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Comparing the Science Pedagogical Content Knowledge of Elementary Teachers Who Participated in Reformed or Non-Reformed Undergraduate Entry-Level Science Courses

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The *National Study of Education in Undergraduate Science* (NSEUS), funded by the National Science Foundation, investigated the pedagogical content knowledge (PCK) in science of in-service elementary teachers of science who graduated from institutions throughout the country. These institutions, and one or more of their courses, were involved in the NASA/NOVA Program initiated in 1996. The NASA/NOVA program and offered courses at various times in a large professional development effort to create reforms in higher education undergraduate, and mostly entry-level, science courses.

Pedagogical content knowledge (PCK) was first posited by Lee S. Shulman (1986) to describe the transformation of subject-matter knowledge into forms accessible to the students being taught (Abell, 2007, p. 1120). Shulman (1986) posits that pedagogical content knowledge goes beyond knowledge of the subject to the dimension of subject matter knowledge for teaching. It includes the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations: in a word, the ways of representing and formulating the subject that make it comprehensible to others (Shulman, 1986, pp. 9). Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons (Shulman, 1986, p.9). If those preconceptions are misconceptions, which they so often are, then teachers need knowledge of the most effective strategies that are most likely capable of reorganizing the understanding of learners while ensuring meaningful learning**.**

In an effort to ascertain in-service teacher's pedagogical content knowledge (PCK), teachers were interviewed using the Content Representation (CoRe) and Pedagogical and Professional - experience Repertoires (PaP-eRs) instruments designed by Loughran, Mulhall, and Berry (2004). According to Loughran et al. (2004), the purpose of the CoRe is to discuss science teachers' understanding of particular aspects of PCK (e.g., an overview of the main ideas; knowledge of alternative conceptions; insightful ways of testing for understanding; known points of confusion; effective sequencing; and important approaches to the framing of ideas). Attached to the CoRe are PaP-eRs. The authors posit that PaP-eRs illustrate how such knowledge might inform effective classroom practice (Loughran et al., 2004, p. 377). A PaP-eR is a narrative account of a teacher's of a teacher's PCK that highlights a particular piece, or aspect of science content, to be taught (Loughran, Berry, & Mulhull, 2006, p. 24). A PaP-eR specifically is designed to purposefully unpack a teacher's thinking about a particular aspect of PCK in that given content and so is largely based around classroom practice (Loughran et al., 2006, p. 24). The PaP-eR is intended to represent the teacher's reasoning, that is, the thinking and actions of a successful science teacher in teaching specific aspects of science content (Loughran et al., 2006, p. 24). PaP-eR, thus, develops through the interaction of the prompts, questions, issues, and difficulties that influence the particular approach to teaching that content to which the PaP-eR is tied and reflects the richness of the teacher's understanding of science teaching and learning in that field (Loughran et al., 2004, p. 377). Accordingly, the more specific a PaP-eR is the more it informs the relationship between teaching and learning.

The following CoRe and PaP-eR was used with in-service elementary teachers to establish their Pedagogical Content Knowledge in science (see Figure 1).

	Important Science Ideas/Concepts
What will be the main ideas of this lesson?	
What do you intend the <u>students</u> to learn about these ideas?	
Why is it important for students to know this?	
What do you anticipate will be some difficulties and/or limitations connected with teaching this idea?	
What knowledge about students' thinking influences your teaching of this idea?	
What are other factors that influence your teaching of this idea?	
a) Describe how you will teach the main ideas in this lesson. b) Why will you be using this procedure to teach these main ideas?	
What are specific ways you will use to determine students' understanding or confusion around this idea?	

Figure 1: CoRe and PaP-er Format

Analysis of the CoRe and PaP-eR considered the following categories: (a) Content Knowledge; (b) Knowledge about how students think; (c) Science Teaching Knowledge; and (d) Professional Development. Data analysis reveals a statistically significant difference between reform and non-reform teachers in the areas of content knowledge *t* = (39, 2.034), *p* = .049; knowledge about how students think, *t* = (39, 2.10), *p* =.042; and knowledge about science teaching, *t* = (39, 2.220), *p* = .032. There is not, however, a statistically significant difference between reform and non-reform teachers in the area of Professional Development, Collaboration, and Leadership Roles, *t* = (39, 1.689), *p* =.099. Reform teachers appear to exhibit greater proficiency in understanding science content knowledge, M = 2.90, student thinking, M = 2.71; and science teaching knowledge, M = 2.79 than non-reform teachers, M = 2.40, M = 2.15, and M = 2.15 respectively. See tables and charts below.

