Reform in science education and science teacher learning

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Some problems in science education

- Curricula are traditional and overloaded
  (e.g. De Vos & Van Berkel)
- Conceptual learning problems
  (e.g. Driver, Ogborn, Gilbert, Treagust, Duit)
- Traditional teaching methods dominate
  (e.g. Aubusson, Pampaka)
- Attitudes towards science education are problematic
  (e.g. Osborne, Simon & Collins; Kessels)

Some solutions

- Curricular and extra-curricular initiatives (e.g. modern science content; public understanding of science; technology and design)
- Innovative approaches to science learning (e.g. inquiry-based; technology-enhanced; context-rich; collaborative)
- Research indicates positive impact on student learning and attitudes towards science (Vaessen et al., 2015)

The central role of teachers

"For the research evidence shows clearly that it is the teacher variables that are the most significant factor determining attitude, *not* curriculum variables."

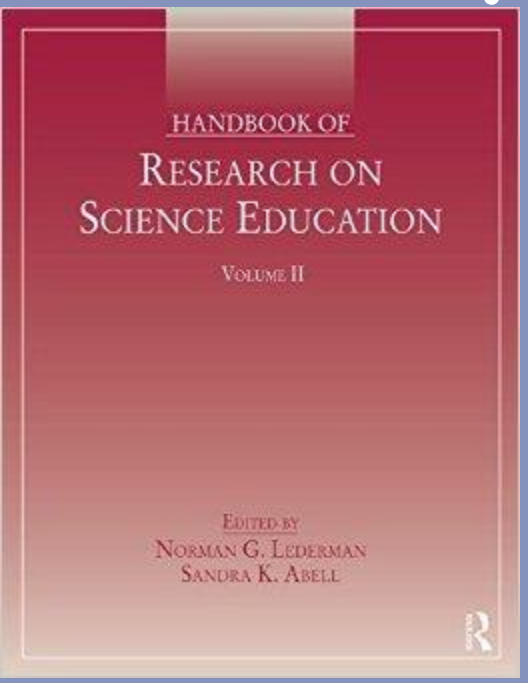
(Osborne, Simon & Collins; 2003, p. 1070)

Historical overview of research on teachers and teaching

- Teacher personal traits and attributes
- Teacher behaviour and classroom actions
- Teacher planning and decision making
- Teacher knowledge and beliefs
- Teacher learning and development

(Cochran-Smith, 2015)

Section VI. Science Teacher Education (Section Editor –John Loughran)



- 40. Developing Understandings of Practice: Science Teacher Learning - *John Loughran*
  41. Science Teacher Attitudes and Beliefs: Reforming Practice - *Gail Jones & Megan Leagon*
  42. Research on Science Teacher Knowledge – *Jan van Driel, Amanda Berry, & Jacobiene Meirink*
  43. Learning to Teach Science – *Tom Russell, Andrea K. Martin*
  44. Research on Teacher Professional Development Programs in Science – *Julie A. Luft & Peter W. Hewson*

Questions for practice and research:

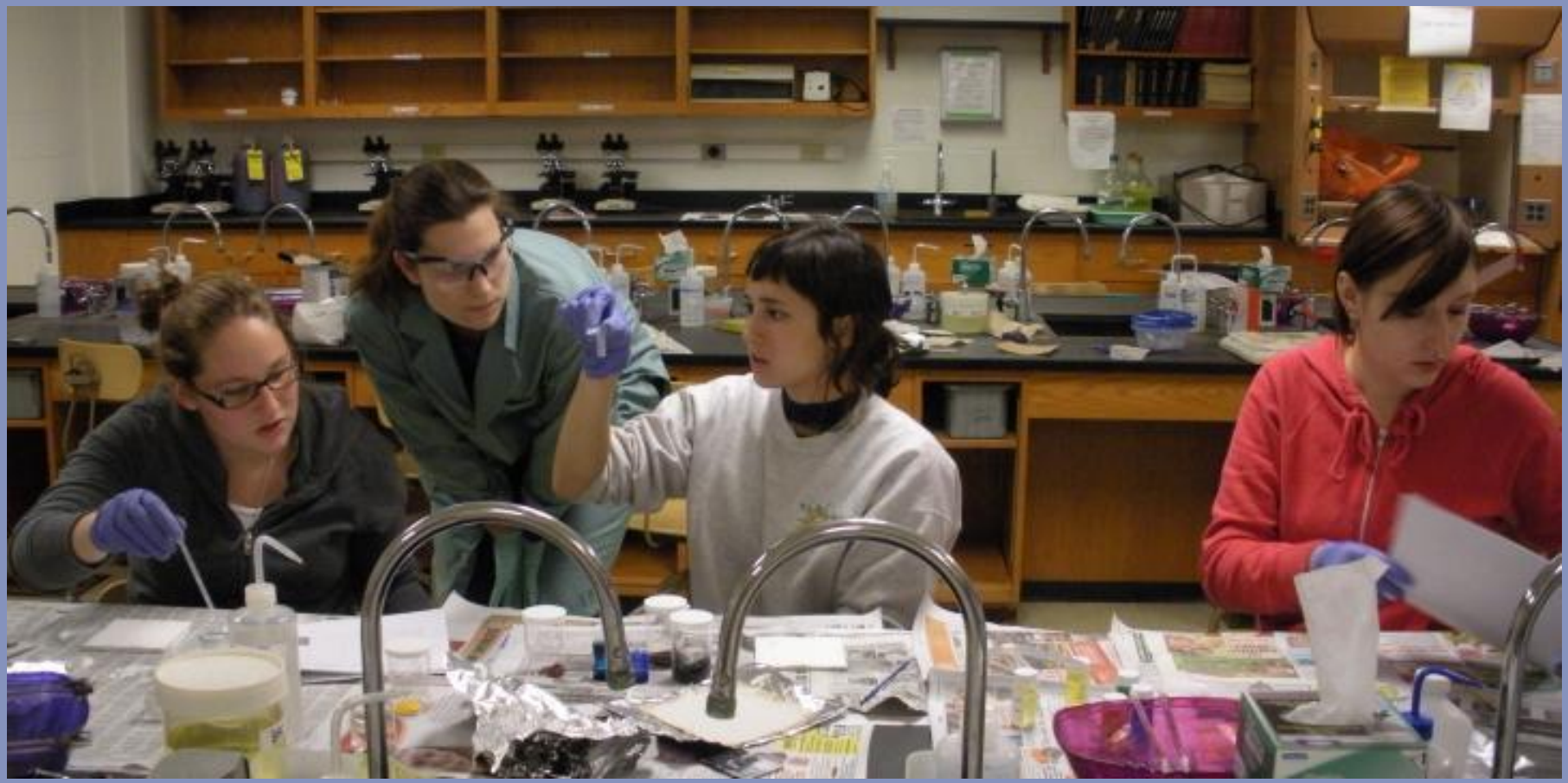
- How to prepare high quality science teachers and how to foster their ongoing professional development?

