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Effective Professional Development in Agriscience Education: An Examination of Core Features

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Abstract

Reform efforts that are designed to increase student achievement often include in-service teacher professional development (PD) as a foundational component. However, the content and activities included in PD sessions varies greatly. Guided by Desimone's (2009) Core Features of Professional Development, this study sought to describe agriscience teachers' perceptions regarding various aspects of science integration based on their participation in PD. Participant responses to the survey instrument differed after attending the PD from what was reported prior to the event, supporting previous research regarding the effectiveness of PD on teacher behavior change. A comparison of the participant responses based on attending the PD prior to or following the restructuring of the PD or the number of times the respondent participated in the PD did not show practical differences, indicating that a PD's repeated participation and the inclusion of active learning in PD were not directly influential in its effectiveness.
Keywords: professional development; agricultural education; NATAA

Student achievement is the educational currency by which secondary school programs have been measured for at least the past three decades. In the report titled, *A Nation at Risk: The Imperative for Educational Reform*, the National Research Council (Gardner, 1983) cited evidence of the American school system's failure to its students, including a steady decline in standardized test scores, an increase in illiteracy, and a lack of "higher order intellectual skills" (p. 9). The No Child Left Behind Act (2001) cited similar problems related to student achievement and proposed improving educational quality through a blueprint which focused on increasing school and teacher accountability for student achievement and providing funds for enhancing teacher quality through numerous avenues, including professional development (PD).

Efforts in career and technical education (CTE) have followed a similar path. Business leaders have anticipated shortages in "areas ranging from non-residential construction and energy to information technology, healthcare and the STEM fields" (Harvard Graduate School, 2011, p. 4) as a result of inadequate educational preparation. In 1988, the National Research Council recommended that secondary agricultural education programs be substantially revised to better prepare students for further education and future employment, and that the quality of programs be enhanced. The constantly increasing overlap between agricultural science and science, technology, engineering, and math (STEM) (NRC, 2009) led to the development of CTE programs that strive to teach students aspects of scientific literacy, including the acquisition of STEM principles, problem solving, and scientific inquiry (Asunda, 2012; Clark & Ernst, 2008; Phipps, Osborne, Dyer, & Ball, 2008). However, numerous studies (Myers, Thoron, & Thompson, 2009; Myers & Washburn, 2008; Shelley-Tolbert, Conroy, & Dailey, 2000; Spindler, 2010; Stewart, Moore, & Flowers, 2004) have found that CTE teachers expressed feelings of

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inadequacy related to science integration, citing barriers including insufficient background in science content and lack of personal experience in science integration. Castellano, Stringfield, and Stone III (2003) stated that teachers in general, including CTE teachers, lacked the training necessary to develop curriculum which integrates CTE and academics.

In 2001, Layfield, Minor, and Waldvogel summarized a group of 11 studies from 1989 to 2000 concerning the state of science integration in agricultural education, and concluded five themes:

1. many teachers feel that they did not receive adequate science coursework in college to teach agriscience effectively;
2. there is a shortage of in-service training available to make up for this lack of science knowledge;
3. there is a need for more interaction between agriculture and science teachers;
4. teaching resources and institutional support for agriscience curriculum revision are not always available in needed amounts; and
5. pre-service agricultural education curricula need to focus specifically on agriscience as a core theme. These programs also need to provide would-be teachers with practical experience in how to successfully integrate science with agriculture in the classroom (p. 423).

In-service teacher PD is a foundational component of many reform efforts aimed at increasing student achievement (Supovitz & Turner, 2000), and has been recommended as a means of increasing academic integration in CTE courses (Castellano et al., 2003; Levin, 1995; Myers, Thoron, & Thompson, 2009; Myers & Washburn, 2008; Spindler, 2010). Billions of dollars are spent annually on a myriad of PD activities in an effort to improve student achievement (Birman et al., 2007). Although these activities can vary greatly, the specific features of PD activities have been shown to impact desired outcomes (Desimone, 2009). This study was designed to determine the impact of a PD opportunity which used recommended core PD features on agriscience teachers' perceptions regarding various aspects of science integration.

Conceptual Framework

Professional development is considered the most effective means of changing teacher practices (Supovitz & Turner, 2000). Desimone (2009) proposed a list of empirically based core features to be incorporated into PD activities, including a focus on content, active learning strategies, coherence between new content and previous knowledge and beliefs, sufficient duration, and collective participation among teachers (see Figure 1).

Desimone (2009) recommended these core features be included in "studies of the effectiveness of PD, to allow studies to build on each other and refine and expand our knowledge base" (p. 183). Although we identified the above framework as conceptual, it meets Camp's (2001) criterion as a substantive theory. The distinction between theoretical and conceptual frameworks is far from uniform (Camp, 2001; Dyer, Wittler, & Washburn, 2003); however, the purpose of both conceptual frameworks and substantive theory is to "begin with a supportable premise and then extend that premise through a logical path of reported research and clear reasoning to form the basis for the study" (Camp, 2001, p. 18). This study examined the impact of PD employing Desimone's (2009) core features on agriscience teachers' perceptions regarding aspects of science integration. Therefore, the above proposed framework provided a substantive theoretical basis for this study.

