Reform in Entry-Level Undergraduate Science Coursework: Impacts on Pre- and In-Service K-6 Teachers in a National Sample

Donna Turner, Erika Steele, Dennis W. Sunal, Cynthia Szymanski Sunal

The University of Alabama

Glenda Ogletree

Armstrong Atlantic University

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Background

- **Reforms in entry-level undergraduate science courses impact student learning outcomes during the course and for the long-term.**
- **Science teaching requires specialized knowledge that is refined by instructors over time and through extensive experience.**
- **We should expect to see differences among faculty instructors of science in our undergraduate science classrooms based on differences in their knowledge of teaching and its application to actual classrooms with students.**

Study Context

- **The National Study of Education in Undergraduate Science (NSEUS) focuses on an examination of teaching undergraduate science in the US.**
- **The goal of this on-going national multiyear study is to investigate the impact of undergraduate course reform on faculty and students.**
- **The data and findings in this current research report focus on faculty teaching entry level undergraduate science courses and their graduated students who are now in-service teachers involved with teaching science in elementary school classrooms.**

Science Pedagogical Content Knowledge

- **Pedagogical content knowledge goes beyond knowledge of science as a discipline to the dimension of knowledge of science useful for teaching and learning.**
- **Every action taken by undergraduate science faculty that is specifically designed to help students learn science concepts meaningfully is defined as a part of an instructor's science pedagogical content knowledge.**

PCK Includes

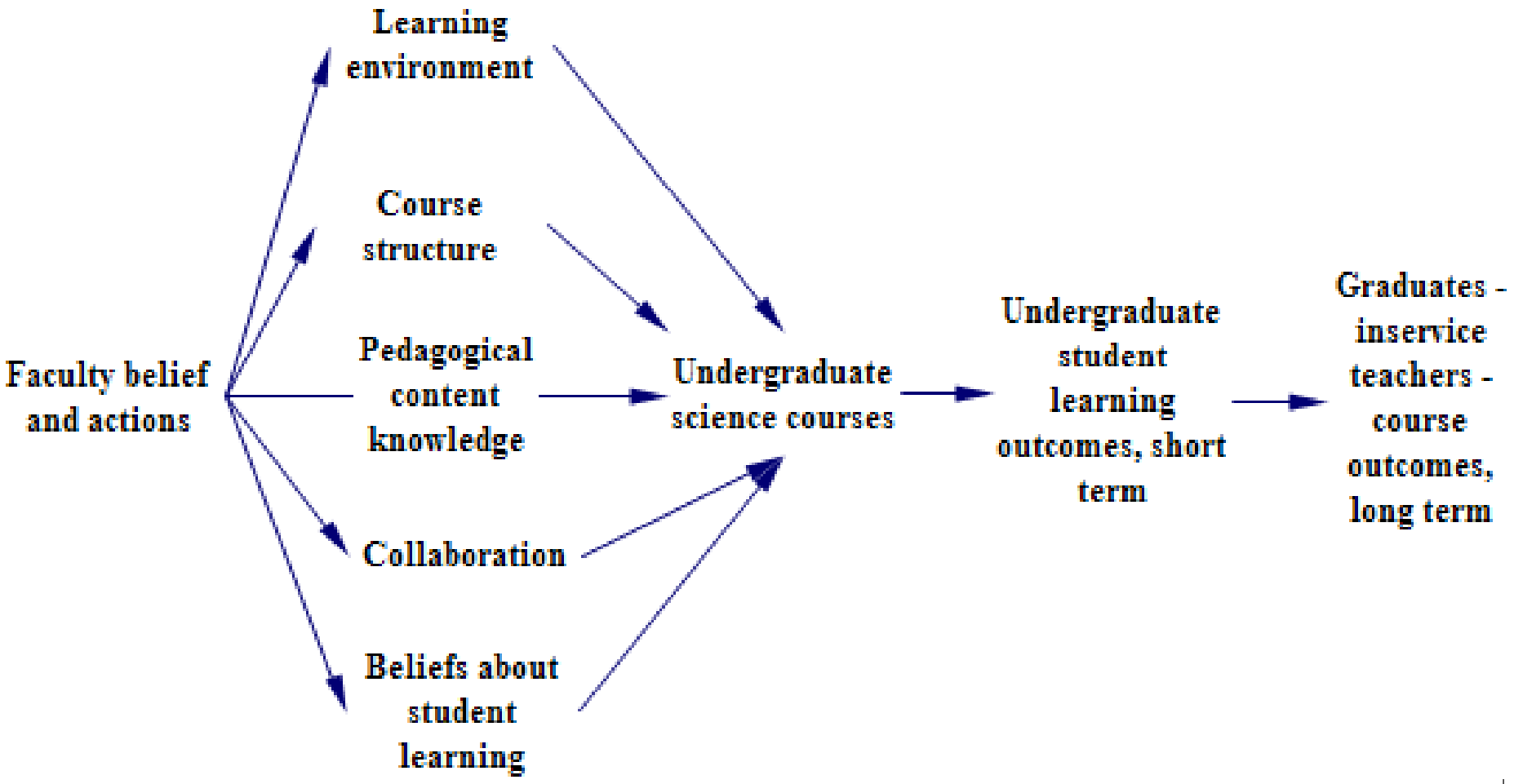
- knowledge of the most useful forms of representation of those ideas,
- the most powerful analogies, illustrations, examples, explanations, and demonstrations ,(Shulman, 1986)
- the ways of representing and formulating the subject that make it comprehensible to others,
- understanding of what makes the learning of specific topics easy or difficult,

