The Role of Education Research in PER and in Teacher Preparation

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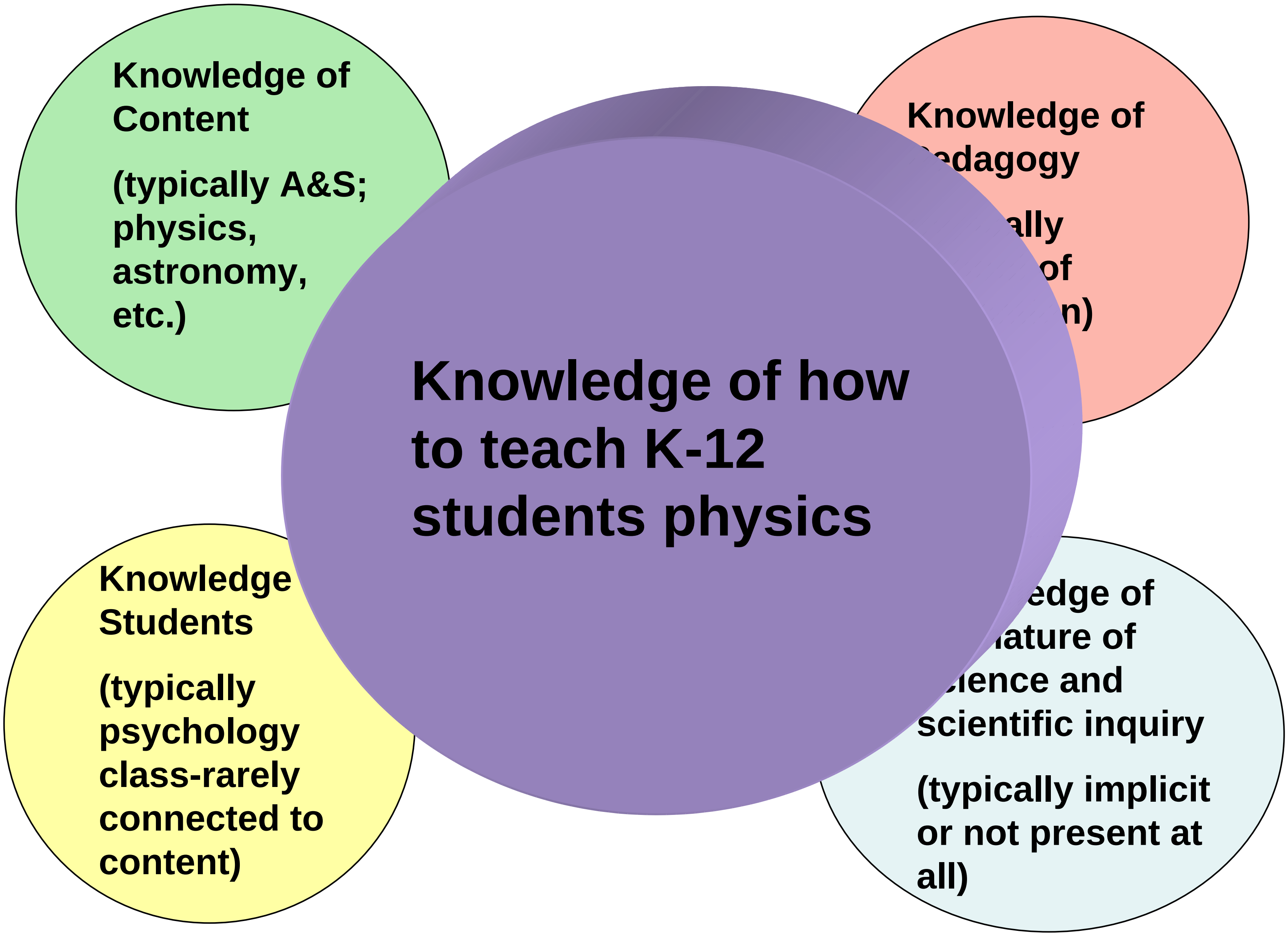
Outline of this Presentation

- **Present the problem PER faces in educating teachers**

- **Describe some of the education research relevant to the question of Critical Factors in Preparing K-12 Teachers**

- **Present some solutions and research-based outcomes (exemplary research projects)**

- **Present some research-based solutions that I am currently involved in**


Knowledge of Content
(typically A&S; physics, astronomy, etc.)
Knowledge of
Knowledge of how to teach K-12 students physics
Knowledge Students
(typically psychology class-rarely connected to content)
scientific inquiry
(typically implicit or not present at all)

Research in Education

"Scholastic knowledge is sometimes regarded as if it were something quite irrelevant to method. When this attitude is even unconsciously assumed, method becomes an external attachment to knowledge of subject matter" (Dewey, 1904/1964, p. 160).