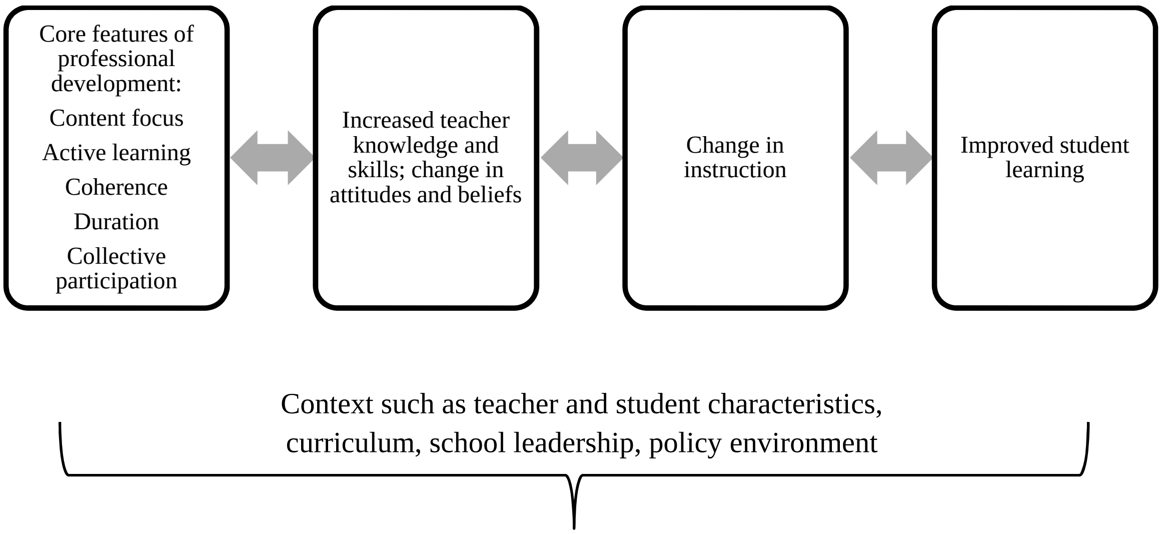

Figure 1. Proposed core conceptual framework for studying the effects of PD on teachers and students (Desimone, 2009).

Encompassing "any activity that is intended partly or primarily to prepare paid staff members for improved performance in present or future roles in the school districts" (Little, 1987, p. 491), PD experiences constitute a variety of teacher training activities, ranging from "formal, structured topic-specific seminars … to everyday, informal 'hallway' discussions" (Desimone, 2009, p. 182). Among the myriad of PD venues and activities, a national consensus regarding effective components of teacher training has emerged (Supovitz & Turner, 2000). Research contributing to the effectiveness of these established attributes can greatly improve the body of knowledge on effective PD. As previous research has shown, characteristics of the PD influenced the impact the training had on teacher behavioral change. (Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon (2001). According to Desimone's (2009) model, these effective components include content focus, active learning, coherence, duration, and collective participation (see Figure 1).

Content Focus

Research has indicated that effective PD activities focus on subject matter content (Cohen & Hill, 1998; Desimone, 2009; Kennedy, 1998; Little, 2001; Supovitz & Turner, 2000). Loucks-Horsley, Stiles, and Hewson (1996) stated that this focus can help teachers gain a more thorough understanding of their disciplines while helping them better understand how students will react to specific conceptions. Among the benefits of PD with content focus are increased student learning, increased teacher knowledge and skills, and improved teaching practices (Desimone, 2009; Kennedy, 1998; Supovitz & Turner, 2000).

Active Learning

In a variety of forms, active learning has been shown to positively impact the effectiveness of PD activities (Desimone, 2009; Supovitz & Turner, 2001). Active learning opportunities engage teachers in activities that require interactive feedback (Desimone, 2009), inquiry and experimentation (Supovitz & Turner, 2000), and learning in and from practice (Little, 2001). Professional development activities which model scientific reasoning have been found to have a greater impact on student achievement than that which only informs about specific curricula (Marek & Methaven, 1991).

Coherence

Coherence refers to "the extent to which teacher learning is consistent with teachers' knowledge and beliefs," as well as to "the consistency of school, district, and state reforms and policies with what is taught in PD" (Desimone, 2009, p. 184). Supovitz and Turner (2001) alluded to coherence through their recommendations for PD that is grounded in standards, alignment with other aspects of school reform, and connected to teachers' standards of student performance. Coherence can be a challenge for CTE-based reform, as the delivering entities are often groups not associated with the school or district (Anderson, Barrick, & Hughes, 1992).