- How can we understand science teachers' development in relation to their professional and personal contexts?

Teaching –
From a subject matter perspective:

What does a teacher need to know and be able to do?

- Stating learning goals, based on thorough analysis of subject matter
- Knowing how students learn specific subject matter; what is difficult and interesting for them
- Applying strategies aimed at learning and appreciating of specific subject matter
- Knowing which strategy is adequate, when and for whom



Pedagogical content knowledge

Lee Shulman (1986, 1987*):
What knowledge distinguishes a physics teacher from a physics expert? And from a history teacher?

“ That special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding.”

*See also Berry, Loughran & Van Driel (2008)

Professional learning of in-service teachers

(Continued) Professional development:

- Formal or driven by supply (In-service teacher education; coursework; summer institutes)

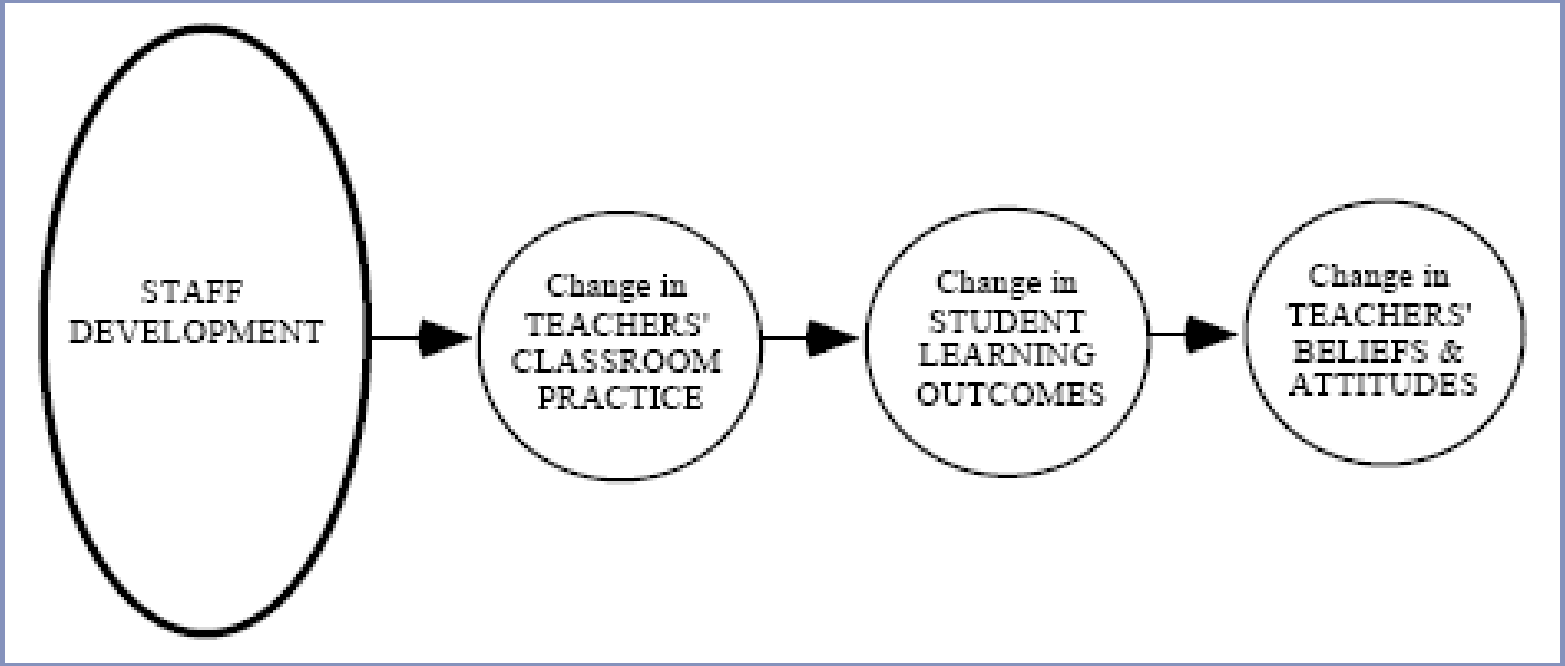
- Informal or driven by demand (Teacher learning communities; peer coaching; action research)

