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Connections between science teachers' professional development preferences and their teaching practices and beliefs

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CONNECTIONS BETWEEN SCIENCE TEACHERS' PROFESSIONAL DEVELOPMENT PREFERENCES AND THEIR TEACHING PRACTICES AND BELIEFS

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Abstract

The effect of professional development preference, in relation to its effect on teacher practices and beliefs, has not been well studied. In order to better understand this dynamic, a nationwide online survey was developed and sent to secondary science teachers. The findings of this survey indicate a relationship does exist, but only within specific practices. During analysis, teachers were grouped by preference of professional development type including collaboration, reflection, conducting research, and professional development (such as conferences and workshops). Significant differences emerged from each group and implications for effective professional development practices will be addressed.

Introduction

Participation in teacher professional development is commonplace in a teacher's commitment to lifelong learning. Professional development can have a large impact on science teacher classroom practices depending on the type and duration of the professional development (Supovitz & Turner, 2000). Many forms of professional development exist, such as conferences, reflections, professional learning communities, and action research, but teacher participation differs per type. Kwakman (2003) determined a variety of factors affect why teachers participate in certain professional development programs including: professional attitudes, loss of personal support, and feasibility of innovative activities. Since professional development participation is an expected part of teacher learning, and a common way to expose new ideas to teachers, and therefore classrooms, it is necessary to explore how professional development itself affects teachers. In order to promote positive, reform-based change in the classroom, it is critical to make sure professional development programs are as effective as possible. The purpose of this study is to determine how professional development preference affects science teachers' teaching practices and beliefs in order to illuminate one aspect of this overarching goal to improve teacher professional development.

Literature Review

Teaching Practices

As long as there are subjects to teach, there are seemingly endless ways to teach them and science is no exception. However, in recent decades there has been a shift towards a more student-centered approach to teaching practices (National Research Council, 2012). Teaching styles are differentiated into either teacher-centered or student-centered at their core because of this newest wave of educational reform. Defining these two types of teaching styles and determining their outcomes is necessary in order to explore the effects of professional development on teaching practices.

Teacher-centered teaching. Teacher-centered teaching is considered the more traditional method of teaching. Teacher-centered teaching denotes the role of the teacher as one to direct the classroom and act as the expert who presents the material to the students (Pedersen & Liu, 2003). Pedersen and Liu (2003) elaborated on the purpose of assessment in this teaching style is to assign a grade, the goals of activities are to meet objectives set by the teacher, and student group interaction and actions are primarily controlled by the teacher. Teacher-centered teaching appears in many forms. Mascolo (2009) described the main method of providing information as a traditional lecture where the student sits quietly, listening to the teacher. Hancock, Bray, and Nason (2002) further explained that students can ask questions, but receive a response along the lines of “right/wrong feedback… prompts and cues” or “correct answers” maintaining the role of the teacher as the expert and returning control of the discussion to the teacher. The teacher keeps the students on schedule by summarizing what was learned and moving on to the next topic after that lesson has concluded (Hancock et. al, 2002). Group work may occur within a teacher-centered classroom, but it’s often through cooperative learning rather than collaborative learning. Nunan (1992) described cooperation in the classroom as a small group of students with explicit roles to play where the teacher determines when and how the work will be done with students executing the expected steps. Teacher-centered teaching can use group work, but it still maintains control of that group’s actions. Anderson (2002) expressed an underlying tone of teacher-centered teaching: the student is a passive learner while the teacher is active. The students are approached as empty cups to be filled with knowledge dispensed by the teacher as the expert.

Student-centered teaching. Student-centered teaching differs greatly from teacher-centered teaching because it is grounded in the concept that students need to be actively involved in their learning process by participating in activities that are meaningful for them (Pedersen & Liu, 2003). Pedersen and Liu (2003) explained that many approaches fall under the umbrella of student-centered learning, but common aspects to all of them include students working to answer a central question, the teacher acting as a facilitator of learning, assessments that help students understand their learning, and students collaborating with each other rather than simply cooperating. They further noted that collaboration differs from cooperation because students control how they work together rather than being assigned roles that may or may not benefit them as a learner. Student-centered teaching involves several different specific pedagogies. Cervone and Cushman (2013) indicated students, in a student-centered classroom: work with advisers who conference with the student to keep track of their academic progress, demonstrate their understanding with projects, videos, experiments, products they create, offer opportunities for student self-reflection, choose content with real-world applications, and provide and receive feedback. By utilizing these strategies, and others, teachers provide a learning experience tailored to the needs of the student rather than applying a one-size-fits-all framework.

These student-centered approaches align well with reform-based practices promoted by the National Research Council. Reform-based practices, as outlined by the National Research Council (2000), follow an inquiry approach and include five key points: learners are engaged via questioning, learners provide evidence for claims they make, learners formulate explanations from evidence, learners evaluate explanations, and learners communicate, or justify, their explanations. One of the most popular forms of student-centered teaching in science education is inquiry teaching as it fulfills the requirements of truly student-centered teaching (Anderson, 2002). Inquiry teaching is a multi-faceted concept where students create authentic research questions and engage in scientific argumentation and reasoning to further their understanding (Berland & Reiser, 2010). Students are active participants and learning cannot occur without the participation of the student.

Outcomes of teaching practices. Different teaching strategies result in different student outcomes. The difference in student outcomes becomes very clear when comparing student-centered teaching and teacher-centered teaching. Schroeder, Scott, Tolson, Huang, and Lee (2007) conducted a meta-analysis of 61 different studies concerning teaching strategies and student achievement. The authors determined that more traditional, teacher-centered, approaches were often less effective, with respect to student achievement, than more student-centered, reform-based, approaches. These findings are supported by Cornelius-White (2007) whose meta-analysis also determined that learner or student-centered teaching strategies resulted in above average student outcomes. Student-centered teaching approaches most often lead to positive student outcomes, but there is a caveat. The largest problem associated with student-centered teaching is how to concisely define it as it encompasses many teaching approaches. Teachers often think they are using student-centered approaches, but in actuality, their practices are still more teacher-centered than student-centered because of the vague definition of student-centered teaching practices (Pedersen & Liu, 2003). Teachers incorporating true student-centered teaching put the learning in the hands of the students which, if used well, benefits students in achieving their learning goals. The mechanism to push teachers towards these beneficial student-centered teaching practices is often through professional development programs.

Professional Development

Participating in professional development is common practice by teachers. The National Center for Education Statistics (2013a) reported 98.5% of all teachers in the United States participated in some form of professional development from 2011 to 2012. The intent of professional development is to train teachers to effectively promote and incorporate best practices. Currently best practices are reform-based, or student-centered, practices, but there are many types of professional development programs available to teachers.