- **conceptions and pre-conceptions students of different cultures, ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons**
- **If those pre-conceptions are misconceptions, then teachers need knowledge of the most effective strategies that are most likely capable of reorganizing the understanding of learners while ensuring meaningful learning.**
- **pedagogical content knowledge is the synthesis of all knowledge needed in order to be an effective science teacher (Julie Gess-Newsome,1999)**

Research Question

How does the science pedagogical content knowledge of undergraduate science faculty relate to their classroom teaching and to the science pedagogical content knowledge of their students who upon graduating are now in-service elementary teachers?

Research Model



On site case studies with completed with

- **A sample of 11 higher education institutions selected from a national population.**
- **Site visits to each institution's campus, each one week in duration.**
- **19 faculty teaching entry level undergraduate science courses with an average class size of 35 students and a range of 18 to 70 students**
- **Inservice elementary classroom teachers in 41 schools**
- **Faculty interviews ranging from 45 to 105 minutes**
- **Teacher interviews lasting from 30 to 50 minutes**

Data Collection Instruments

- Structured and open interviews
- Content Representation (CoRe) and Pedagogical and Professional-experience Repertoires (PaP-eRs) – assessed faculty science pedagogical content knowledge Loughran, Mulhall, and Berry (2004).
- Classroom session/lesson field notes, and classroom artifacts
- Reformed Teaching Observation Protocol (RTOP) - designed to measure quantitative characterization of the degree to which a science classroom is reformed (Sawada & Pilburn, 2000).

CoRe and PaP-eR Results for Undergraduate Faculty: Science Pedagogical Content Knowledge

	Significance
Significant Differences were found between faculty with	
• **CoRe & PaP-eR Total Score**	• p= 0.007
• **Content Knowledge**	• p= 0.049
• **Student Thinking**	• p= 0.014
• **Science Teaching**	• p= 0.010
Significant Differences were not found between faculty with	
• **Professional Development, Collaboration, and Leadership Roles**	• p= 0.062

RTOP Results for Science Faculty: Teaching Undergraduate Science

Significant Differences were found between faculty with

Significance

- **Total Score** — p= 0.027
- **Procedural Knowledge** — p= 0.026
- **Communicative Interactions** — p= 0.010
- **Student and Teacher Relationships** — p= 0.023

- Significant Differences were not found between faculty with

- **Propositional Knowledge** — p= 0.070
- **Lesson Design** — p= 0.265

Undergraduate Science Classroom Observations

Sample of Classroom Observations Made in the Reform Undergraduate Science Course Classrooms