Profesional development and education reform

Traditionally:

- Emphasis on curriculum reform
- Followed by development of teaching materials
- “What do teachers need to know and how should they act?”
- Teacher ‘training’ aimed to acquire knowledge and skills

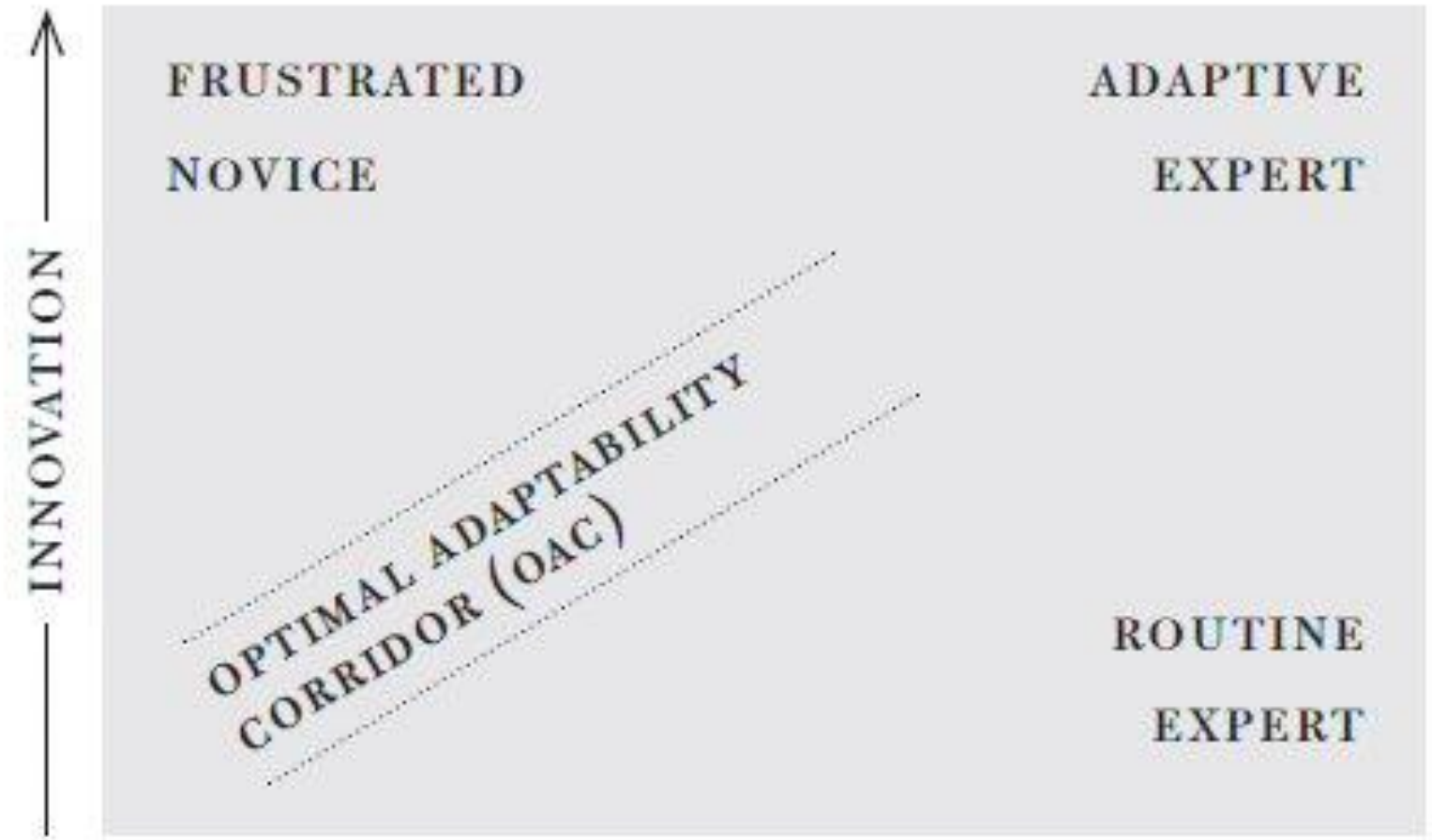
A model of teacher change
(Guskey, 1986)