Duration

Effective PD initiates teacher behavioral change through intensive practice which is sustained over a sufficient period of time (Desimone, 2009; Little, 2001; Supovitz & Turner, 2001). Although "sufficient" is less than prescriptive, "research has not indicated an exact 'tipping point' for duration but shows support for activities that are spread over a semester and include 20 hours or more of contact time" (Desimone, 2009, p. 184). Opportunities for sustained PD in CTE teacher education are rare, as the majority of sustained programs occur within schools (Shoulders & Myers, 2011b).

Collective Participation

Collective participation by teachers provides opportunities for sustained discourse and collaboration among a group of teachers (Desimone, 2009). While supported both financially and verbally in recent reform efforts, PD activities enabling effective, sustained collective participation have been scattered and inconsistent (Little, 2001). Collective participation in CTE PD is even less documented. Desimone (2009) recommended that collective participation can occur through the establishment of groups "from the same school, grade, or department" (p. 184), yet omitted any collective participation opportunities beyond the single school setting. However, in a collection of CTE teacher interviews, Ruhland and Bremer (2002) found that support, through mentors or a peer support group, was identified as a needed component of PD. The professional identity of CTE teachers as a group, apart from other teachers, gives merit to the notion of collective participation in PD designed specifically for these teachers (Shoulders & Myers, 2011b).

The need for effective PD is high among CTE teachers, as can be seen in agricultural education. In their study, Roberts and Dyer (2004) found that over half of the sample of traditionally certified teachers indicated a high need for PD in aspects of FFA and SAE supervision, teaching through technology, student motivation, teaching leadership, and aspects of technical agricultural concepts, including biotechnology, genetic engineering, and global positioning systems. However, the PD needs and professional identities of CTE teachers are varied, causing some researchers (Ruhland & Bremer, 2002; Shoulders & Myers, 2011b) to recommend individualized PD programs for these teachers. The five core features of effective PD can be included in studies examining the components of PD opportunities for CTE teachers to recommend best practices in CTE teacher in-service (Shoulders & Myers, 2011b), as well as to add to the body of knowledge on effective core features of PD (Desimone, 2009).

Agriscience teachers currently have the opportunity to participate in a PD program which employs Desimone's (2009) five core features. The National Agriscience Teacher Ambassador Academy (NATAA) was established in 2002, and for the first five years of its existence focused "primarily on offering science curricula PD to agriculture teachers … as well as showcasing the importance of promoting careers in science" (Shoulders & Myers, 2011a, p. 60). Beginning in 2006, the program offers agriscience teachers intensive, week-long immersion in recommended inquiry-based teaching techniques through active participation in agricultural contexts (Thoron, 2010). The teachers create a cohort through the program, which is sustained through workshops and leadership in further PD throughout the year (Shoulders & Myers, 2011a). Teachers are also permitted to participate in the program for up to two years, further enabling sustained PD in a participatory environment coherent with their identities as agriculture teachers (Shoulders & Myers, 2011b).

Purpose and Objectives

The purpose of this study was to describe agriculture teachers' perceptions of their behavioral practices related to scientific literacy based on their participation in PD opportunities employing Desimone's (2009) five core features. To achieve this purpose, the following objectives guided this study:

1. Describe teachers' perceptions regarding their use of inquiry-based teaching practices and laboratory activities following participation in PD.
2. Describe the difference between teachers' perceptions of their use of inquiry-based teaching practices and laboratory activities following participation in PD that either did or did not utilize all five of Desimone's core features.
3. Describe the difference between teachers' perceptions of their use of inquiry-based teaching practices and laboratory activities following either one- or two-year durations of participation in PD.

Methods and Procedures

This study utilized a descriptive survey research design. The population was all participants of the NATAA since its establishment in 2002 (N = 133). Through its evolution toward greater focus on inquiry and the opportunity for teachers to participate more than once, as well as through the opportunities for collective participation within a nationwide group of CTE teachers, the NATAA provided an opportune environment in which Desimone's five core features of PD could be examined. The study employed a census, thereby limiting all findings and related discussion to the population.

The population was sent an electronic questionnaire which was adapted from a collection of previously developed questionnaires: a) the Teacher Inquiry Scale (Dunbar, 2002; Washburn & Myers, 2010); b) the Student Inquiry Scale (Dunbar, 2002; Washburn & Myers, 2010); and c) the Perception of the Role of Practical Work Instrument (Al-Naqbi & Tairab, 2005). The Teacher Inquiry Scale and Student Inquiry Scale were adapted by Washburn and Myers (2010) from Dunbar's (2002) questionnaire by modifying items to include the term "agricultural" and substituting terms to improve clarity. These sections of the questionnaire included nine teacher-related statements and 14 student-related statements asking teachers to indicate on a Likert-type scale the frequency with which they proceeded in a certain manner, such as, "encourage students to initiate further investigation," or asked students to proceed in a certain manner, such as, "memorize scientific facts or information separately from activities." The six choices on the Teacher Inquiry Scale ranged from "never" to "5x per week," while the six choices on the Student Inquiry Scale ranged from "never" to "1x per day."