PER has pedagogical content knowledge

However, we are not sure how to teach teachers physics knowledge that will be useful for their classroom practice – How do we help teachers develop pedagogical content knowledge?

What We Teach and How It's Used: Closing The Gap

Questions:

(1) What physics knowledge is needed to teach school physics well?

(2) How must it be understood and held so that it is available for use in the K-12 classroom?

(3) How do we create opportunities for learning subject matter that would enable teachers not only to know, but to learn to use what they know in the varied contexts of teaching practice?

The answer to these questions can be found in: Collaboration between Physics Departments, Schools of Education, and K-12 practitioners

Pedagogical Content Knowledge (PCK)

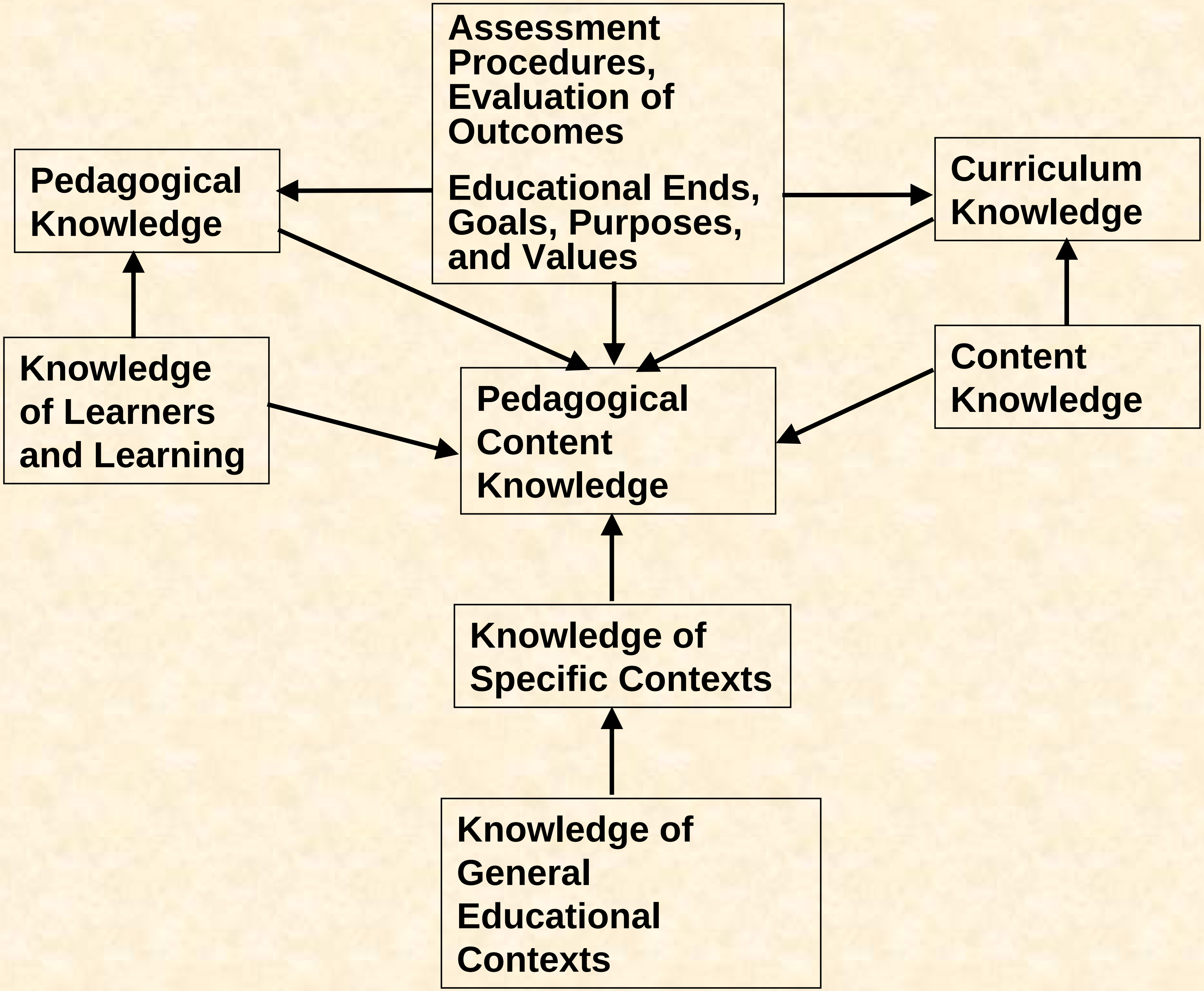
First defined by Schulman (1986, 1987)