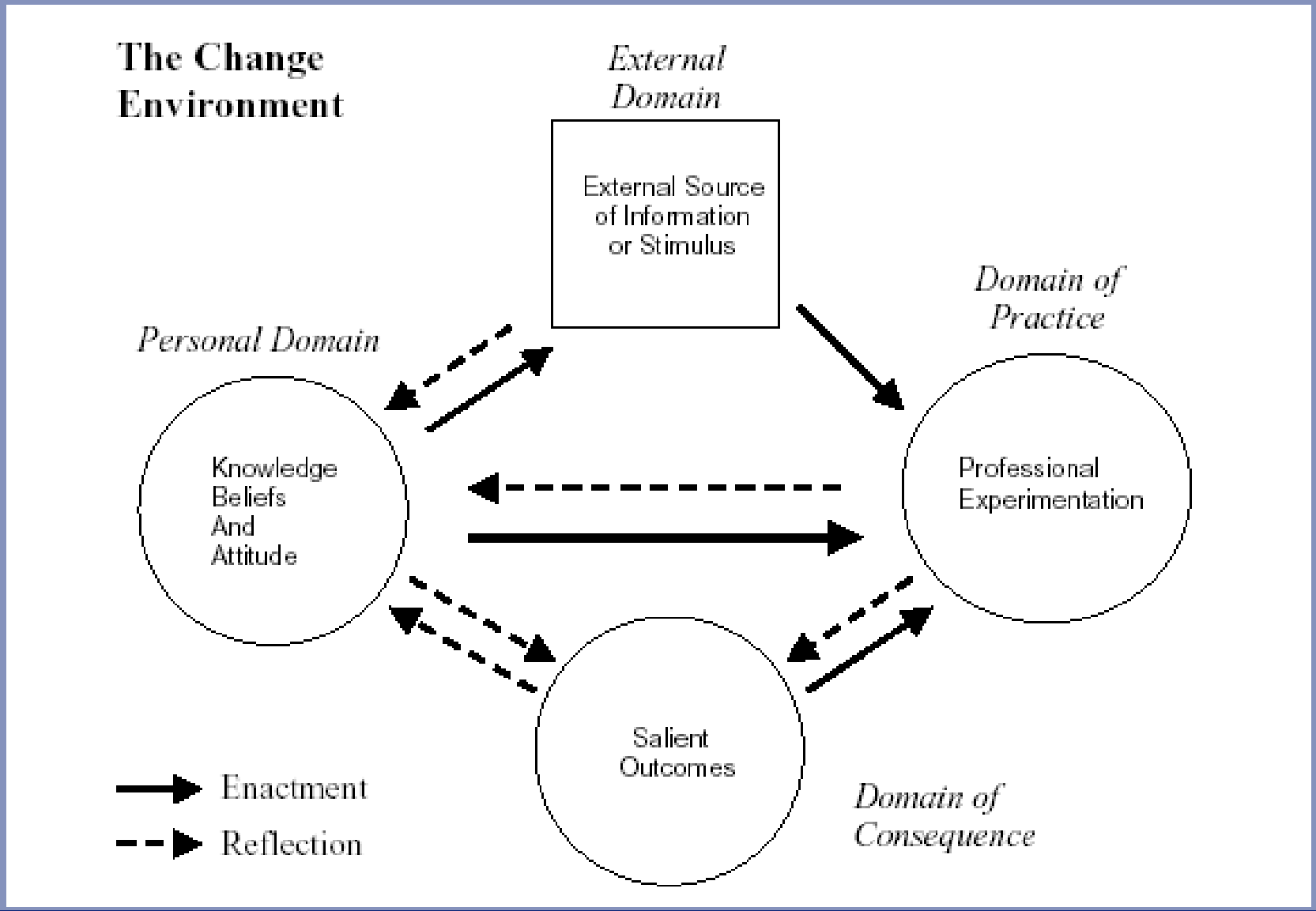
What and how do teachers learn in the context of reform?

- Teachers respond quite differently to reform initiatives;
- This is determined by their personal ideas and goals, as well as their context;
  (Doyle & Ponder, 1977; Kennedy, 2010)
- Collaboration (formal as well as informal) may stimulate teacher learning;
  (Meirink, 2007; Zwart, 2007)
- Teachers learn in different ways (Henze, 2006)

Adaptive expertise
(Hatano & Inagaki, 1992)



Interconnected Model of Teacher Professional Growth (IMTPG; Clarke & Hollingsworth, 2002)