The Perception of the Role of Practical Work Instrument utilizes 20 statements to ascertain teachers' perceptions about the role of laboratory work in knowledge acquisition, process skill development, and attitude development (Al-Naqbi & Tairab, 2005). Face and content validity were established by the developers through consultation with seven educators in post-secondary and secondary science education.

The questionnaire items used in this study were adapted from Washburn and Myers' (2010) version and Al-Naqui and Tairab's (2005) instrument by including an area for teachers to respond to the question regarding their perceptions both before and after their participation in the NATAA. This method of retrospective pretesting is designed to counter potential response bias, "where participants may under- or overestimate their knowledge, skills, abilities or understanding prior to course implementation or any program intervention" (Reston, 2007, p. 3). The retrospective pretest has been identified as particularly appropriate when assessing PD, as "the traditional pretest may not be effective if participants do not sufficiently understand, prior to the workshop, terms or concepts needed to answer pretest questions" (Lamb, 2005, p. 18). While vulnerable to limitations including social desirability to display a learning effect, the retrospective pretest enables respondents to fully understand the terminology included in items regarding a newly-introduced theory or technique (Campbell & Stanley, 1963). Because of the complex nature of inquiry-based instruction and scientific literacy and ease with which longitudinal data can be collected, the other researchers deemed the retrospective pretest an appropriate means of instrumentation for this type of investigation (Phillips & Myers, 2013). Post hoc reliability analysis yielded results of .69 for the retrospective pretest scores and .74 for the posttest scores for the Teacher Inquiry Scale, .87 for the retrospective pretest scores and .80 for the posttest scores for the Student Inquiry Scale, and .87 for the retrospective pretest scores and .90 for the posttest scores on the Perception of the Role of Practical Work Instrument. These scores were deemed acceptable, as all tests had scores at or above .70 (Nunnaly, 1978).

Data were analyzed according to the intentions specified by the original instruments. Data from the Teacher Inquiry Scale and Student Inquiry Scale were analyzed by calculating grand means from the individual items on each scale, which resulted in one grand mean per instrument (Dunbar, 2002). The Perception of the Role of Practical Work Instrument originally analyzed each Likert-type item separately (Al-Naqbi & Tairab, 2005). Because each of these instrument items pertains to student roles in laboratories and because this research was not designed to differentiate between specific components of laboratory work, we determined that the calculation of a grand mean from the overall instrument was appropriate for this study. This decision was confirmed by Clason and Dormody's (1994) clarification regarding the intentions of the Likert scale, which should be analyzed only in summated form. Effect sizes were calculated between grand mean differences according to the objectives to supply readers with guidance in extracting meaning from the differences found. To further interpret the effect sizes, Coe's interpretation (2002), which converts *Cohen's d* to percentiles, was utilized to calculate the percentage of pretest scores that would fall below the mean posttest score.

While this study was designed to gather data on a census, it did not achieve a response rate of 100%, indicating that non-response error can be a limitation to the generalizability of the findings. In an attempt to reduce potential non-response error, a total of eight respondent contacts were made (Dillman, 2000). These included a pre-study electronic mail contact, electronic instrument mailings, and reminders via both electronic mail and telephone. A total of 105 respondents returned questionnaires for a 79% response rate. Findings are limited to these respondents.

Findings

A majority (78%, n = 82) of the respondent group was found to still be engaged in teaching agriculture at the secondary school level. Further, 82% (n = 86) of the respondents attended the NATAA PD after the format change which occurred in 2006. Less than one-third (31%, n = 33) of the respondents participated in more than one NATAA PD session. Only those respondents who were still actively engaged in teaching agriculture at the secondary school level (n = 82) provided their responses on the remainder of the instrument. This decision was made because the respondents were asked to indicate the level to which specific ideas, skills, and methods were implemented in the agriculture classroom. Those individuals not engaged in teaching would not have had the opportunity to implement these items in the setting of interest.

Objective 1

The first objective of this study was to describe teachers' perceptions regarding their use of inquiry-based teaching practices, teaching practices, and laboratory activities following participation in PD. This was achieved through the use of three difference scales, including the Teacher Inquiry Scale and the Student Inquiry Scale (Dunbar, 2002) and the Perception of the Role of Practical Work Instrument (Al-Naqbi & Tairab, 2005). The Teacher Inquiry Scale asked respondents to indicate the frequency in which they engage in inquiry activities in their classrooms prior to (see Table 1) and following (see Table 2) the PD. A grand mean of 2.42 (*SD* = 0.87) for this scale was calculated from teacher responses prior to the PD with a grand mean of 4.11 (*SD* = 0.80) following the event. These means yielded an effect size of 2.02, which is interpreted to state that approximately 98% of teachers' responses on the pretest would be lower than those on the posttest.