"The concept implies that not only must teachers know content deeply, know it conceptually, and know connections among ideas, but also must know the representations for and the common student difficulties with particular ideas" ***(Ball, Lubienski, and Mewborn, 2001 p. 449).***

Five Aspects of PCK:

- **Science curriculum (goals, objectives, approaches)**
- **Student understandings of specific science topics**
- **Assessment (what to assess, how to assess)**
- **Instructional strategies for teaching science**
- **Orientations toward science teaching (purpose-conceptual change; process)**

Grossman (1990); Magnusson, Krajcik, and Borko (1999)



Morine-Dershimer & Kent (1999)

Content Knowledge is Not Enough

Linking content to children: Although pre-service teachers underwent significant changes in how they viewed mathematics for themselves, their views of mathematics for young children often remained unchanged (Schram et. al., 1988; Wilcox et al. 1991)

Threshold of Content Knowledge: Begal (1979) and Monk (1994) found that upper level content knowledge has very little effect on K-12 teacher practice. (by measuring numbers of courses, scores, degrees, etc.)

Undergraduate education: Interactive engagement is more effective in impacting student learning - Hake (1998)

Nature of Science: Lederman (1992) reports that learning about and understanding the nature of science does not necessarily impact teacher practice with respect to the nature of science.

Despite their superior subject matter knowledge, some teachers were **unable to effectively use that knowledge** to help their students develop scientific knowledge (Hollon, Roth & Anderson, 1991).

Knowledge of Pedagogy is Not Enough

Teachers' knowledge and beliefs about content and about learning continue to shape their interpretations and uses of new curriculum materials. (Ball, D., Lubienski, S., and Mewborn, D., 2001; Yerrick, Parke, Nugent, 1997). Unless serious collaboration exists (Blumenfeld, Krajcik, Marx, Soloway, 1994).

Teacher Beliefs have a strong impact on teacher practice (Gess-Newsome, 1999): Even after attending a 4-day intensive workshop where teachers were walked through a radically different curriculum teachers do not change their beliefs and therefore end up enacting a different curriculum than intended (Franke, Carpenter, Levi, and Fennema, 1998).

Apprenticeship of Observation: Teachers have had over 10,000 hours observing teachers in traditional mode. Despite methods instruction they tend to teach content as they were taught content (Lortie, 1975).

Knowledge of Common Misconceptions does not ensure that teachers can respond in appropriate ways when students exhibit such conceptions (Smith and Neale, 1989, 1991).

Studies of teachers in situations within and outside their areas of expertise show major differences in practice, adaptation, students (Sanders, Borko, & Lockard, 1993; Hashweh, 1987).

Pedagogically useful knowledge of Mathematics (Ball and Bass, 2000; Ball, 1989).

And what about the Nature of Science and Scientific Inquiry

Nature of Science	Science knowledge is typically tentative
	Science knowledge is empirical
	Science knowledge is partly a product of imagination and creativity
	Distinction between observation and inference

Implicit Instruction is Not effective; Explicit instruction is effective- Abd-El-Khalick, Bell, Lederman (1998); Akerson, Abd-El-Khalick, Lederman (2000), Shapiro (1996).

Even when teachers understand the nature of science this does not translate to their teaching – Lederman (1995); Nature of Mathematics-(Schram, Wilcox, Lappan, and Lanier,1989; Wilcox, Schram, Lappan, and Lanier, 1990).

NOS instruction is more effective when coupled with in-depth, inquiry-based instruction of particular content (Abd-El-Khalick, 2001)

They’re all finding the same thing:

Conceptual Content Courses Integrated with Instruction on Students’ Thinking within the Content Area at minimum.

Field Experiences connected to such courses is necessary.

(Putnam and Borko, 1997).