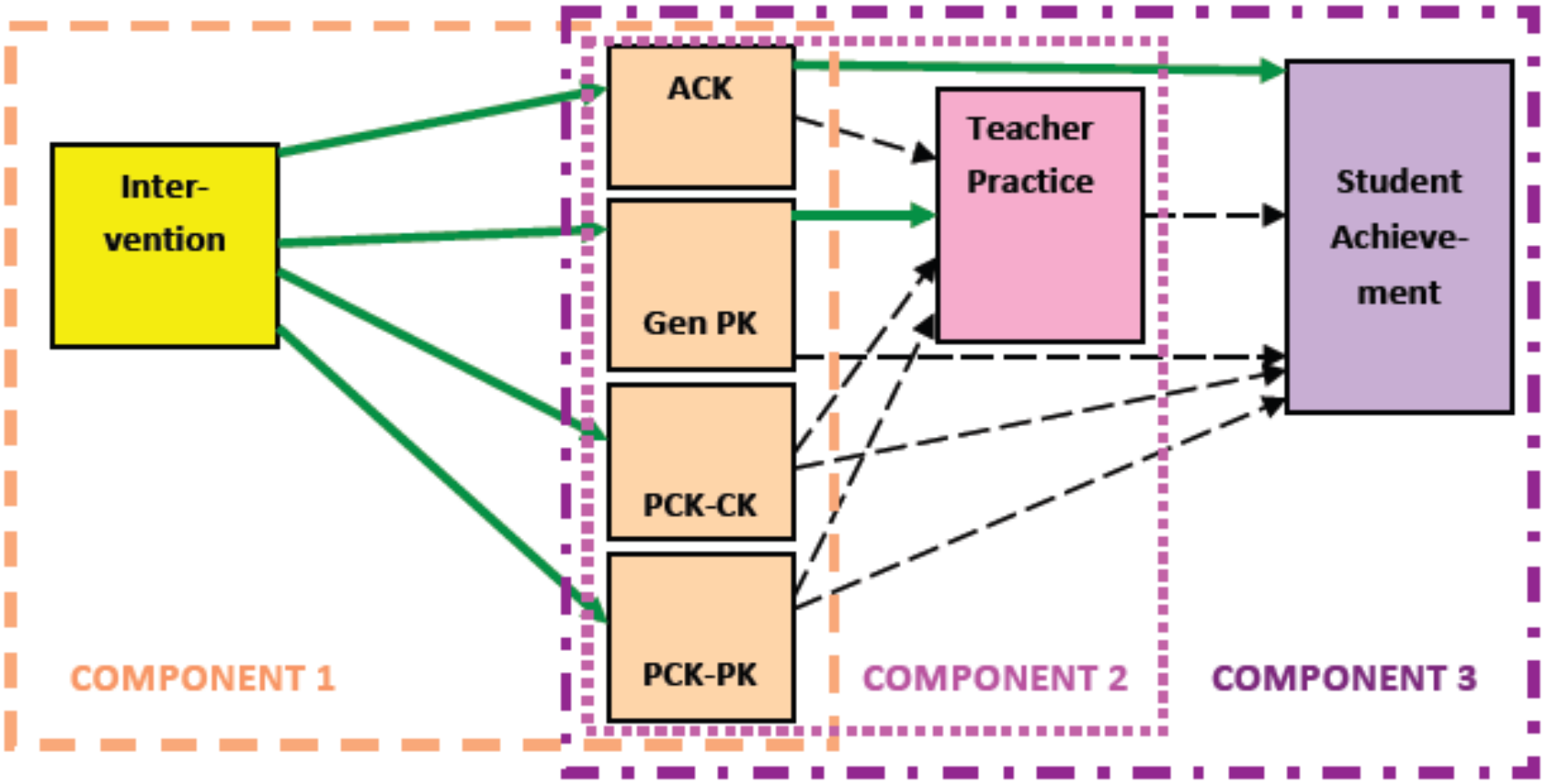


Review of recent studies on PD in science (Van Driel et al., 2012)

- In most studies it was found that the ‘general’ characteristics of effective PD were applied (e.g., connected to teaching practice, external input, duration, collaboration, support)
- Focus of PD is usually on enhancing teacher knowledge combined with changing practice
- Studies on science PD show a lack of attention for school organisation and role of facilitators
- Few studies on relation of PD with student learning