Research on the effects of different professional development programs is often conducted in isolation and limits the ability to discuss trends in professional development effectiveness. Oliveira (2010), for example, studied the impact of a one-day summer institute for three elementary science teachers' use of inquiry questioning in the classroom. This study had a very narrow scope and the authors noted its limitations as being unable to draw conclusions on the effects of similar programs in different social contexts (i.e. rural or urban settings). These highly specific studies make it difficult to study general trends for what professional development science teachers around the country choose to participate in and how effective these types of programs are with respect to other programs. Available professional development programs must first be identified before discussing what defines effective professional development in general.

Examples of professional development. Professional development programs across the country vary greatly, but are best broken into two categories: short-term and long-term programs. Yoon, Duncan, Lee, Scarloss, and Shapley (2007) defined short-term as fourteen hours or less. Short-term programs often occur over the span of one or two days, often within the context of the school or district. The most common example of this implementation comes in the form of one-day in-service programs put on by a school (Sandholtz, 2002). These in-service programs focus on providing information in a “one-shot workshop” where teachers absorb information provided on topics typically chosen by administrators often with a specific method in mind for teachers to adopt (Sandholtz, 2002). These workshops often resemble a teacher-centered classroom regardless of the content taught. One-day programs are common in schools with 91.5% of teachers participating in one from 2003-2004 (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). One-day programs may be prevalent, but greater variety is found within long-term programs.

Long-term programs often consist of research experiences. Some programs within the realm of research experiences focus on scientific research in labs (Schwartz, Westerlund, Garcia, & Taylor, 2010), others on action research in the classroom (Lebak & Tinsley, 2010), and others still are a combination of the two (Herrington, Bancroft, Edwards, & Schairer, 2016). Scientific research, often in the form of Research Experiences for Teachers (RETs), provide a fully immersive research experience in authentic laboratory settings with fellow scientists (Schwartz, Westerlund, Garcia, & Taylor, 2010). Silverstein, Dubner, Miller, Glied, and Loike (2009) included explicit science education application days within their scientific research experience with an emphasis on collaboration between research mentors along with other teachers. The program, as a result, included a research experience along with a direct link to classroom practice. RETs and similar programs emphasize work outside of the classroom, but action research differs in this regard. Action research is the development of strategies, implementation of those strategies within an authentic teaching experience, and analysis of the outcome with the intent of improving teaching practices (Eilks & Markic, 2011). Lebak and Tinsley (2010) conducted a similar program combining action research and reflection. Teachers recorded their teaching, brought the videos to a group of peers during which all teachers reflected on their teaching and worked together to come up with action plans for each of the teachers in the group (Lebak & Tinsley, 2010).

One-day programs, research experiences that take place over the course of years, and programs created to promote teacher reflection and collaboration all exist as current forms of professional development through which teachers can develop their skills and improve their teaching. However, the effectiveness of programs varies depending on the characteristics of the program.

Characteristics of effective professional development. The search for effective professional development is not a new process. Garet et. al (2001) found that the connection between professional development activities and their effectiveness relies on multiple factors such as duration of the activity, the degree of collective participation, and the focus on content. The largest difference, according to Darling-Hammond and Richardson (2009), came in the form of “one-stop” versus long-term, continuous professional development. Yoon et. al (2007) found that for elementary school teachers longer-term, sustained professional development positively correlated with student achievement more so than professional development with less than 14 contact hours. The findings by Garet et. al (2001) echoed a similar sentiment: professional development of shorter durations is ineffective compared to professional development of longer lengths.

A focus on specific pedagogies also appears to have a large impact. Darling-Hammond and Richardson (2009) elaborated that professional development with a focus on specific pedagogical skill development and collaboration with teachers (in the same school if possible) via professional learning communities yields the greatest gains in student achievement. This student achievement was attained because teachers were given the opportunity to work with other teachers to 1) reflect on classroom practices and 2) work together to problem solve by utilizing the experiences of other teachers in that community. By creating a group where teachers work with each other for the betterment of all, the effect is more positive than a workshop where teachers watch a presentation on a new strategy to implement.

Teachers participate in professional development, but the effectiveness of the professional development is dependent on the program's structure and implementation, specifically with regard to whether teachers are active or passive participants. Student-centered practices rely on students being active in their learning and the same is true for professional development programs aiming to promote student-centered teaching practices. Herrington and Daubenmire (2016) echoed the notion that if professional development is to promote student-centered practices, the teachers in the programs must play an active role in their learning in a similar fashion as their students. Professional development cannot be effective until the structure of the program embodies the pedagogy these teachers are trying to implement in their classrooms.

Efforts to improve professional development effectiveness. Similar to studies that examined what makes professional development effective, there is a small effort to try to bridge the gap between *knowing* what is effective to *making* professional development more effective. These efforts include new models of professional development and changing who takes the active role during professional development program planning and implementation.

Different models of professional development have been created to increase professional development effectiveness. For example, the Pathways Model (Lieberman and Wilkins, 2006), creates standards for professional development programs similar to how classrooms have learning standards. This model then incorporates a combination of school wide development for general training sessions (like with new technology), and department and individual development to create and implement inquiry activities. After the programs are finished, all three groups reflect upon the effectiveness of the professional development in order to have a quick turnaround for improving the programs. The professional development program would ideally take place over the course of a year, with collaboration between teachers, and focus on content needs within the context of the department and individual development. This model incorporates characteristics that result in effective professional development in terms of duration, role of the teachers, and focused content (Garet et. al, 2001).

Not only do models of professional development exist, but also a new attitude on who should be in charge of choosing professional development programs. A key finding from Darling-Hammond et. al (2009) noted a lack of support for teachers in their opinion of what they need in professional development. The authors further explained that the United States does not provide opportunities for teachers to spend time together working through classroom or pedagogical problems, or for teachers to participate in the kind of professional development they feel is needed. Colbert, Brown, Choi, and Thomas (2008) tested the effects of teacher-driven professional development on pedagogy and student learning and found that teacher participants thrived under this model and were empowered to institute change in their teaching. By allowing teachers to seek out development of their specific needs, teachers felt supported to succeed and took steps to improve their practices at a quicker pace than with prescribed professional development programs.

In order for teachers to make significant gains from professional development programs, short and prescribed programs are not going to work. Different models that incorporate characteristics of effective professional development must be utilized and teachers need to take agency in their professional development experiences. Current literature illuminates programs with positive characteristics, but does not delve into why teachers chose to participate in these programs over other programs. If the goal is making professional development more effective in instituting true change in teaching practices, it is crucial to study not just the program, but the reasons teachers prefer one program over another. Further research on how to improve professional development programs is necessary and this study aims to add to that discussion.

Research Questions

Current literature exists on what teachers do in the classroom, the benefits and drawbacks of those practices, what professional development science teachers choose to do, and the definition of good professional development. Supovitz and Turner (2000) reported a strong relationship between the length and intensity of the professional development with science teaching practices. Yet, it is unclear if professional development program preference, not just length or intensity, by secondary science teachers has an effect on their teaching practices. It is necessary to ask the following questions in order to determine if a relationship exists between science teacher practices and beliefs in the classroom and what those teachers do to improve their practices:

1. How do the professional development practices secondary science teachers use to better their teaching reflect their self-reported teaching practices in the classroom?
2. How do the professional development practices secondary science teachers use to better their teaching reflect their self-reported teaching beliefs?