Courses that explicitly address K-12 Students’ Mathematics Thinking

CGI – 1st grade addition/subtraction: Franke, Carpenter, Levi, and Fennema (2001)

Conceptual Content Courses with Instruction on Student Thinking

LINCS Geometry- Swafford, Jones, Thornton, (1997)

Conceptual Content Courses w/ Student Thinking Instruction w/ Field Experiences

IMAP- Philipp, Thanheiser, and Clement (2003)

CU Assessment Project-Borko, Mayfield, Marion, Flexer, Cumbo (1995)

Projects that I am currently involved in:

1. **Science, Technology, Engineering, Mathematics Teacher Preparation: STEM-Colorado:** Secondary Mathematics and Science Early Intervention

- Early field experiences in undergraduate courses combined with a mathematics and science education course.
- STEM Colorado is designed for mathematics and science majors who have not necessarily considered becoming teachers.

2. **Physics for Elementary Teachers**

- Physics Curriculum designed for prospective elementary teachers.
- The course combines instruction on elementary students' physics ideas with inquiry-based instruction in physics

Physics for Elementary Teachers (PET) Curriculum

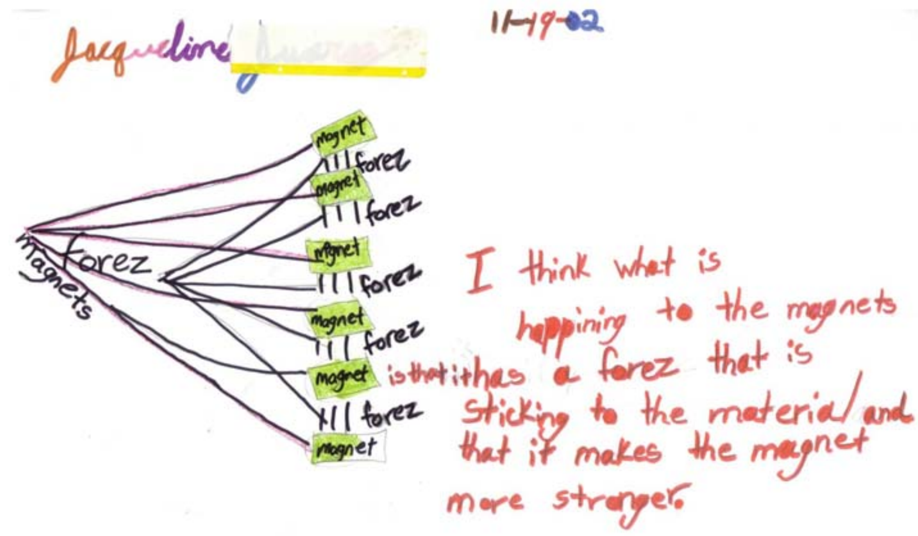
(Fred Goldberg, Steve Robinson, Valerie Otero)

Physics Content: To help prospective teachers develop a deep understanding of physics ideas that can be used to explain interesting phenomena, and are included in the elementary school science curriculum.

Nature of Science: To help prospective teachers practice and develop an understanding of how knowledge is developed within a scientific community: science involves using evidence and creative thinking, knowledge is established through collaboration and consensus, science knowledge can change over time.

Elementary Students' Ideas: To help prospective teachers analyze and appreciate the thinking of elementary students while they engage in scientific inquiry, and to make connections with teachers' own learning of physics.

Learning about learning: To help prospective teachers become more aware of how their own physics ideas change and develop over time, and how the structure of the learning environment and curriculum facilitate these changes.



[Link to Electricity ESI Activity]

[Link to Force and Energy ESI Activity]

Preliminary Findings

We are finding that non-PER physicists have difficulty implementing the curriculum as intended.

We believe that this has to do with different understandings and values for teaching physics in the classroom and that the workshop they attended did not explicitly address beliefs about teaching, learning, and students.

We are finding that PER experts are finding some difficulty leading the Elementary Students' Ideas discussions. We believe this is due to a lack of knowledge of elementary science and of elementary students' thinking.