Studies on PD relating science teacher learning to student learning

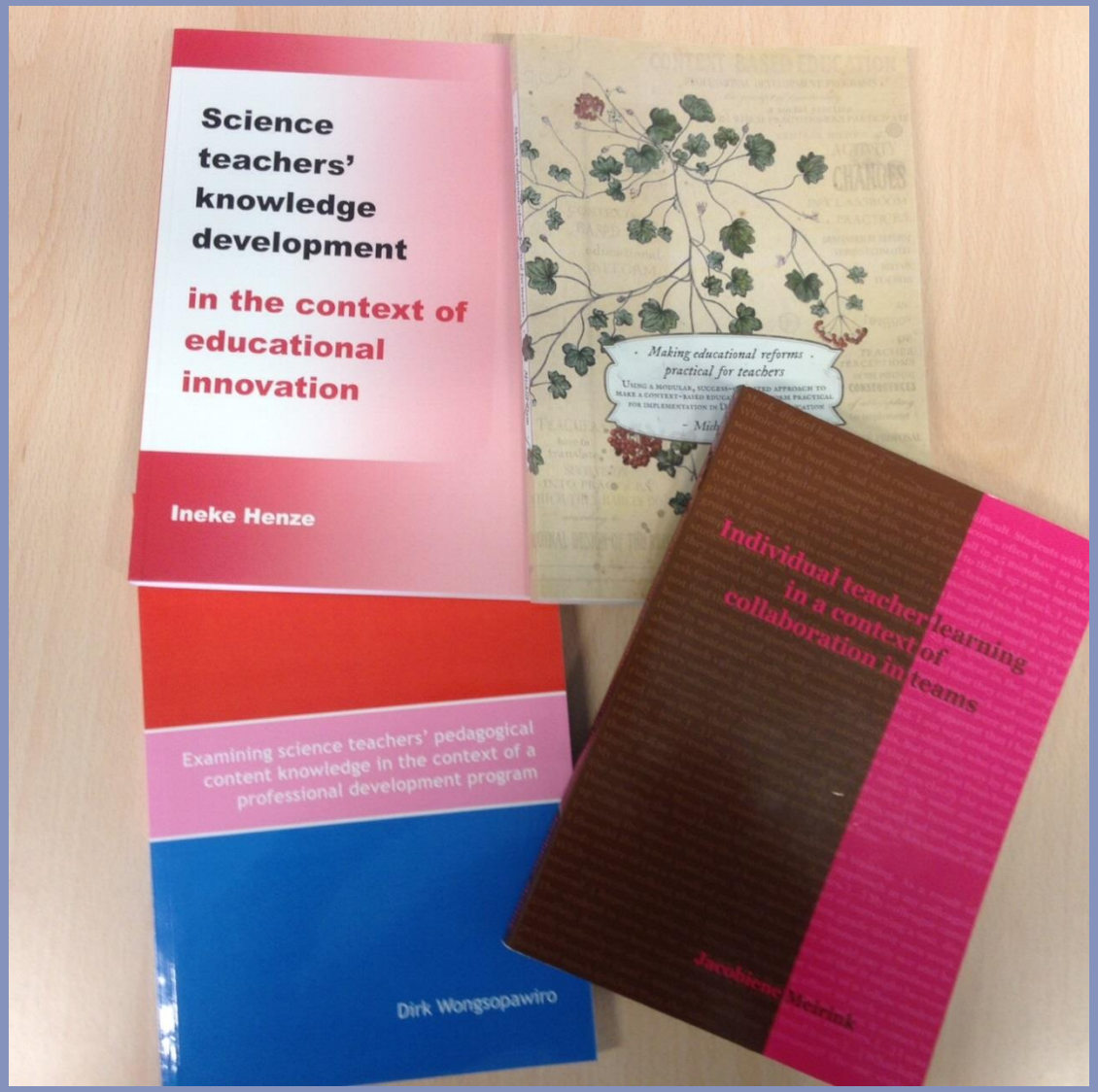
- Some studies found that a PD program promoted both teachers' content knowledge and PCK, which was correlated with student learning gains (e.g., Heller et al. 2012; Roth et al. 2011)
- Other studies found that both content knowledge and PCK increased, but only content knowledge was related with student achievement (Gess-Newsome et al., 2011)



From : Gess-Newsome et al. (2011)