It may be possible to determine a link between practices outside the classroom and the use of teacher-centered or student-centered practices and beliefs held by those same teachers by asking about their practices inside and outside the classroom along with their beliefs. Exploring this deeply makes it feasible to draw conclusions on the effects and benefits of promoting certain types of professional development to increase the quality of secondary science teachers in the United States.

Methodology

Data Collection

An IRB approved survey was created as part of a larger project on teacher practices in the fall of 2014 utilizing Qualtrics survey software. The 45 question survey was broken down into the following topics: demographics, information about research experiences, teaching practices, teaching beliefs, data usage, data collection, professional development, professional learning communities (PLCs), and how the participants improve their teaching. To ensure clarity in writing, each question was reviewed by two other individuals. Survey questions were formatted as quantitative Likert scale questions to understand frequency of practices, “yes or no” and ranking questions about teaching beliefs, “check all that apply” questions about professional development and its usefulness, and qualitative open-ended questions about professional development preferences.

This survey was piloted before sending it out to a national audience. The pilot was sent to only Iowa science teachers through regional listservs and other organizations such as the Iowa Academy of Sciences. There were 139 responses collected from Iowa teachers. After the pilot was completed, the survey structure and content were analyzed to determine if any changes needed to be made. The only influential change was to require participants to answer “yes” or “no” to consent to the survey as all survey participants who did not consent were deleted from the survey data. After this change was made, the survey was sent out nationwide to 6-12 secondary science teachers, excluding Iowa since the survey data from Iowa had already been collected. The survey was disseminated by contacting state science teacher associations and national science teacher organizations and requesting they send out the survey link (with the inclusion that survey participants were eligible to be entered in a drawing for either an iPad or tablet). There were 26 state science teacher associations spanning from Alaska to Florida along with two national organizations (American Association of Chemistry Teachers and National Middle Level Science Teachers Association) that agreed to send out the survey through listservs, email blasts, newsletters, or by posting the information on their websites. The survey was live from March 2015 to April 2015 with data analysis occurring from summer 2015 through January 2017.

Analysis

Data analysis of the survey data was completed with the use of NVivo10 and IBM SPSS Statistics Software. To begin, the Iowa (N=199) and National (N=422) survey responses were merged into one file since no questions differed between the two. After the initial merging and stripping responses of identifying information (e.g. IP addresses), researchers deleted responses that did not consent to the survey, did not answer more than half the questions, or, from their demographic information, were elementary science teachers. This yielded 474 survey participants. However, the basis of the research presented here relied on the participant's answer to "Overall, what do you do to improve your teaching practices?" (which will be referred to as their professional development preference), so any participants who did not answer that question were deleted, leaving 460 participants for analysis.

Qualitative responses to professional development preference were imported into NVivo 10 where they were coded using "check-coding" in which three individuals code the same answers to confirm the clarity of code definitions and to promote inter-rater reliability (Miles & Huberman, 1994, p. 64). Initial codes were determined based on trends in data about how teachers improve their teaching practices (Table 1). Responses could have been categorized with multiple codes, with one exception. Responses coded as “not codeable” consisted of statements like, “yes,” or “plan to retire.” Those responses did not include usable data for analysis. Depending on the level of detail the participant chose to note, individual responses were coded with anywhere between one to five codes. Initial codes were only a subset of the final coding categories after using the “minimal information” code as a catchall for codes that did not fit into the original categories. After the first few rounds of coding, the researchers went through the “minimal information” code and added additional categories so the final code categories were created and all responses were re-coded to account for their existence (Table 2).

Table 1

Initial Code Categories

Code	Code description
Collaboration with other teachers	Talking with other teachers to better practices either in person or online, but could not simply include “listening to others”
Conducting research on their own time	Reading current literature, collecting data, action research, scientific research; Requires cognitive development, not just “using data”
Including applicable content	Incorporating real-world applications, making the content relatable, and adding real world connections
Mentoring other teachers	Mentoring pre-service or novice teachers
Minimal information	Participants indicate they do something, but do not clearly fit within other code categories

Code	Code description
Not codeable	Does not answer the question, but includes responses like "yes"
Observing other teachers	Must clearly indicate the participant observed another teacher, but the purpose of that observation could vary
Participate in committees	Non-PLC type committees on the national, state, district, or school level
Professional development	Had to clearly note what the "PD" was such as workshops, webinars, conferences, but had to specify further than "go to PD"
Professional learning communities	Could refer to joining or participating in professional learning communities or describe evaluating common assessments, data, outcomes without specifying the phrase "PLC"
Receiving feedback	Feedback could come from teachers, parents, students, but feedback must be in reference to teaching practices
Reflection	Reflecting on teaching or student learning
Taking classes	Includes for a degree or unspecified, but with respect to university-like courses rather than PD-like courses
Trying new things	New pedagogies incorporated in the classroom and willing to try new ideas; Cannot indicate trying "different" things, have to be new
Utilize online/outside sources	Includes finding or trying lessons from forums, listservs, blogs, other teachers, but focused on the activity or lesson rather than a pedagogical shift

Table 2

Final Code Categories in Order of Decreasing Frequency

Code	Code description	*n*
Professional development	Had to clearly note what the “PD” was such as workshops, webinars, conferences, but had to specify further than “go to PD”	175
Collaboration	Talking with other teachers to better practices either in person or online, but could not simply include “listening to others”	142
Doing research	Reading current literature, collecting data, action research, scientific research; Requires cognitive development, not just “using data”; Must indicate what is read in order to distinguish from the “Read” code category	85
Ambiguous action	Participants indicate they do something, but it cannot be fully understood from their response	76
Reflection	Reflecting on teaching or student learning and “I reflect” is clear enough to be included	67
Reading	Participants indicate they “read,” but do not elaborate on what they read to distinguish it from those actively seeking out best practices from literature	46
Trying new things	New pedagogies incorporated in the classroom and willing to try new ideas; Cannot indicate trying “different” things, have to be new	41
Generic "PD"	Responses indicate participants prefer “PD,” but do not define what PD they do	40
Utilizing outside sources	Includes finding or trying lessons from forums, listservs, blogs, other teachers, but focused on the activity or lesson rather than a pedagogical shift	31
Receiving feedback	Feedback could come from teachers, parents, students, but feedback must be in reference to teaching practices	28

Code	Code description	*n*
School culture	Learn from or listen to other teachers, but unclear if these individuals actually collaborate	26
Observing other teachers	Must clearly indicate the participant observed another teacher, but the purpose of that observation could vary	23
Changing instruction	Participants indicate they change instruction, but do not specify if it is new, only different	22
Not codeable	Does not answer the question, but includes responses like “yes”	20
Classroom culture	Listening and attending to the needs of the students, but not necessarily through specific feedback avenues; Emphasis is on creating an environment for students to learn best in	16
PLCs	Could refer to joining or participating in professional learning communities or describe evaluating common assessments, data, outcomes without specifying the phrase “PLC”	16
Applicable content	Incorporating real-world applications, making the content relatable, and adding real world connections	14
Mentoring other teachers	Mentoring pre-service or novice teachers	12

