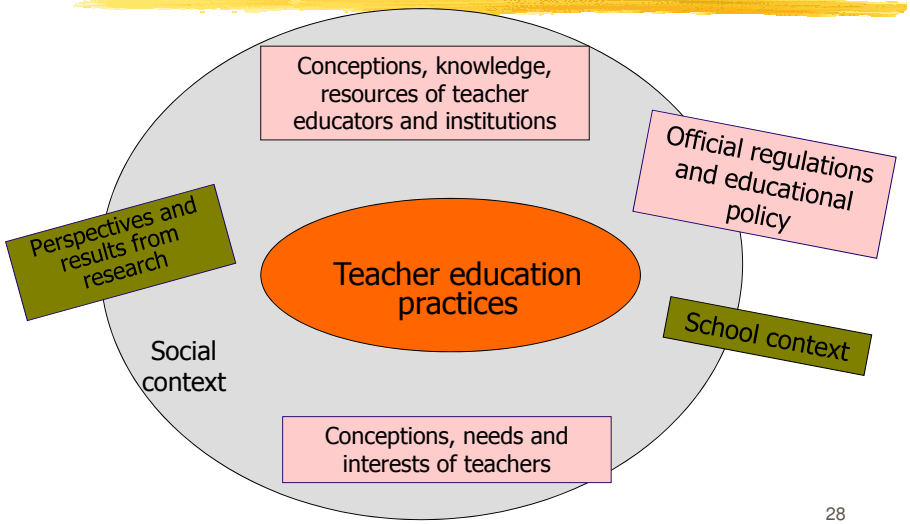
Use teachers' knowledge and competency

- About students, curriculum, schools, and communities,
- Also use external contributions, e.g., university staff.

Sustentability and cohesiveness

- Set experiences that amplify each other and contribute towards a coherent plan (project),
- Involving a significant time...

Influences on teacher education practices



Examples

Large scale teacher education

National Teacher Education Plan for primary teachers (1-4 and 5-6) in mathematics

- Coord.: Lurdes Serrazina
- 1 year of work
- weekly meetings and supervisions at school

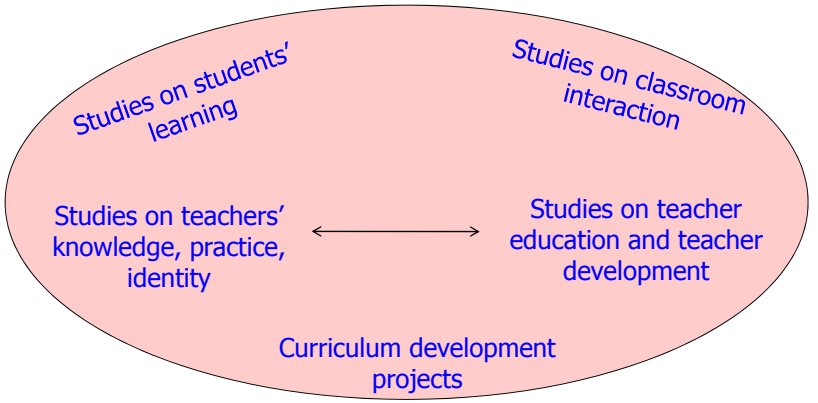
Teacher education for the new basic education curriculum (1-4, 5-6, 7-9)

- Coord. Curriculum team
- "Workshops" with 20 teachers
- 6 sessions 4 hours each (3—4 months), with the planning, doing, reporting and discussing of a classroom experience.

School based teacher education for the new basic education curriculum

- Involving all teachers of a school-grouping of schools
- Focused on school improvement plans, working on yearly cycles.

Understanding teacher development



5.

Questions for discussion

- Is mathematics teaching moving towards becoming a **professional activity**? Are mathematics education researchers supporting or opposing it?
- Is the mathematics **teachers' identity** changing? If so, what are the driving forces of such change?
- Is it possible to **investigate teaching** without the (implicit/ /explicit) collaboration of teachers?
- Is it possible to **improve teaching** without improving mathematics teachers' craft knowledge?
- Is it possible for **mathematics educators** to work (collaboratively) with teachers and get (full) academic recognition?
- How to design large scale **in-service teacher education** with real impact in teaching practices?
- What are the critical choices that a **pre-service teacher** education program (for math / for elementary teachers) faces?

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