Some examples

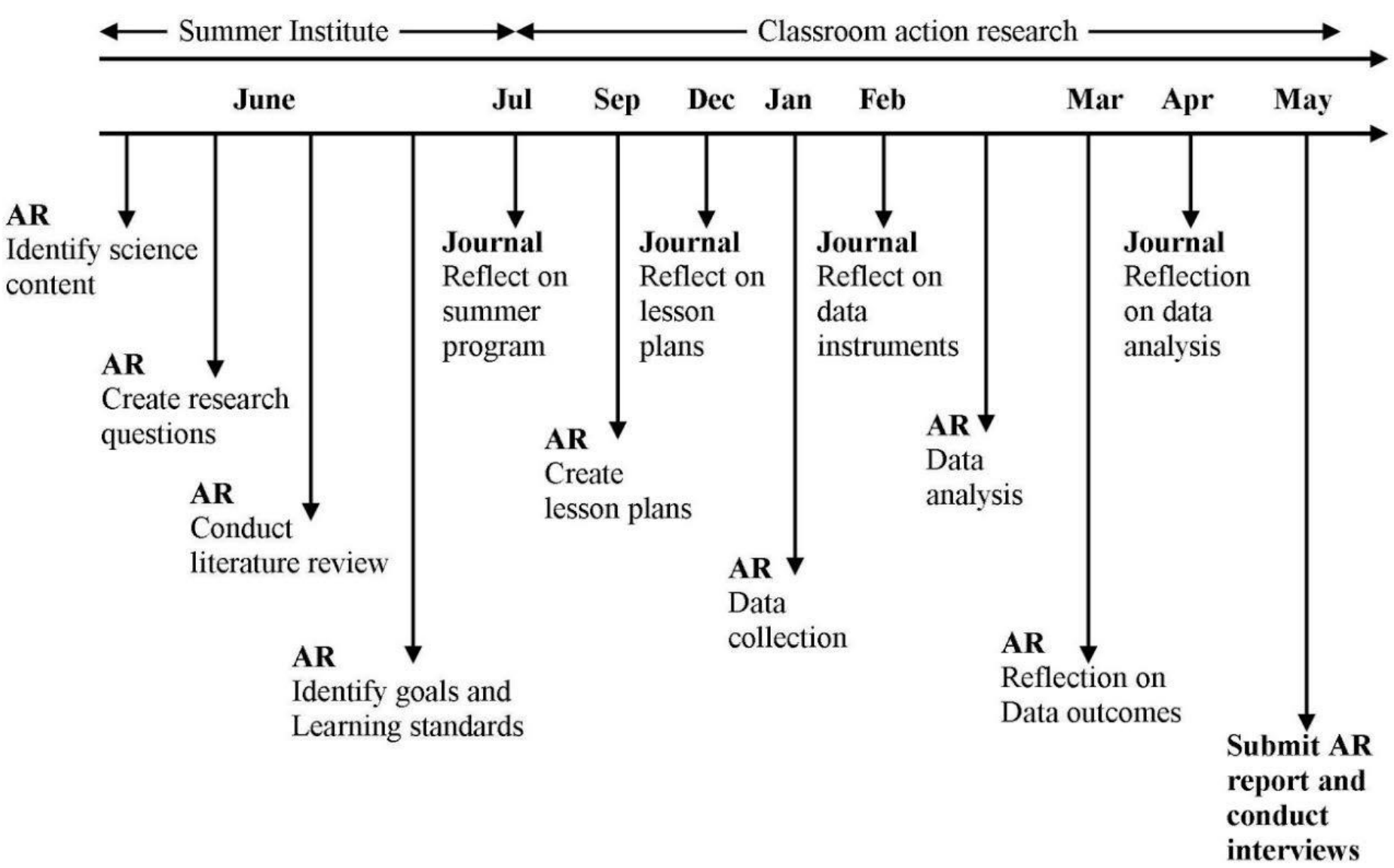
(ICLON PhD studies)



Professional development aimed at PCK enhancement

(PhD thesis Dirk Wongsopawiro, 2012)

- Two week summer institute, resulting in plan for action research
- Development of lesson plans, focused on topic of own choice
- Action research project during next school year
- Support from university staff and colleagues
- Teachers kept electronic journal and were interviewed

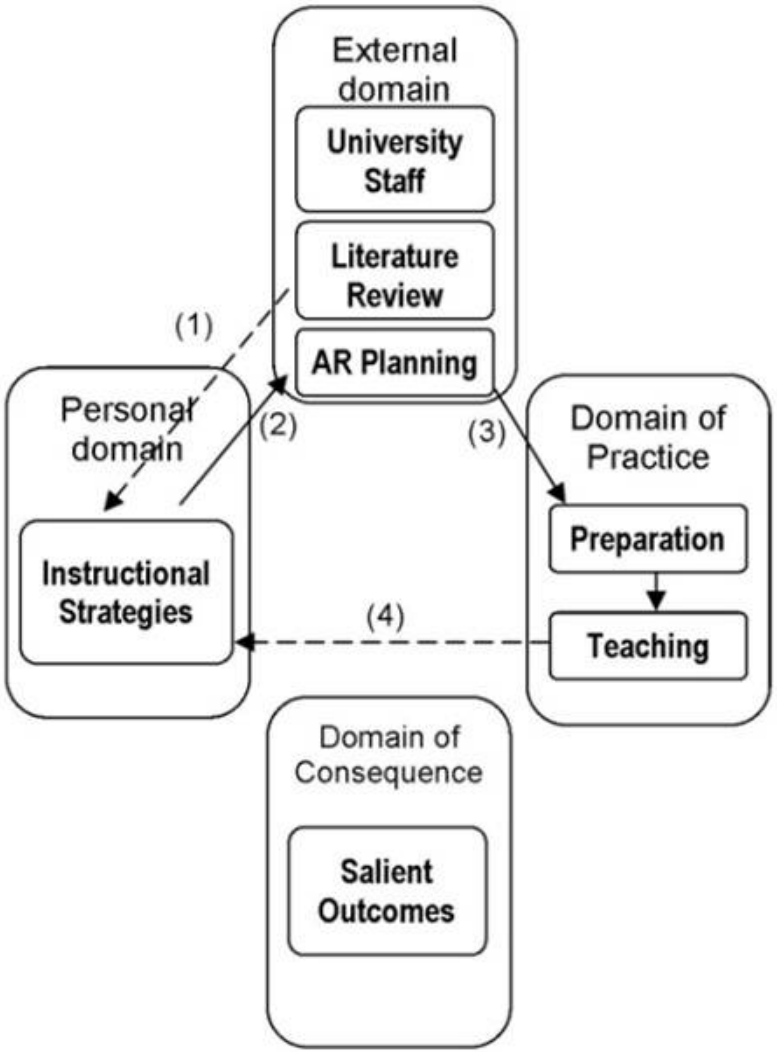


AR: Action Research Report
Journal: Teacher's Reflective Journal
Interview: Teacher's Interview

