Weaving theory and practice together in science and mathematics education

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Homi Bhabha Centre for Science Education

One-day Seminar

Road Ahead in Science, Technology and Mathematics Education in India

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Homi Bhabha Centre for Science Education

Tata Institute of Fundamental Research

Theory and practice of science and mathematics education (Post Independence)

- School education (State, aided, low cost private, elite)
- University education
  - Facts, relations and practices of science / mathematics
  - Philosophy and sociology of science / mathematics
  - Developmental psychology, Cognitive science
  - Educational theory
- Curriculum development - NCERT / SCERT / Balbharati / SISE
- Professional education of teachers, 'educational research'

Theory and practice of science and mathematics education

1990s onwards

- In-service programs - SSA / DRC / BRC / CRC
- NGOs - material development, local interventions
- Teacher associations, Olympiads
- Private service providers - ex-IIT, IIM
- Science outreach - CSIR, TIFR, etc.

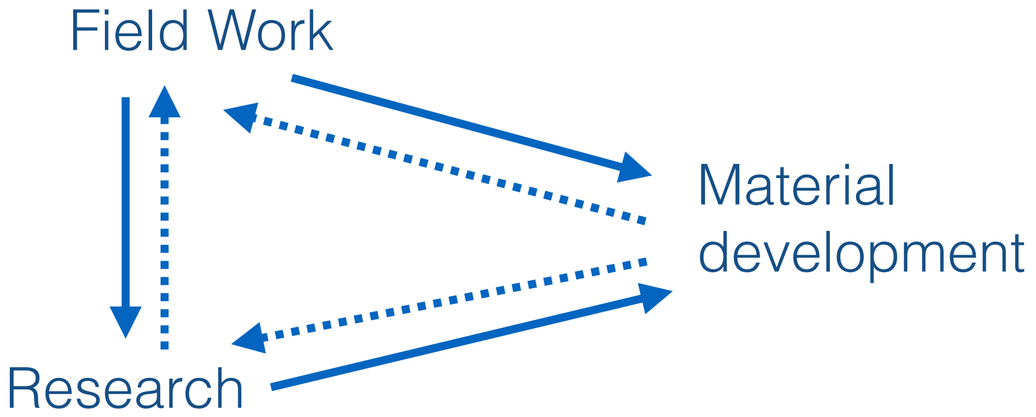
HBCSE's quest

- Practice-based R&D in science and mathematics education (1970s - 90s)
- Field-work / action research of 1970s and 1980s

To identify the socio-cultural, linguistic and pedagogic factors that hamper the progress of first generation learners in school (and force them to drop out), and to develop and test remedial measures to overcome these difficulties

V. G. Kulkarni (1987)

- 1990s



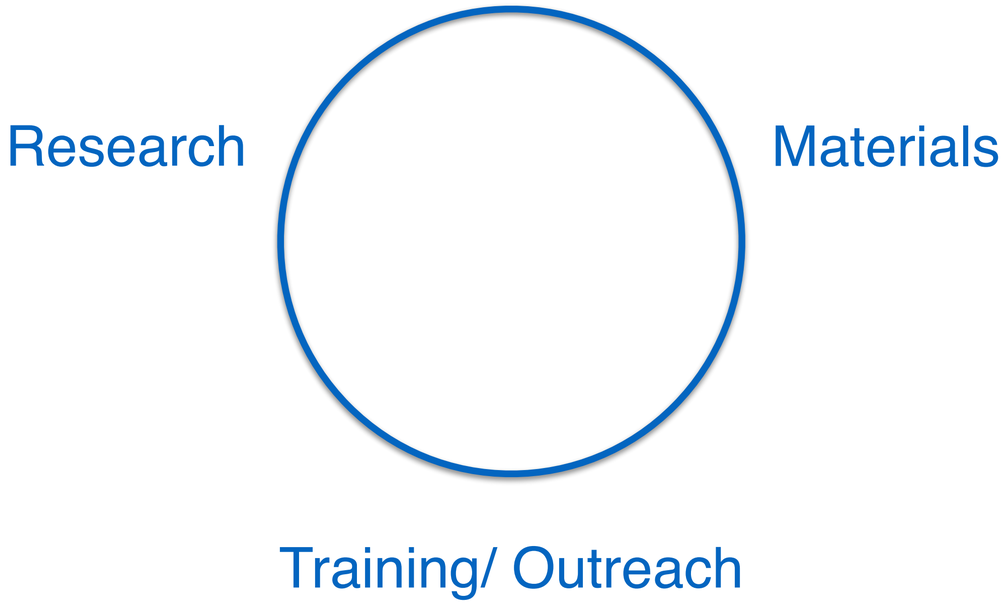
Source: V. G. Kulkarni, HBCSE brochure of 1990s (edited)