Table 1:

CoRe and PaP-eR Analyses for Reformed and Non Reformed Teachers

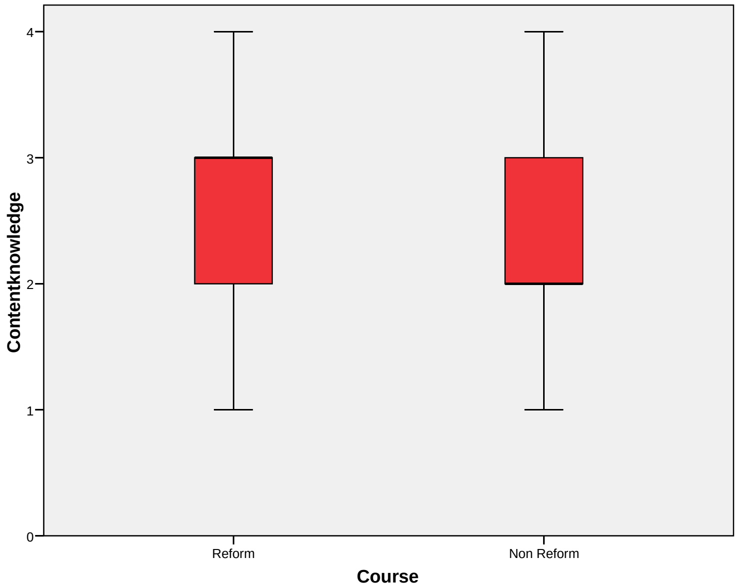
			N	Mean	Std. Deviation	Std. Error Mean
Contentknowledge	Course	Reform	*21*	*2.90*	*.831*	*.181*
		Non Reform	*20*	*2.40*	*.754*	*.169*
StudentThinking	Course	Reform	*21*	*2.71*	*.644*	*.140*
		Non Reform	*20*	*2.15*	*1.040*	*.233*
ScienceTeaching Knowledge	Course	Reform	*21*	*2.76*	*.831*	*.181*
		Non Reform	*20*	*2.15*	*.933*	*.209*
ProfessionalDevelopment	Course	Reform	*21*	*2.43*	*.926*	*.202*
		Non Reform	*20*	*1.95*	*.887*	*.198*

Table 2:

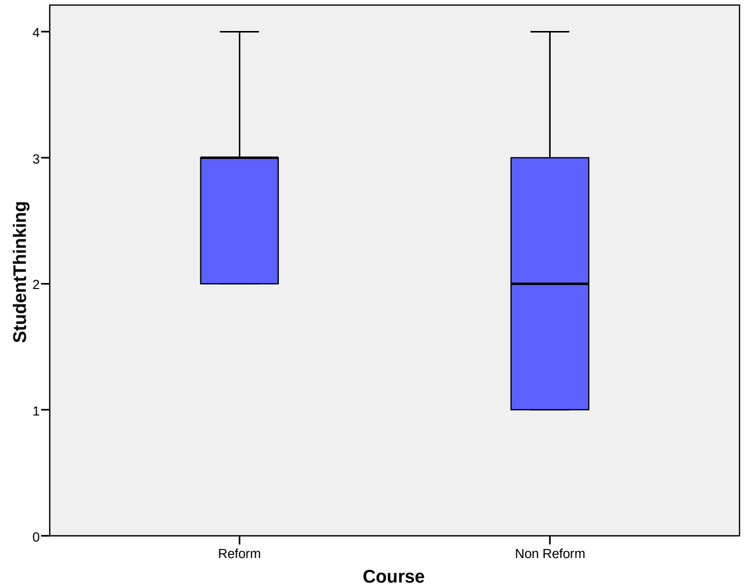
CoRe and PaP-eR Independent Samples T-Test for Reform and Non Reform Teachers