Once all 460 responses were coded, they were exported as an Excel file that could be uploaded to the IBM SPSS Statistical Software as new variables. After determining the percentage of participants coded in each category for professional development preference, only the top four categories with the highest percentage were analyzed: collaboration, conducting research, professional development, and reflection. While the n-value of the “ambiguous action” group is technically the fourth largest group, due to the nature of the code, it was omitted from the decision to further analyze the four largest groups. The number of participants in each group (collaboration, conducting research, professional development, and reflection) analyzed are noted above (Table 2). Due to the high number of categories created in the coding process, not every participant is included in the groups, but they are included in analysis when comparing one group to the rest of the participants not coded within a group. Further, individual participants could exist within multiple groups depending on their answer to how they best improve their teaching practices since it was an open-response question rather than a question that forced a single answer from participants. For example, a single participant's answer may be concurrently coded under "Collaboration" and "Reflection" because their response indicated elements of both codes.

Quantitative analysis was conducted with SPSS with respect to the four aforementioned code categories. Demographic information (number of years teaching, age, and gender of participants) and questions regarding teaching beliefs and professional development practices were also tallied as percentages. Frequency data was calculated in the form of mean values and percentages for Likert scale questions about teaching practices teachers self-reported in looking back on the week previous to taking the survey, which teaching tools each teacher utilized, and how often those tools were utilized. Data analysis for relationships between variables was conducted with correlational tests, t-tests, and chi-square tests for determining statistical significance and trend analysis. Results reported below include t-test results, used to compare statistical significant differences between means, along with their respective degrees of freedom and Cohen's d effect size. Data analysis began during the summer of 2016 and ended in January 2017.

Participants

The survey participants who responded to the professional development preference question were further analyzed and the resulting demographics were calculated (Table 3). Average number of years of teaching reported by participants (15.29) is similar number to the national average of 13.8 (NCES, 2013b). Average age of participants (43.99) also relatively follows the national average of 41.2 (NCES, 2013b).The survey sample differs more greatly from the national average by having a slightly larger percentage of female science teachers (69.3%) versus the national average of 53.6% (NCES, 2013b). The participants were located around the United States, but not every state is represented in the survey population.

Table 3

Participant Demographics

Demographics	Participants	National Demographics
Total Participants	460	N/A
Gender	69.3% female 30.2% male	53.6% female 46.4% male
Average age	43.99	41.2
Average number of years as a teacher	15.29	13.8

Questions

The survey itself contained a variety of questions, but the responses utilized for this analysis included only a select few. They will be described below, along with their abbreviated names that will be used to reference them throughout the reporting of the results (Table 4). A full copy of the survey questions can be found in Appendix A.

Table 4

Abbreviations for a Sample of Survey Questions

Question Abbreviation	Question	Question Description
Student Practices	Thinking about last week in the course you just listed, how often did students do the following?	Participants were asked about the roles of their students in the classroom ranging from working in groups on practices problems, taking quizzes, to collecting or analyzing data in a lab activity.
Teaching Tool Use	Which of the following teaching tools have you used for the course you listed in the past week, past month, past year, or not at all?	Participants were asked about how frequently they used different teaching tools such as non-graded homework, whiteboards, and conferences with students.
Teaching Tool Purpose	In your opinion, the purpose of each of the following teaching tools is (check all that apply even for tools you do not use):	Participants were asked what they thought the purpose of different teaching tools were, regardless of their use of that tool, including purposes like assigning students a grade or collecting data on student understanding.
Student Learning Ranking	Please rank by dragging and dropping the following items with the most significant to student learning at the top of your list.	Participants were asked to rank a variety of teaching tools in order of their significance to student learning with tools ranging from using models to lab experiments.
Rank #1 for Student Learning	Please choose the one item you feel is the most important for a student's learning of science.	Participants were asked to choose one tool from the list of tools in the “Student Learning Ranking” question as the most significant to student learning.

Question Abbreviation	Question	Question Description
Lab Styles	Please rank by dragging and dropping the following items about laboratory styles with the most significant to student learning at the top of your list.	Participants were asked to rank different types of laboratory styles with respect to their impact on student learning and ranged from more inquiry-based labs to more cookbook style labs.
Assessment Styles	Please rank by dragging and dropping the following items about student assessment with the most significant to student learning at the top of your list.	Participants were asked to rank different types of assessment with respect to their impact on student learning ranging from diagnostic, formative, to summative assessment styles.
Individual PD	For professional development on your own time, please indicate whether or not you participate in the type of professional development described and then indicate if you think they are useful in achieving your professional goals.	Participants who indicated participating in professional development on their own time were asked to indicate if the professional development programs they participated in were useful, not useful, or they did not participate in them.
School PD	In your school/district sponsored professional development, please indicate their level of usefulness.	Participants who indicated participating in school/district-sponsored professional development were asked to indicate if the different professional development programs were useful, not useful, or not offered.
Participation Reasons	Please rank the following options in describing your reasons to participate in professional development on your own time PD.	Participants were asked to rank reasons for participating in professional development on their own in terms of how influential it was to their participation.

Results

Significant relationships were determined through various analyses. To further elaborate, the results are categorized into two groups: intra-group comparisons with respect to all other participants and inter-group comparisons comparing each group side by side. First, the intra-group results, comparing coded responses to non-coded responses will be discussed. Second, inter-group results about professional development practices will be reported by elaborating on how the four analysis groups answered across the board.

By Groups

Collaboration. Participants within the group "collaboration" (n = 142) all indicated, in their response to professional development preference, that their teaching practices are best improved through collaborative efforts with other teachers and administrators. The effect of this opinion is noted below in terms of differences in teaching practices and beliefs.

Practices. Two questions, "Student Practices" and "Teaching Tool Use," were analyzed in order to determine if statistically significant differences existed between the collaborator and non-collaborator groups.

When asked about their practices in the past week, those in the collaboration group did not provide more feedback to students on laboratory activities with respect to the non-collaborators (Table 5). Rather, those in the non-collaborator group more frequently provided feedback to their students about lab activities. The effect size for this difference is small (0.21), so while the difference is statistically significant, the actual difference between the groups is not very big. As noted by Bird (2004), the Cohen's d effect size range between zero to one with 0.2, 0.5, and 0.8 indicating a small, medium, and large effect size, respectively.

Table 5

Differences between Collaborators and Non-collaborators for "Student Practices"

Teaching practice	Collaborators averages	Non-collaborators averages	*t*	*df*	*d*
Received teacher feedback on their results in lab activities.	2.08	2.24	-2.02*	244	0.21

1= zero days, 4= every day, *denotes p value <0.05

When determining the frequency of different teaching tools, the collaboration group reported using small group discussion more frequently in the classroom (Table 6). The high average of the collaboration group indicates that the majority of the group incorporate small group discussions at least monthly, but often weekly in their classrooms. Similar to above (Table 5), the effect size for the difference between groups is small.