The Student Inquiry Scale asked respondents to indicate the frequency students were asked to engage in various inquiry activities prior to (see Table 3) and following (see Table 4) the PD. A grand mean of 2.47 (*SD* = 0.64) for this scale was calculated from teachers' responses prior to the PD with a grand mean of 3.36 (*SD* = 0.46) following the event. These means yielded an effect size of 1.60, which is interpreted to mean that approximately 95% of the pretest responses would fall below (less frequent) the average posttest response.

Table 1

Teacher Inquiry Scale Prior to Professional Development (n = 82)

	Percent						
On average, to what extent do you:	Never[b]	<1x per week[c]	1x per week[d]	2x per week[e]	3x per week[f]	4x per week[g]	5x per week[h]
Use a textbook as the primary method for studying agriscience[a]	14.6	30.5	11.0	17.1	20.7	3.7	2.4
Use open-ended questions that encourage observation, investigations, and scientific thinking	2.5	15.0	27.5	32.5	16.3	5.0	1.3
Identify agricultural situations/issues that can be investigated at varying levels of complexity	6.1	18.3	40.2	24.4	6.1	2.4	2.4
Encourage students to initiate further investigation	8.9	24.1	27.8	26.6	7.6	5.1	0.0
Ask a question or conduct an activity that calls for a single correct answer[a]	0.0	6.2	9.9	25.9	25.9	12.3	19.8
Facilitate and encourage student dialogue about science	3.9	20.8	18.2	32.5	15.6	6.5	2.6
Encourage students to defend the adequacy or logic of statements and findings	8.8	25.0	25.0	22.5	16.3	2.5	0.0
Make readily available to students a wide variety of resource materials for scientific investigations	4.9	38.3	14.8	23.5	8.6	2.5	7.4
Encourage students to design and conduct experiments	14.6	48.8	14.6	11.0	6.1	1.2	3.7

Note. Grand mean = 2.42 (*SD* = 0.87) [a]Reverse coded for analysis. [b]Coded as 0; [c]Coded as 1; [d]Coded as 2; [e]Coded as 3; [f]Coded as 4; [g]Coded as 5; [h]Coded as 6

Table 2

Teacher Inquiry Scale Following Professional Development (n = 82)

	Percent						
On average, to what extent do you:	Never[b]	<1x per week[c]	1x per week[d]	2x per week[e]	3x per week[f]	4x per week[g]	5x per week[h]
Use a textbook as the primary method for studying agriscience[a]	22.0	51.2	12.2	13.4	1.2	0.0	0.0
Use open-ended questions that encourage observation, investigations, and scientific thinking	0.0	1.2	3.7	12.3	28.4	23.5	30.9
Identify agricultural situations/issues that can be investigated at varying levels of complexity	0.0	2.4	9.8	29.3	26.8	20.7	11.0
Encourage students to initiate further investigation	0.0	2.6	9.0	19.2	30.8	23.1	15.4
Ask a question or conduct an activity that calls for a single correct answer[a]	3.8	29.1	22.8	24.1	8.9	6.3	5.1
Facilitate and encourage student dialogue about science	0.0	1.3	2.6	17.9	25.6	29.5	23.1
Encourage students to defend the adequacy or logic of statements and findings	0.0	1.3	8.8	26.3	21.3	23.8	18.8
Make readily available to students a wide variety of resource materials for scientific investigations	0.0	3.7	17.3	18.5	17.3	22.2	21.0
Encourage students to design and conduct experiments	0.0	12.2	15.9	23.2	24.4	11.0	13.4

Note. Grand mean = 4.11 (*SD* = 0.80) [a]Reverse coded for analysis. [b]Coded as 0; [c]Coded as 1; [d]Coded as 2; [e]Coded as 3; [f]Coded as 4; [g]Coded as 5; [h]Coded as 6

Table 3

Student Inquiry Scale Prior to Professional Development (n = 82)