- **Extensive student-student & teacher-student interaction during the class**
- **Lectures were short and provided in a "just in time manner" coordinated with students' inquiry activities**
- **Lecture and laboratory were more often integrated**

Sample of Common Classroom Observations Made in Both Classrooms

- **Instructors used technology: smart boards, *PowerPoint* etc.**
- **Content presented in both courses was current, and accurate.**

Sample of Classroom Observations Made in the Comparison Undergraduate Science Course Classrooms

- **Little requested, or planned, student-student interaction**
- **Teacher lecture took up the majority of the time**
- **Students appeared unengaged with the teacher and the content**
- **Lecture and laboratory were separated in time**

CoRe and PaP-eR Results for In-service Teachers:Pedagogical Content Knowledge

• Significant Differences were found between faculty with	• **Significance**
• **Total Score**	• p= 0.015
• **Content Knowledge**	• p= 0.049
• **Student Thinking**	• p= 0.042
• **Science Teaching**	• p= 0.032
Significant Differences were not found between faculty with	
• **Professional Development, Collaboration, and Leadership Roles**	• p= 0.099

Elementary School Science Classroom Observations

Sample of Classroom Observations of In-service Teachers' who Had Completed a Reform Undergraduate Science Course

- **used more hands-on/minds-on activities**
- **relied less on the textbook and more on students activities and discussion**
- **described their science lessons using terms compatible with constructivist pedagogy**

Sample of Common Classroom Observations Made in Both Groups of In-service Teachers' Classrooms

- **Teachers used technology: e.g. smart boards, *PowerPoint* presentations**

Sample of Classroom Observations of In-service Teachers' who Had Completed a Comparison Undergraduate Science Course

- **presented a reading lesson using the science textbook**
- **had elementary students read passages out loud,**
- **teacher asked questions,**
- **students searched for answers in textbook passages**

Conclusions

- Faculty instructors who taught reform undergraduate science course(s) were rated higher in science pedagogical content knowledge.
- The level of PCK for faculty instructors was found to be significantly related to:
  - their observed undergraduate teaching actions
  - to the teaching and learning experienced by students
  - to classroom culture, and
  - to learning outcomes
- In-service elementary teachers who had completed these same reform undergraduate science course(s) were rated higher in science pedagogical content knowledge in their elementary school setting

Conclusions

Results of the data reviewed for this sample reveal that science pedagogical content knowledge of undergraduate science faculty predicts patterns in their science classroom teaching. The undergraduate science classroom course context and teaching were found to be related to the science pedagogical content knowledge of their undergraduate students who upon graduating became in-service elementary teachers responsible for teaching science in their classrooms.

Implications for the way faculty are prepared for teaching undergraduate science: Research based practice asks

- What needs to be done to prepare for teaching specific science concepts to undergraduates?
- What needs to take place during undergraduate teaching of these specific science concepts?
- How do undergraduate students need to be engaged following science lessons if we are to create more meaningful outcomes in undergraduate students' learning of science?

- Recommendations for further research include expanding the sample size, investigating both short term and long term effects, including several independent sources of data in addition to PCK, and relating faculty PCK to teaching actions and to undergraduate student achievement in science.

National Conference in 2011

Research Based Undergraduate Science Teaching: What Works

June 20 – 21, 2011, Bryant Conference Center
University of Alabama Campus, Tuscaloosa, AL

Visit http://nseus.org for more details on the upcoming conference

Submit and present research papers, seminars, forums, participate in web presence. For more information contact Dennis Sunal at dwsunal@bama.ua.edu

References

- National Study of Education in Undergraduate Science (NSEUS) **http://nesus.org**
- Loughran, J., Mulhall, P., & Berry, A. (2004). In Search of Pedagogical Content Knowledge in Science: Developing Ways of Articulating and Documenting Professional Practice. *Journal of Research in Science Teaching*, 41(4), pp. 370-391.
- Sawada, D., & Piburn, M. (2000). *Reformed teaching observation protocol (RTOP): Reference manual*. Phoenix, AZ: Arizona Collaborative for Excellence in the Preparation of Teachers.

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