Table 6

Differences between Collaborators and Non-collaborators for "Teaching Tool Use"

Teaching tool	Collaborators averages	Non-collaborators averages	*t*	*df*	*d*
Small group discussion	3.75	3.59	2.57*	364	0.25

1= does not use, 4= weekly use, *denotes p value <0.05

Beliefs. The collaborator group did not differ much from other groups in practice, but their teaching beliefs showed more variance. Beliefs were examined with three questions: "Teaching Tool Purpose," "Student Learning Ranking," and "Rank #1 for Student Learning." Differences in teaching beliefs with respect to these three questions were noted between the collaborator and non-collaborator groups.

The teaching beliefs of the collaborator group indicate they more frequently believe in the benefits of small group discussion and conferences with students (Table 7). Individuals in the collaboration group more often indicated they believed the purpose of small group discussions were to guide teaching and collect data and that conferences were to help students see their learning. Those not coded in the collaboration group still held these beliefs, but a larger portion of the collaboration group held these beliefs with respect to those teaching tools. The effect sizes for purposes pertaining to small group discussion are small, but the effect size for the purpose of conferences is relatively larger indicating a larger difference in the groups, even though it is still a small effect size.

Table 7

Differences between Collaborators and Non-collaborators for "Teaching Tool Purpose"

Teaching tool	Purpose chosen	Collaborators (%)	Non-collaborators (%)	*t*	*df*	*d*
Small group discussion	To guide my teaching	67.6%	56.6%	-2.28*	285	0.23
Small group discussion	To collect data on the understanding of my students	48.6%	38.1%	-2.10*	264	0.22

Teaching tool	Purpose chosen	Collaborators (%)	Non-collaborators (%)	*t*	*df*	*d*
Conferences with you to assess learning	To allow students to see/understand their learning progress	81.0%	69.5%	-2.74*	314	0.28

*denotes p value <0.05

Within the collaboration group, 60.3% of participants noted that "working in groups" was within the top three of ten teaching tools listed with respect to their impact on student learning (Table 8). However, when asked to choose the most important tool to student learning, only 11.4% of that same group indicated the answer of "working in groups." Rather, it was the fourth most impactful by percentage following lab experiments (Table 9).

Table 8

Collaborator Results for "Student Learning Ranking"

Top 3	Collaborators (%)
Working in groups	60.3%

Table 9

Collaborator Results for "Rank #1 for Student Learning"

Most significant tool	Collaborators (%)
Real-world applications of content	30.7%
Creating/using models or representations	24.3%
Lab experiments	15.7%

Most significant tool	Collaborators (%)
Working in groups	11.4%

Conducting Research. Participants within the "conducting research" group (n = 85) all indicated the best ways to improve their teaching practices were to participate in some combination of the following: seek out best practices from current literature, or engage action research, scientific research, or thesis work. These participants often noted a need to be a continuous learner and seek out information to help them better their teaching.

Practices. The conducting research group analysis included the same two questions as the collaborator group. The "Student Practices" and "Teaching Tool Use" questions yielded different results for the researcher group in comparison to the collaborator group, but only the "Student Practices" question resulted in significant differences.

The "conducting research" group indicated they learn best by participating in forms of research; however, they less often had students conduct internet research in their weekly classrooms (Table 10). Those not coded "conducting research" more often included this form of research in their classrooms, however the effect size was small.

Table 10

Differences between Researchers and Non-researchers for "Student Practices"

Teaching practice	Researchers averages	Non-researchers averages	*t*	*df*	*d*
Did Internet/Web Research	1.71	1.89	-2.14*	133	0.26

1= zero days, 4= every day, *denotes p value <0.05

Beliefs. Analysis for the conducting research group included the "Teaching Tool Purpose" and the "Lab Styles" ranking question. Differences in teaching beliefs were significant when analyzing lab practices of the researchers and non-researchers.

The practices for the "conducting research" group did not show much variance from other groups, however their beliefs with respect to lab notebooks and lab reports did. The researcher group more frequently believed the purpose of lab notebooks and lab reports was to allow students to understand their learning progress and to collect data on student understanding (Table 11). Further, the high percentages with respect to the purpose of assigning a grade for lab reports indicate the researcher group more frequently hold the belief of the incorporation of this teaching tool into the classroom as a part of a student's graded work (Table 11). The effect sizes for these differences were small as well as those found above.

Table 11

Differences between Researchers and Non-researchers for "Teaching Tool Purpose"

Teaching tool	Purpose chosen	Researchers (%)	Non-researchers (%)	*t*	*df*	*d*
Lab notebook	To allow students to see/understand their learning progress	62.4%	48.5%	-2.35*	127	0.26
Lab notebook	To collect data on the understanding of my students	50.6%	38.4%	-2.03*	122	0.26
Lab reports	To collect data on the understanding of my students	75.3%	60.8%	-2.71*	137	0.30

Teaching tool	Purpose chosen	Researchers (%)	Non-researchers (%)	*t*	*df*	*d*
Lab reports	To assign students a grade	76.5%	65.3%	-2.13*	136	0.24

*denotes p value <0.05

Teachers were asked to rank different styles of lab activities with respect to their impact on student learning and ranged from more inquiry-based to cookbook labs. Participants in the "conducting research" group more frequently indicated a preference for inquiry-based labs rather than more prescribed, cookbook, labs which were more highly favored by those not in the "conducting research" group (Table 12). This preference implies the researcher group values inquiry-based labs as more beneficial to student learning than cookbook labs. Nearly 40% of the non-researcher group ranked a more prescribed lab style in the top two most significant to student learning. By contrast, nearly 80% of the "conducting research" group indicated an inquiry-based lab to be in the top two most impactful lab styles for student learning. The effect sizes are some of the largest in the dataset even though they are still considered small effect sizes (Table 12).

Table 12

Differences between Researchers and Non-researchers for "Lab Styles"

Top 2	Researcher averages	Non-researcher averages	*t*	*df*	*d*
Experiments in which students use prior knowledge to answer a question or meet a challenge.	79.0%	65.6%	-2.57*	133	0.30

Top 2	Researcher averages	Non-researcher averages	*t*	*df*	*d*
Experiments in which students are given questions to answer using a general procedure which they might have to modify.	22.2%	39.1%	3.18**	134	0.37

*denotes p value <0.05, **denotes a p value <0.01

Professional Development. The group coded as "professional development" (n = 175) indicated their teaching practices are best improved by participating in activities like workshops, conferences, and webinars.

Practices. The analysis of the professional development group yielded almost no significant differences with respect to teaching practices and no significant difference with teaching beliefs, but the "Student Practices" question illuminated one significant difference: lab notebook usage. Participants in this group more frequently utilize lab notebooks in their classroom (Table 13). The effect size for this group difference is one of the smallest of the dataset.