	Percent					
How often do you ask students in your classroom to:	Never[b]	1x per year[c]	1x per semester[d]	1x per month[e]	1x per week[f]	1x per day[g]
Memorize scientific facts or information separately from activities[a]	25.4	8.5	11.3	32.4	21.1	1.4
Use data to construct a reasonable explanation	5.2	11.7	26.0	36.4	16.9	3.9
Seek and recognize patterns (trends in data)	9.2	11.8	28.9	31.6	17.1	1.3
Follow a set series of steps to get the right answer to a question[a]	2.6	5.2	16.9	26.0	39.0	10.4
Ask questions during investigations that lead to further ideas, questions, and investigations	6.4	3.8	24.4	28.2	26.9	10.3
Wait to act until the teacher gives instruction for the next step in the investigation[a]	3.8	1.3	12.7	22.8	31.6	27.8
Choose appropriate tools for an investigation	10.1	6.3	17.7	31.6	21.5	12.7
Wait for the teacher's explanation before expressing an observation or conclusion[a]	10.3	2.6	10.3	29.5	32.1	15.4
Offer explanations from previous experiences and from knowledge gained during investigations	2.6	3.8	20.5	29.5	25.6	17.9
Make connections to previously held ideas (or revise previous conceptions/assumptions)	3.9	3.9	18.2	29.9	24.7	19.5
Communicate investigations and explanations to others	6.4	10.3	23.1	33.3	17.9	9.0
Use investigations to satisfy their own questions	25.3	8.9	29.1	17.7	16.5	2.5
Listen carefully to peers as they discuss scientific investigations	16.9	10.4	22.1	28.6	18.2	3.9
Use drawing, graphing, or charting to convey new information from an agriscience activity	6.3	12.7	26.6	32.9	19.0	2.5

Note. Grand mean = 2.47 (*SD* = 0.64) [a]Reverse coded for analysis. [b]Coded as 0; [c]Coded as 1; [d]Coded as 2; [e]Coded as 3; [f]Coded as 4; [g]Coded as 5

Table 4

Student Inquiry Scale Following Professional Development (n = 82)

	Percent					
How often do you ask students in your classroom to:	Never[b]	1x per year[c]	1x per semester[d]	1x per month[e]	1x per week[f]	1x per day[g]
Memorize scientific facts or information separately from activities[a]	19.4	8.3	12.5	26.4	26.4	6.9
Use data to construct a reasonable explanation	0.0	2.6	1.3	33.3	51.3	11.5
Seek and recognize patterns (trends in data)	0.0	1.3	10.7	33.3	40.0	14.7
Follow a set series of steps to get the right answer to a question[a]	1.3	1.3	7.9	31.6	50.0	7.9
Ask questions during investigations that lead to further ideas, questions, and investigations	0.0	0.0	2.6	15.6	41.6	40.3
Wait to act until the teacher gives instruction for the next step in the investigation[a]	11.7	5.2	13.0	32.5	23.4	14.3
Choose appropriate tools for an investigation	0.0	2.6	9.1	31.2	37.7	19.5
Wait for the teacher's explanation before expressing an observation or conclusion[a]	26.9	6.4	19.2	19.2	21.8	6.4
Offer explanations from previous experiences and from knowledge gained during investigations	0.0	0.0	3.9	20.8	41.6	33.8
Make connections to previously held ideas (or revise previous conceptions/assumptions)	0.0	0.0	2.6	18.2	35.1	44.2
Communicate investigations and explanations to others	0.0	0.0	5.2	27.3	49.4	18.2
Use investigations to satisfy their own questions	1.3	1.3	10.3	33.3	39.7	14.1
Listen carefully to peers as they discuss scientific investigations	0.0	1.3	7.7	25.6	42.3	23.1
Use drawing, graphing, or charting to convey new information from an agriscience activity	0.0	0.0	5.1	27.8	50.6	16.5

Note. Grand mean = 3.36 (*SD* = 0.46) [a]Reverse coded for analysis. [b]Coded as 0; [c]Coded as 1; [d]Coded as 2; [e]Coded as 3; [f]Coded as 4; [g]Coded as 5

Teachers were also asked to state their perceptions about the role of laboratory work in knowledge acquisition, process skill development, and attitude development using the Perception of the Role of Practical Work Instrument (Al-Naqbi & Tairab, 2005) prior to (see Table 5) and following (see Table 6) the PD. A grand mean of 2.60 (*SD* = 0.33) for this scale was calculated from teacher responses prior to the PD with a grand mean of 2.85 (*SD* = 0.19) following the event. These means resulted in an effect size of 0.92, which indicated that approximately 82% of the pretest responses would be below the mean posttest response.