HBCSE's quest

- Practice-based R&D in science and mathematics education (2000s)
- A vast span of programs
  - From primary school to undergraduate level
  - From education for disadvantaged, underperforming students to talent nurture for the Olympiads

HBCSE's quest

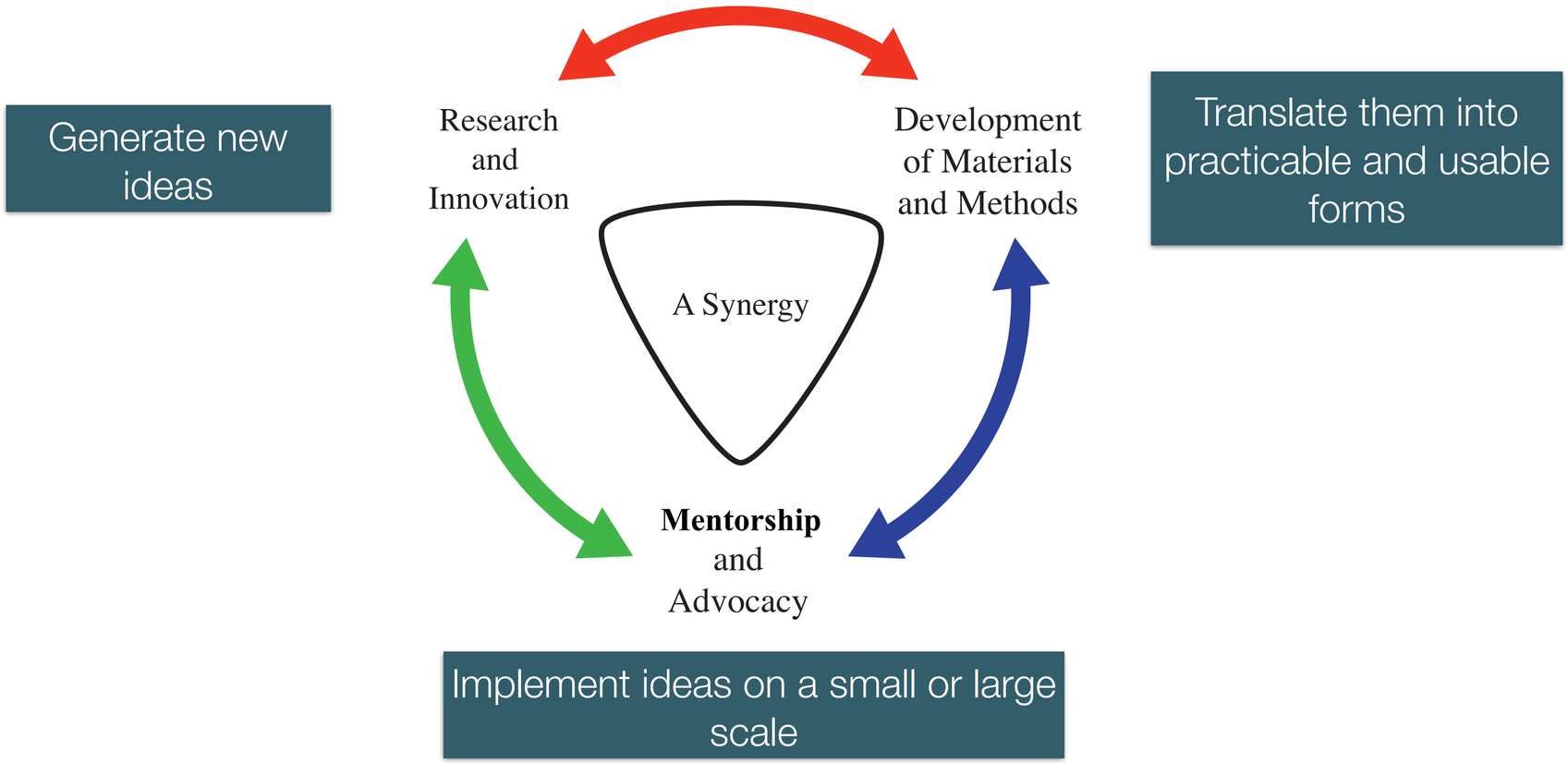
- Linking programs with R&D mandate
- Linking practice with theory