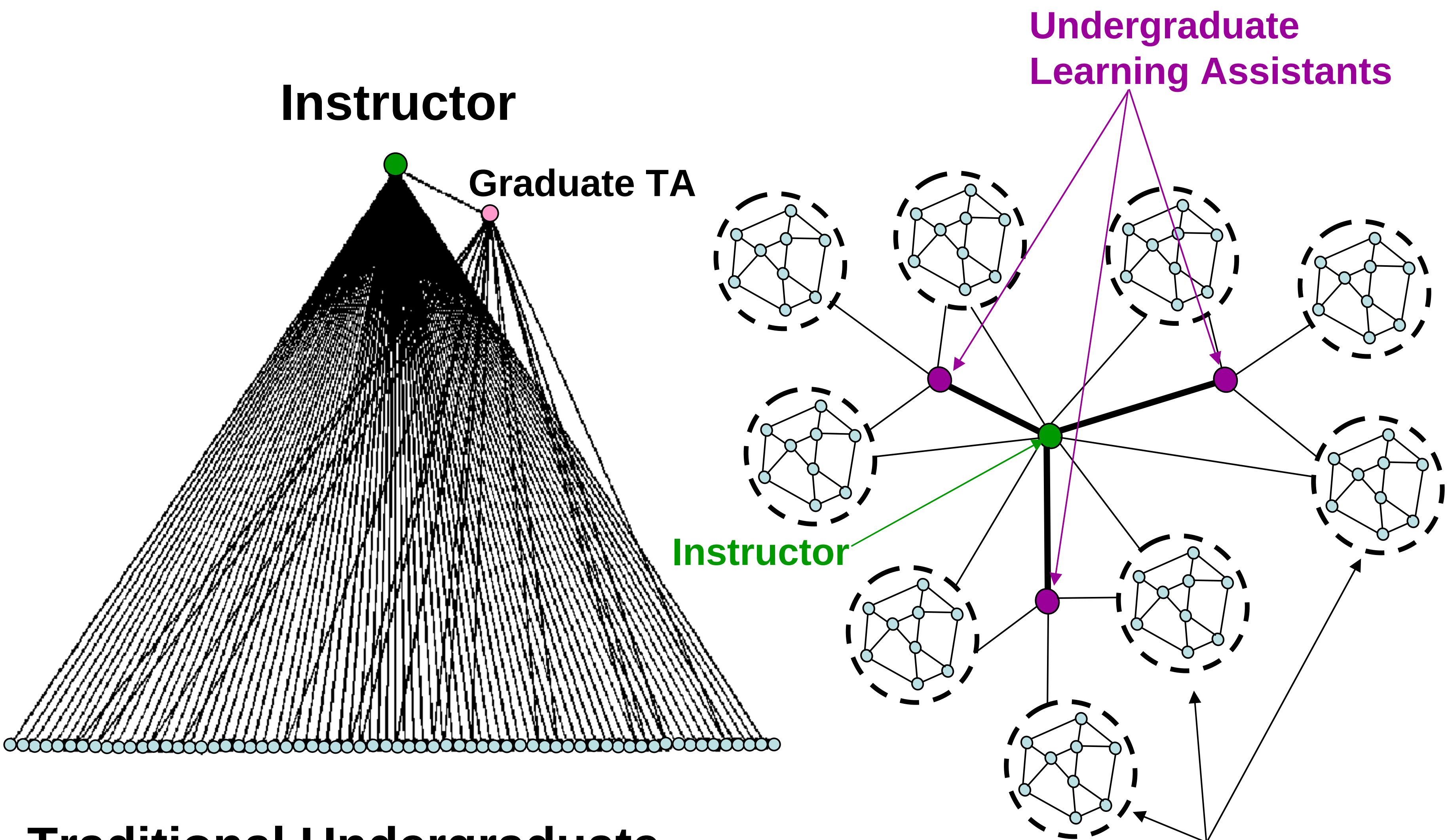
Science, Technology, Engineering Mathematics, Teacher Preparation (STEM Colorado)

(Dick McCray, Valerie Otero, James Curry, Carl Wieman, Bill Wood)