Table 5

Teachers' Perceptions of Laboratory Activities Prior to Professional Development (n = 82)

The purpose of laboratory activities in my classroom are:	%D	%N	%A
To arouse and maintain interest	1.3	1.3	97.3
To develop an ability to comprehend and carry out instruction	2.7	9.5	87.8
To make phenomena more real through experience	2.6	10.5	86.8
To find facts and arrive at new principles	6.7	10.7	82.7
To verify facts and principles already taught	4.0	13.3	82.7
To encourage accurate observation descriptions	3.9	17.1	78.9
To give experience in standard techniques	3.9	19.7	76.3
To promote logical reasoning	5.3	21.1	73.7
To practice seeing problems and seeking ways to solve them	15.8	11.8	72.4
To develop an ability to communicate	16.0	14.7	69.3
To develop a critical attitude	9.3	25.3	65.3
To help remember facts and principles	13.3	21.3	65.3
To develop specific manipulative skills	16.2	20.3	63.5
To indicate the industrial aspects of agriscience	14.5	22.4	63.2
To prepare students for practical examinations	18.7	22.7	58.7
To develop self-reliance	12.2	31.1	56.8
To develop creativity	21.1	22.4	56.6
To elucidate theoretical work as an aid to comprehension	16.2	31.1	52.7
To develop certain attitudes of discipline	11.8	38.2	50.0

Note. Grand mean = 2.60 (*SD* = 0.33) Original scale: 1 = *Strongly Disagree* (SD), 2 = *Disagree* (D), 3 = *Neither Agree or Disagree* (N), 4 = *Agree* (A), 5 = *Strongly Agree* (SA). Responses were collapsed into: *Disagree* (D), *Neither Agree or Disagree* (N), and *Agree* (A)

Table 6

Teacher Perception of Laboratory Activities Following Professional Development (n = 82)

The purpose of laboratory activities in my classroom are:	%D	%N	%A
To practice seeing problems and seeking ways to solve them	0.0	1.3	98.7
To arouse and maintain interest	0.0	1.3	98.7
To promote logical reasoning	0.0	2.7	97.3
To make phenomena more real through experience	1.3	4.0	94.7
To encourage accurate observation descriptions	1.3	3.9	94.7
To develop an ability to communicate	2.7	2.7	94.6
To develop a critical attitude	0.0	5.5	94.5
To develop self-reliance	0.0	6.7	93.3
To find facts and arrive at new principles	4.0	2.7	93.3
To develop an ability to comprehend and carry out instruction	4.0	4.0	92.0
To give experience in standard techniques	3.9	6.6	89.5
To elucidate theoretical work as an aid to comprehension	2.7	8.1	89.2
To develop creativity	2.6	10.5	86.8
To develop specific manipulative skills	5.3	9.3	85.3
To indicate the industrial aspects of agriscience	5.3	10.5	84.2
To develop certain attitudes of discipline	7.9	10.5	81.6
To prepare students for practical examinations	11.8	11.8	76.3
To verify facts and principles already taught	7.9	15.8	76.3
To help remember facts and principles	9.3	14.7	76.0

Note. Grand mean = 2.85 (*SD* = 0.19) Original scale: 1 = *Strongly Disagree* (SD), 2 = *Disagree* (D), 3 = *Neither Agree or Disagree* (N), 4 = *Agree* (A), 5 = *Strongly Agree* (SA). Responses were collapsed into: *Disagree* (D), *Neither Agree or Disagree* (N), and *Agree* (A)

Objective 2

The study's second objective sought to describe the difference between teachers' perceptions of their use of inquiry-based teaching practices and laboratory activities following participation in PD that either did or did not utilize all five of Desimone's core features. In 2006, the NATAA format was restructured to more closely align with the five core features of content focus, active learning, coherence, duration, and collective participation. Therefore responses were separated based on the participants' attendance prior to or following the restructuring. The respondents who attended the PD prior to 2006, when it did not include all five of Desimone's core features, (*n* = 13) had grand means on the three measures of the Teacher Inquiry Scale, Student Inquiry Scale, and the Perception of the Role of Practical Work Instrument of 4.16 (*SD* = 1.24), 3.39 (*SD* = 0.72), and 2.85 (*SD* = 0.17), respectively. The respondents who attended the PD 2006 or after, when the PD included all five of Desimone's core features (*n* = 69), had grand means on the same three measures of 4.10 (*SD* = 0.71), 3.36 (*SD* = 0.41), and 2.86 (*SD* = 0.20), respectively. Effect size calculations yielded 0.06 on the Teacher Inquiry Scale, 0.05 on the Student Inquiry Scale, and 0.05 on the Perception of the Role of Practical Work Instrument. These effect sizes can be interpreted to mean that approximately 50% of the pretest scores would fall below the average posttest scores, indicating that no practical effect was found.

Objective 3

The third objective sought to describe the difference between teachers' perceptions of their use of inquiry-based teaching practices and laboratory activities following either one- or two-years of participation in the PD. Therefore, responses were separated based on the number of times participants attended the PD, i.e., once or twice. The respondents who attended the PD once (*n* = 60) had grand means on the three measures of the Teacher Inquiry Scale, Student Inquiry Scale, and the Perception of the Role of Practical Work Instrument of 4.09 (*SD* = 0.71), 3.33 (*SD* = 0.40), and 2.88 (*SD* = 0.20), respectively. The respondents who attended the PD twice (*n* = 22) had grand means on the same three measures of 4.16 (*SD* = 1.03), 3.43 (*SD* = 0.61), and 2.80 (*SD* = 0.18) respectively. Effect sizes were calculated, and yielded 0.08 on the Teacher Inquiry Scale, 0.19 on the Student Inquiry Scale, and 0.42 on the Perception of the Role of Practical Work Instrument. These effect sizes were interpreted to estimate 54% of the pretest scores on the Teacher Inquiry Scale and 58% of the pretest scores on the Student Inquiry Scale would fall below the mean posttest score. Sixty-six percent of the posttest scores would fall below the mean pretest score on the Perception of the Role of Practical Work Instrument.