Source: K.Subramaniam, NIME presentation (2011)

HBCSE's quest

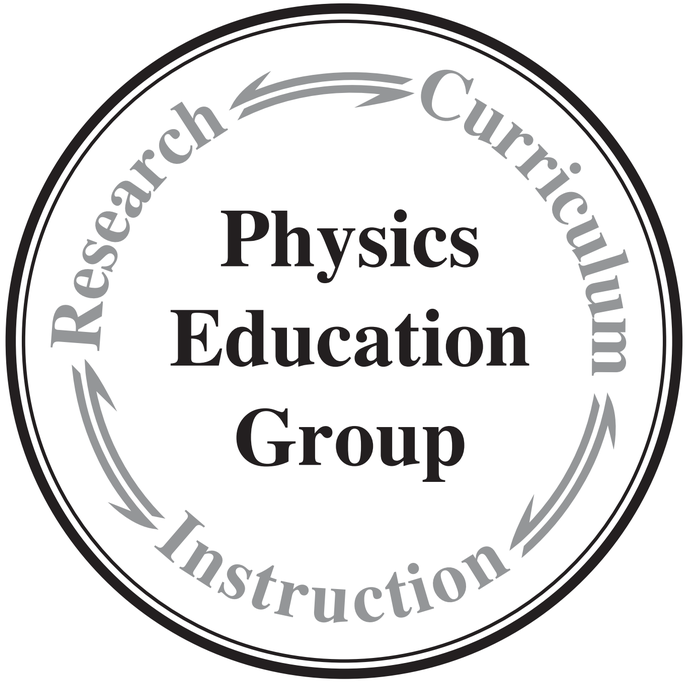
- Practice-based R&D in science and mathematics education



Source: HBCSE Self-Review and Vision, October, 2014

From PEG - University of Washington (1)

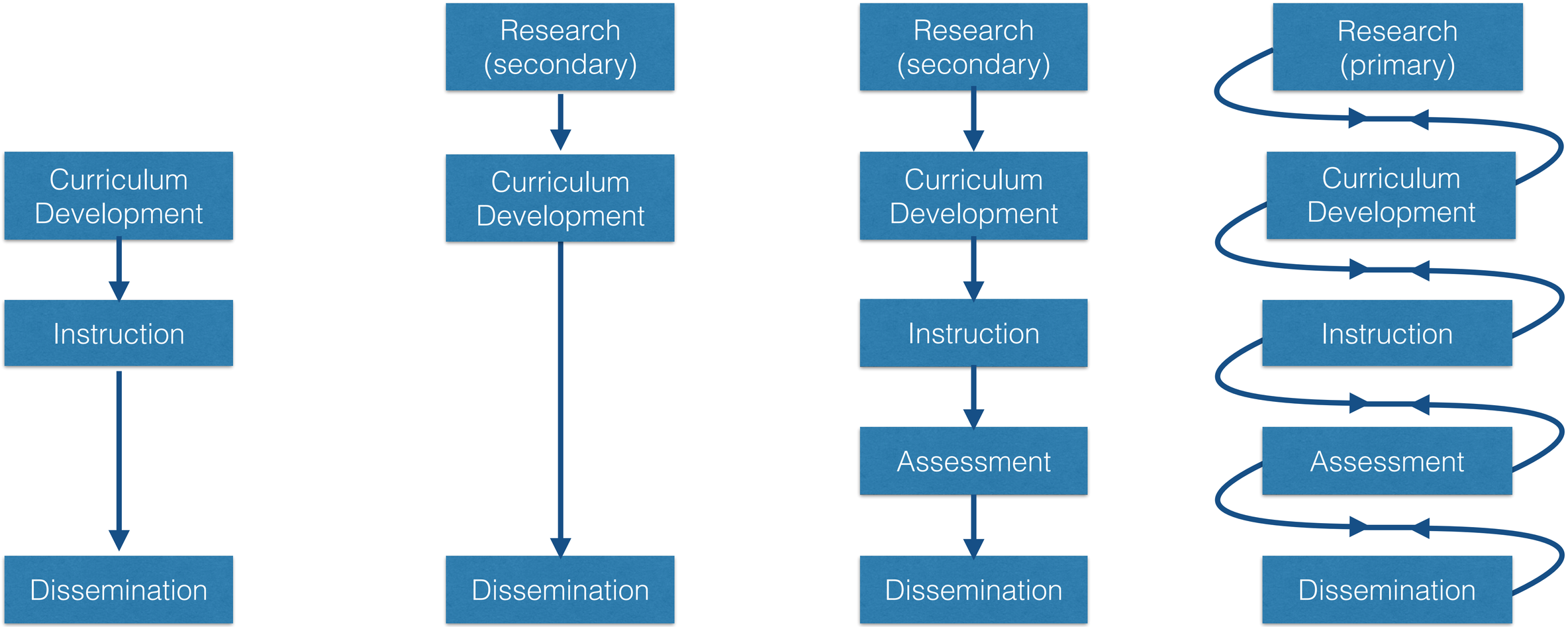
- The Physics Education Group at the University of Washington conducts a coordinated program of research, curriculum development, and instruction to improve student learning in physics from kindergarten through graduate school... For more than 40 years... https://depts.washington.edu/uwpeg/physics-education