Goals: Early integration of content, pedagogy and practice

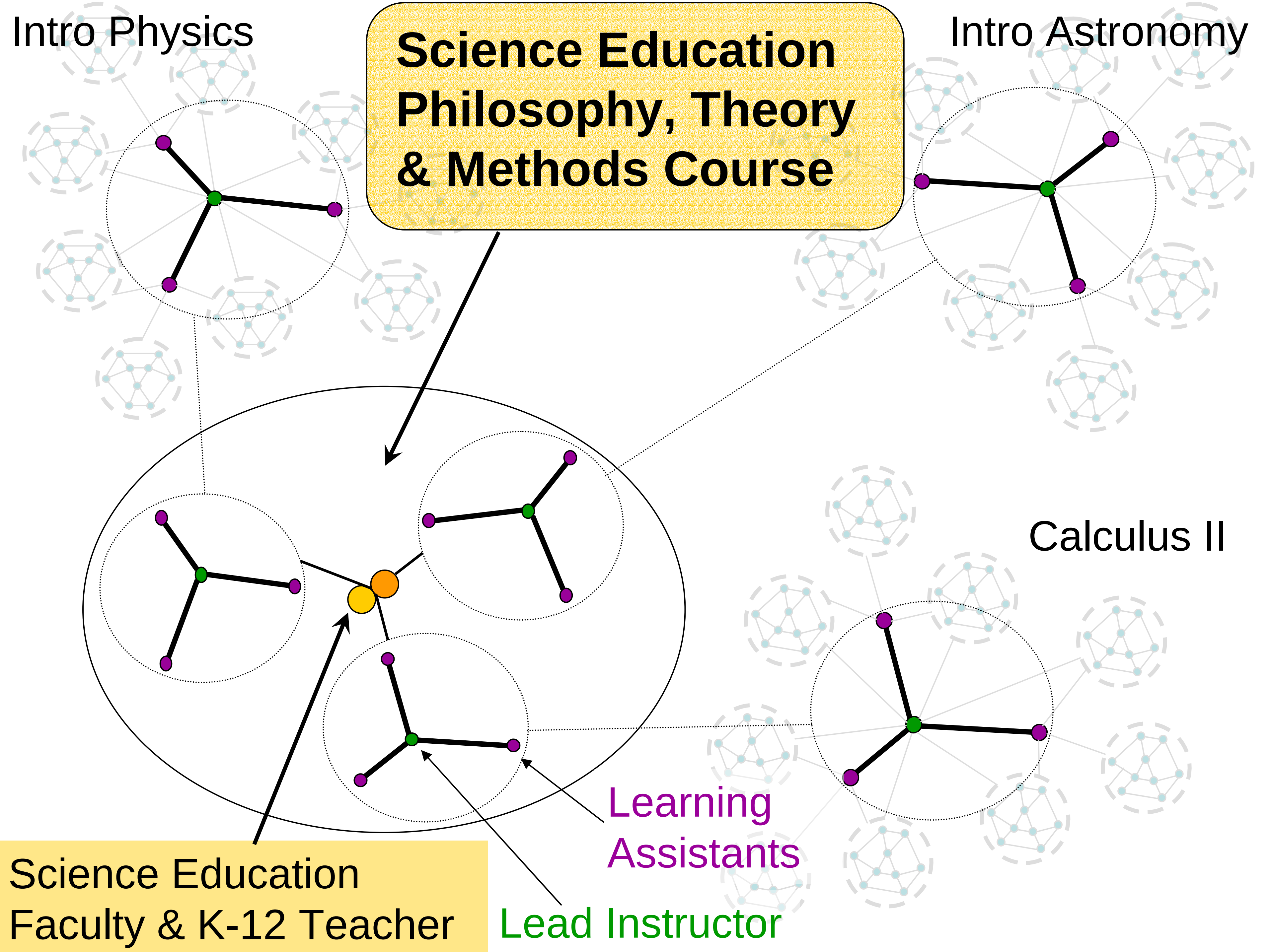
1. **Teacher Preparation:** **Increase the number of qualified mathematics and science K-12 teachers**
2. **Course Transformation:** **Transform large enrollment introductory courses using undergraduate learning assistants, technology, and student-centered approaches**
3. **Nature of Science:** **Increase undergraduate students understanding of the nature and process of science through participation in scientific investigation**
4. **Faculty Attitudes:** **Transform research departments' attitudes toward education as a legitimate endeavor for themselves and for their students**

Transformation of Large-Enrollment Introductory Courses with Undergraduate Learning Assistants



Traditional Undergraduate Physics Course

STEM-TP Transformed Course



Intro Physics
Science Education Philosophy, Theory & Methods Course
Intro Astronomy
Calculus II
Learning Assistants
Lead Instructor
Science Education Faculty & K-12 Teacher

LEARNING ASSISTANTS

gain knowledge of students, teaching and content in their STEM-TP Experience:

1) **Pedagogy/students' Ideas/reflection on practice (Science Education, Philosophy, Theory & Methods)**
2) **Content: Training sessions in content area with faculty member teaching the course**
3) **Practice: Teaching in undergraduate courses**

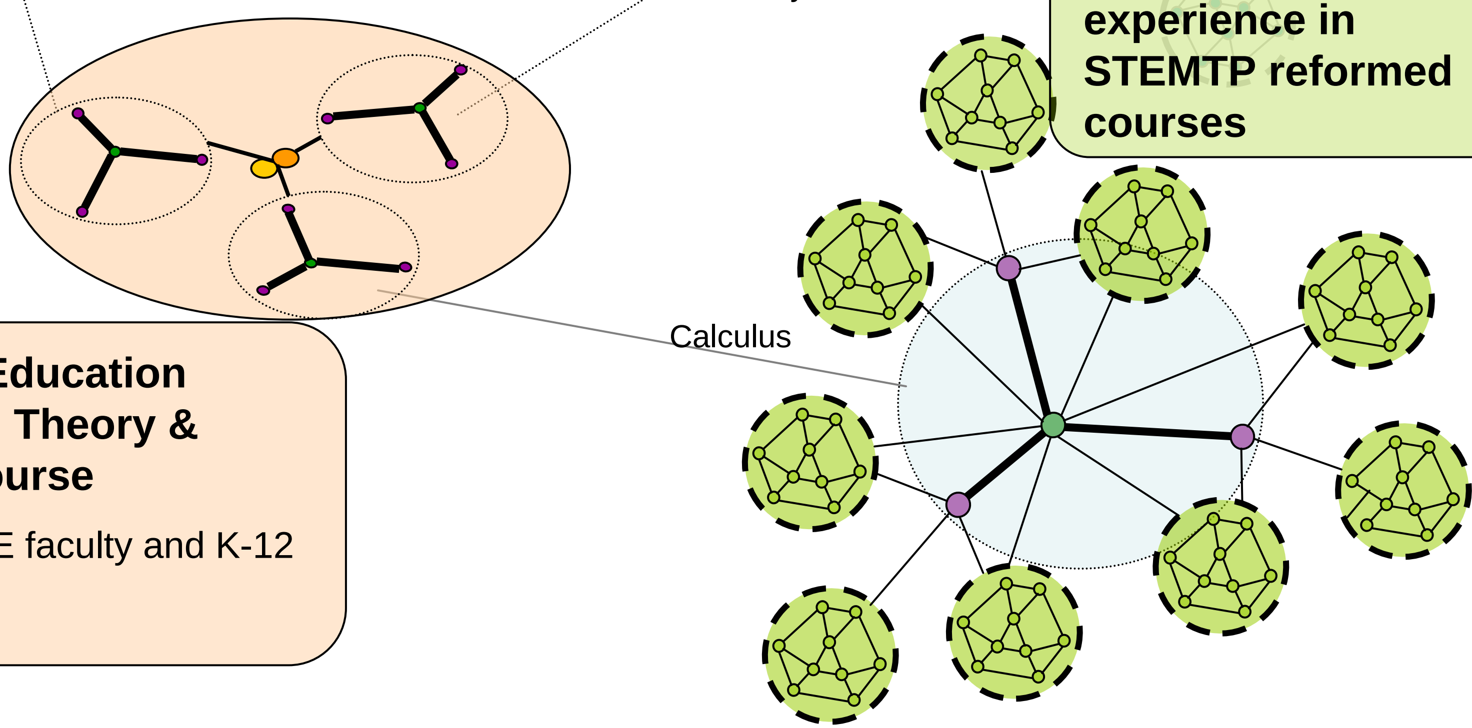
2. Training within content area

Taught by lead faculty

3. Teaching experience in STEMTP reformed courses

1. Science Education Philosophy, Theory & Methods Course

Taught by SOE faculty and K-12 teacher



For more information about research on the STEM Colorado Learning Assistant Experience go to:

DP05: Influencing Attitudes Towards Teaching and Learning of Science Majors
Danielle Harlow: 8:00 pm Tuesday, January 27

For more research on Elementary Students' Ideas and Formal Representations in Elementary School Physics go to:

FD08: The Role of Formal Representations in Facilitating Understanding of Physics (among 2^{nd} and 3^{rd} grade students)

Derya Cobanoglu: 2:45 pm Wednesday, January 28

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