Table 13

Differences between PD Group and Non-PD Group for "Teaching Tool Use"

Teaching tool	Professional development averages	Non-professional development averages	*t*	*df*	*d*
Lab notebook (only used for labs)	2.22	1.97	1.97*	363	0.19

1= does not use, 4= weekly use, *denotes p value <0.05

Reflection. Participants within the reflection group (n = 67) indicated their teaching is best improved by reflecting on their own practices. Rather than seeking an external source for teaching improvement, these individuals choose to utilize data they can gather from their personal experiences to determine what teaching changes are necessary.

Practices. The reflection group's analysis included the "Teaching Tool Use" question as the only question showing a significant difference. The reflection group showed a significant difference from the non-reflection group because those coded "reflection" more frequently use quizzes in their teaching practice (Table 14). The effect size for this group difference is still small, but relatively larger compared to other group comparisons (i.e. Table 13).

Table 14

Differences between Reflection Group and Non-reflection Group for "Teaching Tool Use"

Teaching tool	Reflection group averages	Non-reflection group averages	*t*	*df*	*d*
Quizzes	3.57	3.33	3.19*	134	0.35

1= does not use, 4= weekly use, *denotes p value <0.05

Beliefs. Beliefs of the reflection group yielded more differences with the "Teaching Tool Purpose" question and the "Assessment Styles" question.

Beliefs showed a similar trend where the reflection group more often noted the purpose of "pre/posttests" was to allow students to see their learning (Table 15), even though the effect size of this difference is small. This is interesting because it mirrors an incorporation of reflective practices (Table 14) as a part of classroom practices. This indicates that participants in the reflection group prefer reflection to improve their own practices, believe the purpose of teaching tools can be to help students reflect, and more frequently include quizzes (a tool often used for reflection) in their classrooms. This is a clear example of a connection between professional development preference and classroom practices and teaching beliefs.

Table 15

Differences between Reflection Group and Non-reflection Group for "Teaching Tool Purpose"

Teaching tool	Purpose chosen	Reflection group (%)	Non-reflection group (%)	*t*	*df*	*d*
Pre/Post tests	To allow students to see/understand their learning progress	70.1%	57.0%	-2.13*	94	0.27

*denotes p value <0.05

While significant differences were found between the reflection group and those not coded as "reflection," a non-significant trend appeared when analyzing how these participants ranked the informal questioning and bell ringers/exit slips. Out of an option of five choices, the aforementioned were included with quizzes, tests, and homework. Those coded "reflection" more often ranked these informal assessments within the top two for assessments significant to student learning (Table 16). While not significant, this follows the trend seen throughout the reflection group's practices and beliefs as they more frequently incorporated quizzes (Table 14), believed in a reflective purpose for pre/posttests (Table 15), and highly ranked the importance of assessment types that often align with reflective practices. Because their reported practices align with their reported beliefs, the reflection group appears to bridge the gap between professional development and practice.

Table 16

Differences between Reflection Group and Non-reflection Group for "Assessment Styles"

Top 2	Reflection group (%)	Non-reflection group (%)
Regular informal questions during class	94.4%	88.2%
Bell ringers and/or exit slips	59.3%	54.2%

Professional development views across groups

Comparing individual groups to the rest of the participants yielded interesting results about teaching practices and beliefs, but comparing each group side by side also reveals attitudes towards professional development as a whole. Three questions were analyzed with respect to the usefulness of individual and school-sponsored professional development and the reason participants chose to utilize individual professional development. The questions analyzed included: "Individual PD," "School PD," and "PD Participation Reasons." These three questions yielded unexpected results.

Across groups there are not any significant differences with respect to the perception of professional development usefulness. Both professional development on the participant's own time and school sponsored professional development are fairly consistent across groups with 80-100% of participants indicating individual professional development was useful (Table 17) and only 50-75% of participants indicating school sponsored professional development was useful (Table 18).

Table 17

Group Comparison for Usefulness of "Individual PD"

Types of PD	Collaborators	Researchers	PD	Reflection
Take graduate classes	91.1%	91.4%	95.8%	98.1%
Participate in online workshops	81.6%	87.1%	85.4%	89.8%
Attend workshops	99.2%	98.6%	99.3%	100.0%
General teaching development	84.3%	76.1%	80.0%	82.6%
Content knowledge development	97.4%	97.2%	97.2%	98.1%
Pedagogical content knowledge development	90.7%	88.1%	87.0%	91.8%
Meeting with colleagues	95.8%	93.2%	91.9%	92.7%
Professional conferences	98.2%	97.1%	97.3%	100.0%
Supervising/mentoring pre-service or novice teachers	88.6%	84.4%	89.6%	93.2%

Table 18

Group Comparison for Usefulness of "School PD"

Type of PD	Collaborators	Researchers	PD	Reflection
Content knowledge development	64.9%	60.5%	65.9%	67.9%
Pedagogical content knowledge development	61.4%	74.3%	64.0%	67.3%

Type of PD	Collaborators	Researchers	PD	Reflection
General teaching development	61.3%	62.8%	67.7%	73.8%
Skill development	54.9%	68.7%	66.9%	68.5%
School initiative related	70.3%	56.6%	58.0%	51.6%
Supervising/mentoring pre-service or novice teachers	64.9%	68.1%	69.9%	71.8%

Across groups, there is very little difference with respect to how influential a reason is to participate in professional development on the individual's own time (Table 19). However, it is important to note that across groups the top three reasons to participate in professional development are, respectively: to improve teaching methods, to improve content knowledge, and to renew/maintain teaching licensure. There is a large drop in percentage (around 40%) between the second and third top reason indicating the same top two reasons are the most important for participants across groups. No inter-group comparisons were analyzed with t-tests to look for statistically significant differences since a response from a single person could potentially be coded under multiple groups. Consequently, statistical comparison between groups is not valid.

Table 19

Group Comparison of Responses to "PD Participation Reasons"

Reason	Collaborator (#1 rank %)	Researcher (#1 rank %)	PD (#1 rank %)	Reflection (#1 rank %)
To improve my teaching methods	86.6%	84.8%	85.9%	86.0%

Reason	Collaborator (#1 rank %)	Researcher (#1 rank %)	PD (#1 rank %)	Reflection (#1 rank %)
To improve content knowledge	77.0%	75.6%	72.0%	84.2%
To renew/maintain teaching licensure	36.3%	32.4%	33.5%	25.0%
To get my graduate degree	20.2%	22.4%	31.0%	18.2%
To move up the pay gradient	17.6%	16.0%	20.9%	12.7%
To earn additional endorsements	7.4%	6.5%	10.3%	10.5%

Conclusions

Each analyzed group when compared to the rest of the respondent population followed the same trend: there were few significant differences in terms of teaching practices, but many more differences within the context of teaching beliefs. Beliefs and practices may have differed between groups; however, each group shared similar opinions on the usefulness of a variety of professional development types. First, practice and belief differences will be addressed. Finally, professional development usefulness across groups will be explored.