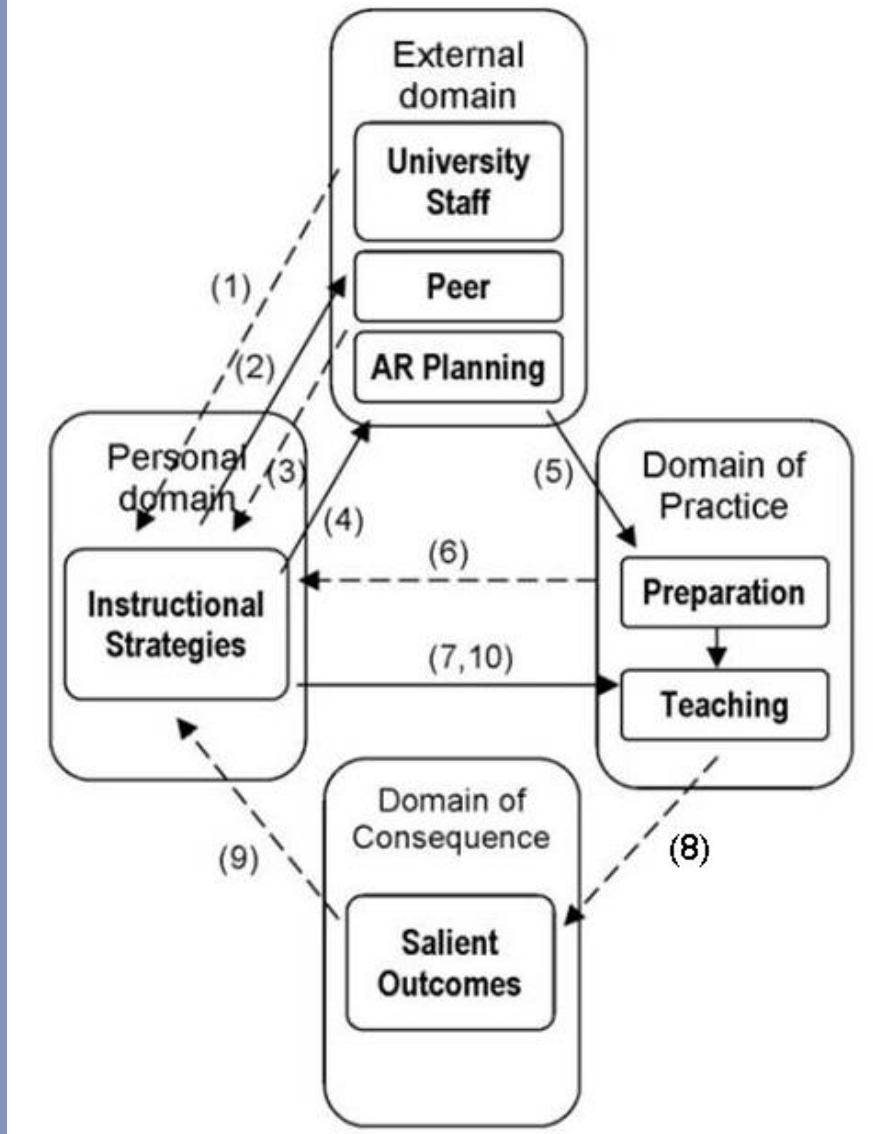
Some findings:

- Learning process was usually initiated by external input (university staff, research literature)
- Action research promoted experimenting in practice, but with different implications
- Distinct pathways were identified, demonstrating differences in terms of impact on personal domain and domain of practice
- Reflections on student learning (domain of consequence) were vital to promote and sustain growth

Knowlegde of instructional strategies



Pictogram 4
Teachers 3,4,5



Pictogram 6
Teachers 1,7,9,12

Making educational reforms practical for biology teachers
(PhD thesis Michiel Dam, 2014)

- Towards implementing a context-based biology curriculum
- PD was based on practically theory (Doyle & Ponder, 1977)
- Teachers were supported to build on earlier success experiences and recombine lesson segments
- Teachers made lesson plans, collected student data, and were observed and interviewed.

Some findings:

- Re-organizing lesson plans in terms of segments (e.g., explaining, introducing central question) helped teachers to make sense of the context-based approach (*instrumentality)*
- Connecting previous success experiences with ideas of the innovation, helped teachers to formulate specific intentions (*congruence)*
- Taken together, teachers made step-wise and efficient progress implementing the innovation (*cost)*

Implications for PD: 'What works' for teacher learning?

- Focus on student learning of specific science topics:
  - Studying research literature on student learning
  - Analysing authentic student work
  - Collecting and analysing data in classrooms.
- Incorporate opportunities to teach science topics in a variety of ways (e.g., planning lesson segments and using innovative curriculum materials).
- Support sense-making activities, e.g., reflecting with peers, mentors, and university staff on (successful) teaching & learning experiences.

Final remarks

- Being professionals, teachers have a responsiblity to keep learning and developing
- Teacher learning is a complex process which is hard to plan and control, and of which outcomes are hard to predict.
- Focusing research on PD on improving student learning outcomes, may lead to ignoring important effects!