Conclusions

Based on an evaluation of the grand means of the various scales utilized in this the study, participant responses differed after attending the PD from what was reported prior to the event, supporting previous statements regarding the effectiveness of PD on teacher behavior change (Desimone, 2009; Supovitz & Turner, 2000). The greatest difference, a change of 1.69, was found in responses to the Teacher Inquiry Scale. This difference was found to be practically important, as the very large effect size and subsequent interpretation indicated that 98% of all summated individual pretest scores would be lower than the grand mean posttest score. This result indicates teachers engaged in inquiry-related activities more often following the PD. More modest differences were found in the Student Inquiry Scale (0.89) and the Perception of the Role of Practical Work Instrument (0.25) after the PD. These more modest differences still resulted in considerable effect sizes, and we estimate that 95% and 82% of the pretest mean scores would fall below the average grand mean score on the scales, respectively. These considerable effect sizes indicate that the recommendation by researchers to improve educational instruction through teachers' training is appropriate and should be expected to positively influence teacher perceptions of their behaviors (Castellano, Stringfield, & Stone III, 2003; Levin, 1995; Myers & Thompson, 2009; Myers & Washburn, 2008; Spindler, 2010; Supovitz & Turner, 2000).

A comparison of the participant responses based on attending the PD prior to or after the restructuring of the PD did not show practical differences according to the effect sizes and interpretations of those effect sizes, indicating that the inclusion of active learning in PD was not directly influential in the event's effectiveness. This finding is contrary to the conceptual framework created by Desimone (2009), which cites active learning as a crucial component to successful PD events. Desimone also recommends that each of the five core features be examined more fully and in a wider variety of educational settings, implying that results could differ as more studies are conducted. The findings of this study do not support the use of active learning in this particular setting, which may be useful in furthering the evolution of a conceptual framework for PD.

The findings also led to a less-than-supportive conclusion regarding the usefulness in increasing the years of participation of PD, as the effect sizes of the differences between pretest and posttest scores between those that attended one and two years of PD were small to moderate. However, mean differences in scores among the Teacher Inquiry Scale, Student Inquiry Scale, and Perception of the Role of Lab Work Instrument varied the most between these two groups, implying that duration of PD may impact these types of teachers' perceptions differently.

Discussion and Recommendations

This study yielded recommendations for both practice and future research. Findings support the continued use of PD as a keystone method in initiating teacher change. Further, organizations that have invested funding and time into PD programs can be assured that these programs are utilizing funds to effectively alter teacher behavior. Those designing and delivering PD can find a research-based model in Desimone's (2009) core features of PD. However, because active learning is included in Desimone's (2009) core features of PD but was not found to be impactful in this study, further research should be conducted to better understand why the inclusion of active learning did not result in a difference in respondents' perceptions of their behaviors. Active learning, like constructivist learning, problem-based learning, and inquiry-based learning, is a broad term that is defined differently by different people (Kirschner, Sweller, & Clark, 2006). Professional development planners' and leaders' definitions of active learning when delivering PD may impact its effectiveness in changing teachers' perceptions, as some methods used under the guise of active learning may not actually be supported by cognitive science (Kirschner, Sweller, & Clark, 2006). Further exploration into which of the specific interpretations of active learning are successful can help researchers better identify whether and how active learning should be included in PD.

The mixed results of the difference between those attending one and two years of the PD do not fully support the increase of PD duration, as the differences between the two groups on the Teacher Inquiry Scale were low. However, the differences between the two groups on the Perception of the Role of Practical Work instrument indicate that, at times, an increase in PD duration can be worthwhile. The content of the PD may have played a role in which areas teachers benefited from increased duration. A lengthened PD session that focused on lab activities might lead to higher scores on the Perception of the Role of Practical Work Instrument, but not on the Teacher Inquiry Scale. Further study focusing on how the content of PD sessions impact the learning that occurs during PD is recommended. It is possible that the *tipping point* in PD duration (Desimone, 2009) may have been reached after one full year of participation. This implication, however, requires further investigation. Therefore, due to the monetary and time costs of PD events, future research should examine the impact of PD offered in varying durations and for multiple opportunities to participate to determine the most appropriate, yet cost effective, duration to impact teacher behavioral change.

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