Source: The development of research-based and research-validated curriculum: Peter S. Shaffer, Lillian C. McDermott and Paula R. L. Heron and the Physics Education Group, Department of Physics, University of Washington, Seattle, WA, USA. http://www.aps.org/meetings/multimedia/april2008/upload/April2008-T7-1-Shaffer.pdf

(Date approx. 2008)

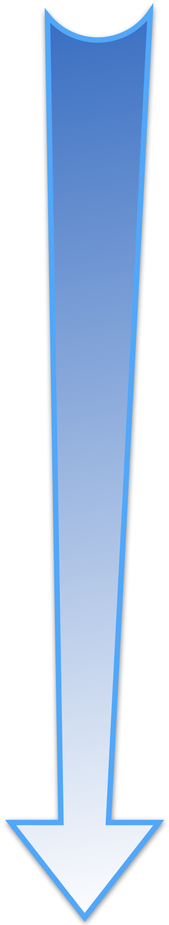
From PEG - University of Washington (2)



Source: Paula R. L. Heron (2015), personal communication

Theory, practice and identity

A timeline of mathematics education at HBCSE



- 1970s: Interaction with teachers of BMC / Jalgaon dist. schools
- 1980s: Talent nurture of first generation learners in BMC schools; teacher training; cascade model
- 1990s: Remedial maths materials; Ashram school teachers – orientation/ training
- 2000s: Primary maths curriculum, primary and middle school teacher orientation, TPD models; learning trajectories in the middle school
- 2010s: Research on teachers' knowledge, out-of-school mathematics, learning trajectories; pre-service education

Mathematical knowledge of teachers

- Has been a consistent focus over the years
- Has included *specialised content knowledge* and *pedagogical content knowledge*
  - Multiplication of fractions using an area representation (SCK)
  - Evolution of number systems (HCK)
  - Common student errors (PCK)

What level of practice-based intervention is appropriate for STME researchers?

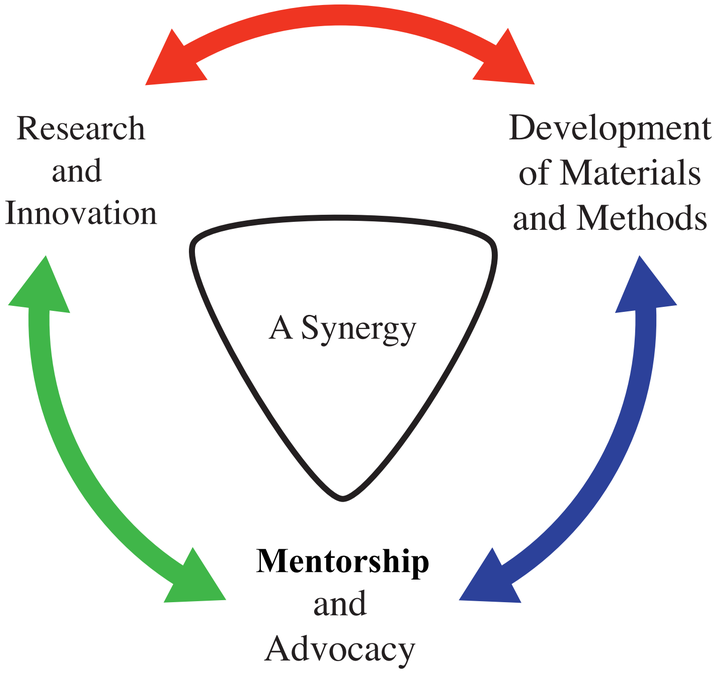
- Small group of teachers or students
- Single school/ small number of schools
  - Whole school improvement
  - Improvement of science and maths education
- Ward / block or district level
- Geographically dispersed but unified school system (Ashram schools)

Theory, practice and identity

- The theory–practice relation and issues of identity
  - Identities and roles within HBCSE
  - Identity of HBCSE within education
  - Teacher identities

Effecting synergy: Issues of identity

Generate new ideas



Translate them into practicable and usable forms

Implement ideas on a small or large scale

Source: HBCSE Self-Review and Vision, October, 2014

What is HBCSE's identity in the field of education?