Beliefs and practices

Collaboration group. The “collaboration” group provided less feedback (Table 5), but included more frequent small group discussion (Table 6) than their non-collaboration peers indicating that their belief in collaboration may affect their practices slightly, but the effect sizes for these differences were small. The group reported less use of inquiry-based lab practices, but since that was not related directly to the professional development preference, it was not explored further. Yet, the beliefs of the collaboration group indicate they placed a higher value on small group discussions and conferences with students compared to other groups (Table 7). This group did not maintain their beliefs, with respect to class discussions and conferences, when reporting on what tools really impact student learning. The majority of the group indicated “working in groups” was in the top three most impactful (Table 8), but it was ranked fourth when teachers were asked to pick the one tool most important to student learning (Table 9). Ultimately, results indicate that teachers who reported their teaching was most improved by collaborating with others value collaboration more, but do not incorporate collaboration into their classrooms more than other teachers in the non-collaborators group. This indicates a lack of effect by professional development preference on participant’s teaching practices.

Conducting research group. Those in the “conducting research” group showed even fewer differences in practice than the collaboration group. The only statistically significant different practice was having students do less internet research than other groups and that had a small effect size (Table 10). On a surface level, the concept of the research group not utilizing more research in the classroom may seem surprising, but this does not mean students are not engaged in other non-internet forms of research. However, it is clear that the “conducting research” group clearly values lab notebooks and lab reports more than other groups for collecting data on student learning and helping students understand their learning (Table 11) even though the effect sizes were small. The higher percentage of this group’s response to the purpose of “assign students a grade” for lab reports may also indicate a greater use of that tool in the classroom, but it cannot be determined based on the format of the survey. Finally, the “conducting research” group believes inquiry-based lab practices are more significant to student learning compared to cookbook style labs (Table 12) and had some of the largest effect sizes, even though they were still small differences between groups. However, as seen with the collaboration group, teaching beliefs often align with professional development preference, but participants often do not implement practices that reflect their professional development preference.

Professional development group. Those responses coded as “professional development” showed the least difference to their non-professional development responses. These participants indicated a greater use of lab notebooks, but other statistically significant differences were scarce for these comparisons and had the smallest effect size of the dataset (Table 13). This may be due to the overlap in groups as well as the defining characteristics of the group: they seek out information through multiple sources (webinars, conferences, and workshops) and may actually participate in more diverse professional development as a result. While each of the other three groups were focused on one characteristic of teacher improvement, those coded as “professional development” may have been receiving a little bit of each type of professional development, resulting in experiencing some effects noted by other groups.

Reflection group. Those responses coded as “reflection” actually use reflective tools in the classroom more frequently than other groups. It is clear that teachers in the reflection group utilize quizzes on a more frequent basis than those not in this group and while the effect size was small, it was relatively large compared to other analyses in the dataset (Table 14). Further, the reflection group more frequently agreed the purpose of pre/post tests were for the students to see their learning progress, which is indicative of a more reflective mindset even though the effect size was small (Table 15). This belief in reflective practices in the classroom is also furthered as the reflection group noted a higher ranking for informal class questions and bell ringers/exit slips for assessments significant to student learning (Table 16). While it is not appropriate to make a definitive claim that reflective practices result in more reflection in class, it is clear that this group utilizes quizzes more frequently and believes formative assessments are for the purpose of students reflecting on their learning progress.

Each group showed differences in terms of practices and beliefs; however, it is clear from the results above that teaching beliefs often align with professional development preference, but that preference is often not reflected in teaching practice.

Professional development usefulness across groups

Individual versus school-sponsored professional development. There are no glaring differences across groups with respect to how useful different groups found individual or school-sponsored professional development (Table 17 & 18). Across groups, there is rarely more than a ten percent difference in how useful each group found each professional development type indicating a consensus about the usefulness of different types of professional development regardless of professional development preference. The major difference occurs between professional development done by teachers on their own time and school/district-sponsored professional development. In every circumstance, the professional development done on the teacher’s own time is considered more useful than the professional development through the school or district (Table 17 & 18). Since this is noted across groups and across professional development types, it is clear that participants generally agree about the usefulness of different types of professional development. Participants also note individual professional development as more useful than professional development sponsored by the school or district. This perspective is supported by current literature which indicates that school/district-sponsored professional development is in need of reform in order to better its influence on teacher practices and beliefs (i.e. Colbert, Brown, Choi, & Thomas, 2008).

Reasons to participate in professional development. Teachers reported on the usefulness of independent professional development with respect to achieving professional goals. Across groups, the same trend appeared: the number one reason was to improve teaching methods, followed by improving content knowledge, and finally to renew or maintain teaching licensure (Table 19). Between improving content knowledge and renewing a teaching licensure, there is a drop of about 40%. This large drop indicates a specific attitude towards professional development done on a teacher's own time: its purpose is not for a raise or promotion, but rather to become a better teacher. This should not be surprising because teachers participating in professional development on their own time are already putting in extra effort toward their professional growth. Additionally, it reinforces the suggestion that teachers who seek out professional development need to be supported since their reasoning is to be more effective in the classroom.

Limitations

While there were a lot of relationships and trends analyzed throughout this study, it is necessary to point out the limitations. To begin, each participant could have included multiple choices for their professional development preference, which means there was a lot of overlap between groups. Isolating each group by participants who fit perfectly in one group and were not coded within a second or third group resulted in very small groups. This overlap means each trend needs to be read with caution because, while supported by literature in some instances, it cannot be determined which of the participants' professional development experiences ultimately affected their teaching practices or beliefs. It was necessary to include participants overlapping in groups partially because the overlap alone does not discredit the results. It simply dilutes the possible significance a "perfect dataset" may provide. Teachers do not usually participate in just one type of professional development and exclude all others and, by following the same pattern, the results are more indicative of reality.

The results of this study indicate teaching beliefs align with professional development preference. However, this is a correlation, and it cannot be said that beliefs affect preference or preference affects beliefs. The responses to the question about the usefulness of professional development programs that participants sought out imply that more participants see those as useful. Is that due to those programs aligning with the teaching beliefs the participants already held or is it due to the impact these programs had on the participants? Further research must be done in order to determine causation as this study could only analyze relationships between variables.

While the overlapping groups make it more difficult to draw clear conclusion, the dataset itself was also not ideal. The average years of teaching was similar to the national average, but there were more female participants and the average age of the teachers was higher than the national average. Further, teachers from all 50 states were not represented in the participant pool. The dataset provided a good sample of many states with a large n-value, but future studies would yield more definitive results with answers from a more representative and diverse population.

Implications and Future Studies

Professional development is a common part of a teacher's career, but this study has shown that there is a disconnect between professional development's effect on teaching practice with respect to implementation in the classroom. There is less of a disconnect between professional development preference and teaching beliefs, however. Finally, there is also a disconnect between the usefulness of independent and school/district-sponsored professional development. Professional development usefulness was not expected to differ as dramatically between independent versus school-sponsored programs, but the findings may be indicative of a larger problem.