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Contentknowledge	Equal variances assumed	*.036*	*.850*	*2.034*	*39*	*.049*	*.505*
	Equal variances not assumed			*2.039*	*38.914*	*.048*	*.505*
StudentThinking	Equal variances assumed	*2.973*	*.093*	*2.100*	*39*	*.042*	*.564*
	Equal variances not assumed			*2.077*	*31.419*	*.046*	*.564*
ScienceTeaching Knowledge	Equal variances assumed	*.505*	*.482*	*2.220*	*39*	*.032*	*.612*
	Equal variances not assumed			*2.213*	*37.962*	*.033*	*.612*
ProfessionalDevelopment	Equal variances assumed	*.605*	*.441*	*1.689*	*39*	*.099*	*.479*
	Equal variances not assumed			*1.690*	*38.998*	*.099*	*.479*

Figures 2 -5:



Contentknowledge
0
1
2
3
4
Reform
Non Reform
Course



StudentThinking
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1
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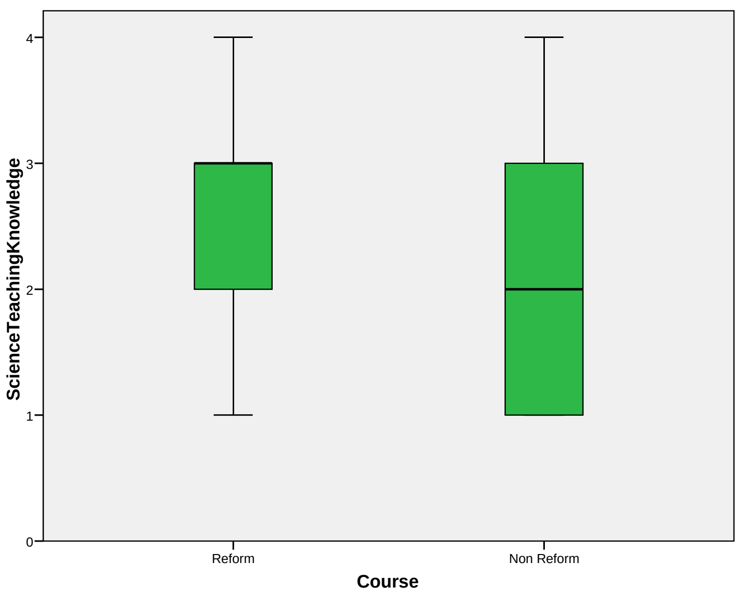
Reform
Non Reform
Course



ScienceTeachingKnowledge
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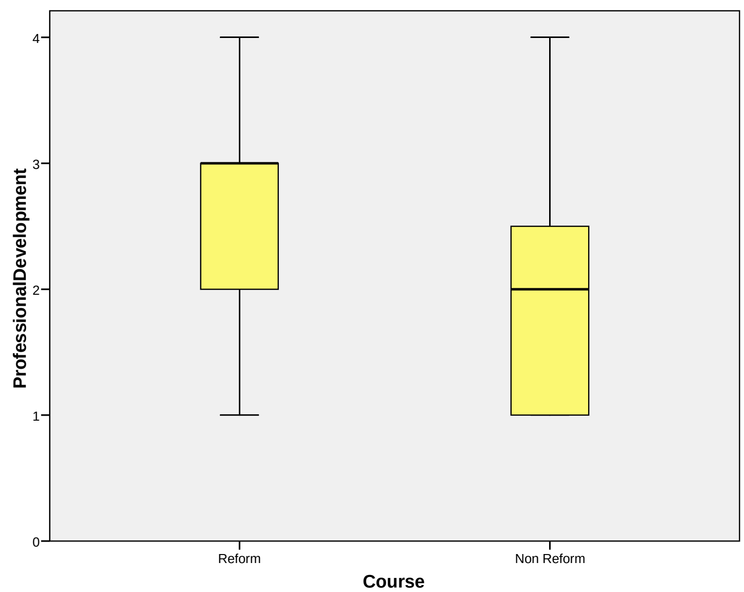
Reform
Non Reform
Course



ProfessionalDevelopment
0
1
2
3
4
Reform
Non Reform
Course

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