The theory-practice relation: multiple levels

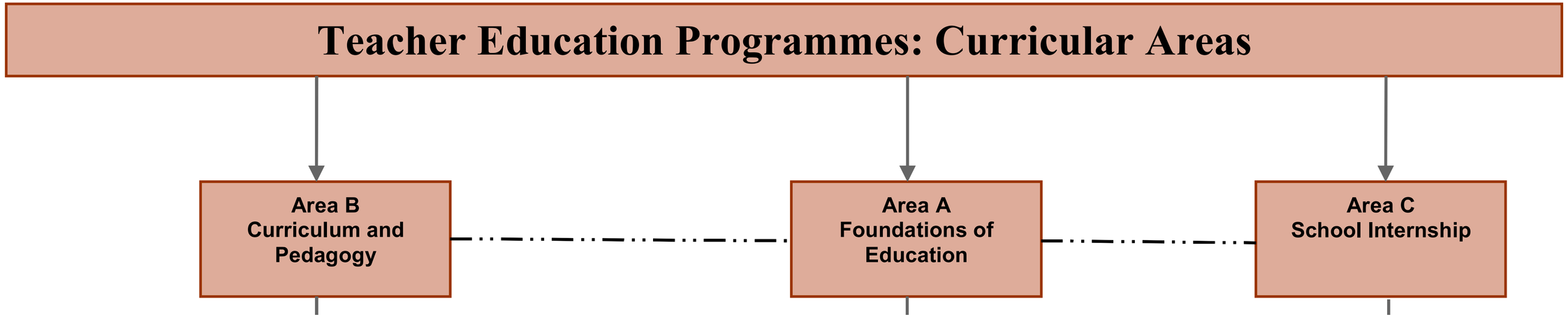
Level 1: What theoretical questions underlie science/maths education research?

- Given both the broad and the specific aims of education, and our understanding of the nature of science/maths, what should the science or mathematics curriculum include, what should it exclude?
- How do theories of cognition help in developing effective pedagogy?
- What implications does history of science / mathematics have for the curriculum and for pedagogy?

Level 2: The theory–practice relation in the field of education

- The interdisciplinary field of education is built around a central activity – the preparation of school teachers.
- Hence it bears a pre-dominant practical orientation.
- Teacher preparation since the early 20th Century has taken place through professional degree-based certification programmes in the University.
- The professional status and the location in the university need a professional knowledge base.
- Hence the need for a curriculum that has theoretical and practical components.

NCTE: Curricular areas (2009)



NCTE B.Ed. Curricular areas (2014)

- Perspectives in Education
- Curriculum and Pedagogic Studies
- Engagement with the field/ practicum
- School Internship

Perspectives in Education

NCTE: “Perspectives in Education” should include courses on

- Childhood, child development and adolescence,
- Contemporary India and education,
- Philosophical and sociological perspectives in education
- Theoretical foundations of knowledge and curriculum, teaching and learning,
- Gender in the context of school and society, and inclusive education. (NCTE, 2014)

Curriculum and Pedagogic Studies

Courses in Curriculum and Pedagogic Studies should deal with:

- Language across the curriculum and communication
- Understanding of a discipline
- Social history of a school subject, and its pedagogical foundations, with a focus on the learner
- Theoretical perspectives on assessment for learning.

Engagement with the field / Practicum

- Tasks and projects with the community, the school, and the child in school and out-of-school… [which] would help in substantiating perspectives and theoretical frameworks studied in a teacher education classroom with field based experiences
- Specialised courses to enhance professional capacities of a student-teacher: language and communication, drama and art, self development and ICT

This formulation of the theory-practice relation is embedded in the standpoint of a generalised pedagogy.

Level 3: What should science/maths teachers know in order for their practice to be effective?

Lee Shulman's intervention

"A central contribution of the work of Shulman and his colleagues was to reframe the study of teacher knowledge in ways that included direct attention to the role of content in teaching. This was a radical departure from research of the day, which focused almost exclusively on general aspects of teaching such as classroom management, time allocation, or planning."

Ball, Thames & Phelps 2008

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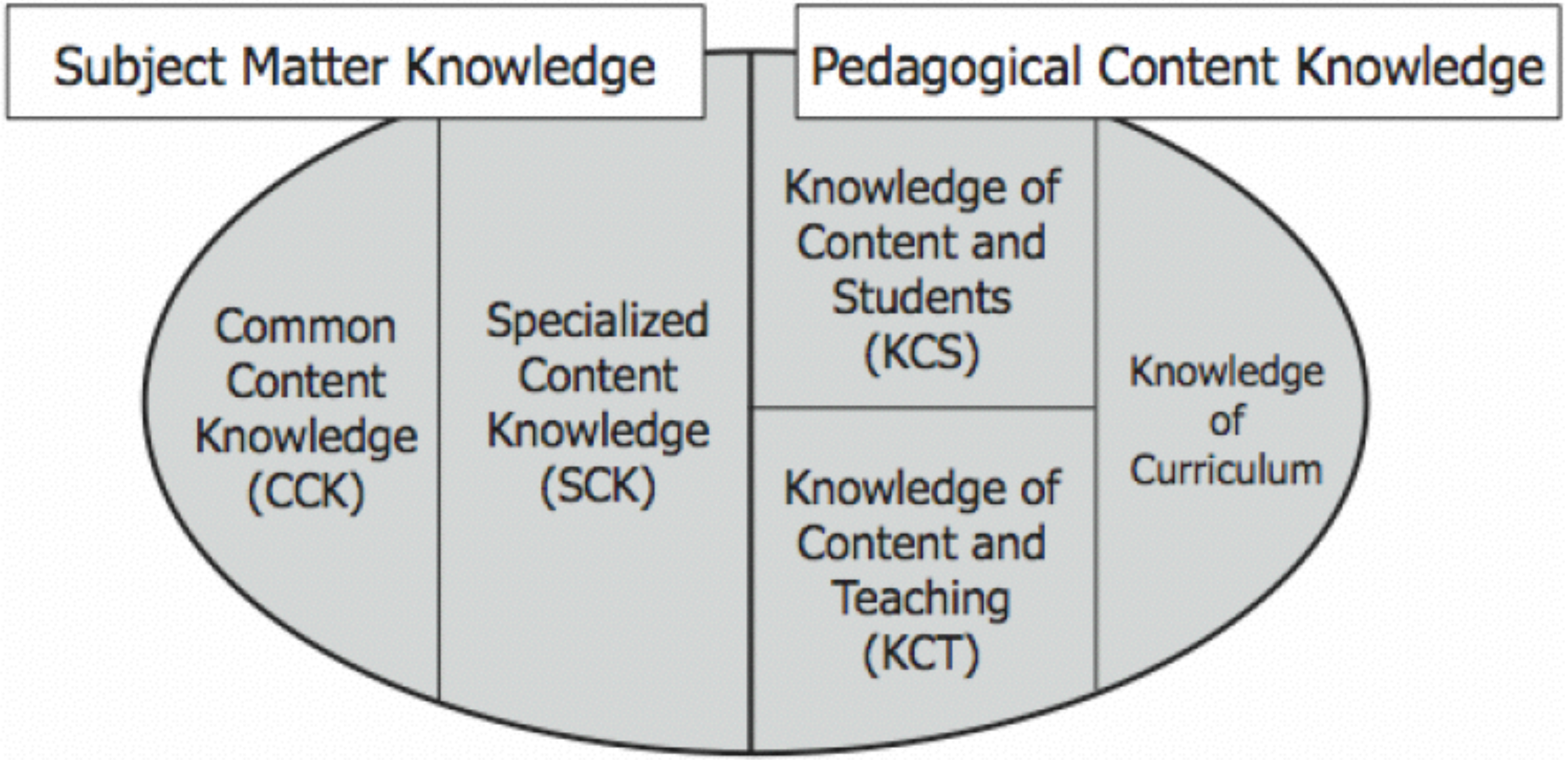

The centrality of subject matter

- Shulman's intervention in teacher education brings subject matter to the centre.
- Teacher identities are primarily subject teacher identities.
- A subject matter standpoint is still to emerge in the field of education.

Education from the subject matter standpoint

- How does subject education relate to the general aims of education?
- How is sensitivity to social issues reflected in subject education?
- How do children construct knowledge of science/ mathematics?
- What do teachers need to know and do to facilitate such construction?

Thank you!