This study showed a clearer impact of professional development preference on teaching beliefs, but often there were no major differences in teaching practices. The differences between groups (those defined by showing a preference to collaboration, reflection, etc.) generally existed within their teaching beliefs, rather than also being present in their classroom. For example, the "Collaborators" group did not include much more collaboration in the classroom, but the participants in that group often favored the idea of collaboration more than other groups. There are other factors that contribute to why a teacher would not act on their teaching beliefs in the classroom, such as policies in their departments or school districts, but it is concerning that disconnect exists as professional development is utilized with the specific intent to implement the new ideas in the classroom.

The differences in usefulness of professional development between school sponsored and personally chosen is echoed in current literature (i.e. Darling-Hammond et. al, 2009). Teachers seek out professional development on their own time and look for resources that benefit them on a personal level. School/district-sponsored professional development needs to be applicable in both breadth and depth. On an economic standpoint, it is beneficial to put on one program for a wide range of individuals. On an effectiveness standpoint, professional development programs must be tailored to meet individual teachers' needs. This speaks to the need for professional development reform. If such a large decrease occurs between professional development usefulness of the same type because it was sought out or required of a teacher, it is necessary to find a way to close that gap. If teachers seek out professional development that affect their beliefs, those programs needed to be studied to determine how the practices of the participants can be altered as well.

Future studies should focus on closing the gap between teaching practices and beliefs along with the gap between the usefulness of professional development sought out or required by a school/district. Professional development preference does appear to have a relationship with teaching practices and beliefs, but until other barriers are removed, analyzing these relationships to determine the ideal type of professional development is not feasible. Efforts to improve professional development programs must include an analysis of teacher preference if a holistic understanding of the problem is to be achieved.

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Appendix A

Complete Copy of the Nationwide Survey Sent to Teacher Participants

Q72 During their pre-service education, some secondary science teachers participate in a research experience while others do not, yet the impact of research experiences on teachers' skills and practice once they are in the classroom remains unclear. This survey has been created to help us understand the effects research experiences have on teachers' skills and practices as teachers once they begin their careers. The survey is for all secondary (6-12) science teachers regardless of their research experience. The survey contains background questions, questions about your classroom and classroom practices, and questions about any research experiences that you may have participated in.   As a science teacher, we are asking for your help with this survey to understand the effects of pre-service research experiences on teachers' practice after graduation. We need teachers who have and have not done research as undergraduates so we are asking any secondary science teacher, regardless of research experience, to complete this survey. We would appreciate it if you would take 20-25 minutes to respond to this online survey. Your responses, together with others, will be combined and used for statistical summaries only. Your participation in this study is voluntary and you may refuse to answer any question, or end the survey at any time. Your responses are anonymous. While there are some general background questions asked, you are not asked for your name, school, or other specific identifying characteristics. There are no foreseeable risks to you as a participant in this project; nor are there any direct benefits. However, your participation is extremely valued. Your anonymity will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet/Email by any third parties.   As a thank you, once you have completed the survey, you will be given the opportunity to enter your name in a drawing for an iPad Mini or a Samsung Galaxy Tablet (if you win, you can pick which you get). Two winners will be drawn. If you choose to enter the drawing, you will be taken to a separate form to enter your name and email address. To maintain your anonymity, your information will not be stored with your responses to the survey questions. If you have any questions about the survey, please contact either Dr. Sarah Boesdorfer at 319-273-7146 or sarah.boesdorfer@uni.edu or Dr. Dawn Del Carlo at 319-273-3296 or dawn.delcarlo@uni.edu. You can also contact the office of the IRB Administrator, Anita Gordon, anita.gordon@uni.edu, University of Northern Iowa, at 319-273-6148, for answers to questions about rights of research participants and the participant review process. Thank you for your help. We appreciate your cooperation.

Respectfully,

Sarah Boesdorfer	Dawn Del Carlo
Assistant Professor Chemical Education	Associate Professor Chemical Education
University of Northern Iowa	University of Northern Iowa

- ❍ I consent to participate in the following survey. (1)
- ❍ I do not consent to participate in the following survey. (2)

Q1 Which of the following best describes you?
- ❍ Female (1)
- ❍ Male (2)
- ❍ I prefer not to answer. (3)

Q2 Please give your current age.

Q4 What is the highest degree you currently hold?
- ❍ Bachelor's Degree (1)
- ❍ Master's Degree (2)
- ❍ Doctorate Degree (3)
- ❍ Other, please specify: (4) ____________________

Q5 How many years have you taught as a lead teacher in a formal classroom?

Q6 Which subjects have you taught? Check all that apply.
- ❑ Biochemistry (1)
- ❑ Earth Science (2)
- ❑ Natural Science (3)
- ❑ General Science (4)
- ❑ Chemistry (5)
- ❑ Biology (6)
- ❑ Physical Science (7)
- ❑ Physics (8)
- ❑ Environmental Science (9)
- ❑ Life Science (10)
- ❑ Mathematics (11)
- ❑ Ecology (13)
- ❑ Anatomy and Physiology (15)
- ❑ Middle School Science (16)
- ❑ HS General/Integrated Science (17)
- ❑ Ecology, Zoology, and/or Botany (18)
- ❑ Engineering, Project Lead the Way and/or STEM\ (19)
- ❑ Geology, Astronomy, and/or Meteorology (21)
- ❑ Other, please specify: (12) ____________________

Q40 At how many schools have you taught? [‡]

[‡] Question numbers are not indicative of the order of questions presented to the participants. Rather, questions are ordered in the appendix with respect to the order they were presented to survey participants.

Q43 Have you ever won a teaching award in which teachers from multiple schools were considered for the award (i.e. not an award for your school alone)?
- ❍ Yes (1)
- ❍ No (2)

Q9 Have you ever conducted research or worked on any research projects?
- ❍ Yes (1)
- ❍ No (2)

Q48 How would you classify the research you have conducted or the research projects you have worked on? (Check all that apply)
- ❑ Science Content Research (biology content, chemistry content, etc. research) (1)
- ❑ Education Research (student learning of science, teaching practices, etc.) (2)
- ❑ Other, please specify: (3) ____________________

Q41 You have indicated that you did education research. Which of these best describes your research experience(s): (Check all that apply)
- ❑ Undergraduate research (1)
- ❑ Graduate level research (2)
- ❑ Research not associated with a degree program (3)

Q49 How many research experiences/projects have you worked on?

Q50 We are going to ask you questions about your education related research experiences. If you have had more than one experience, please focus on just one of your experiences when answering the next questions.

Q55 Please briefly describe the focus of your research.

Q74 Of the following options, please indicate if the term/description would apply to your research experience.

	Yes, it does (1)	No, it doesn't (2)
Honor's thesis (1)	❍	❍
Graduate thesis (2)	❍	❍
Action research project (3)	❍	❍
Undergraduate research experience (4)	❍	❍
As part of a job (7)	❍	❍
Project required for a non-research class, for example, a content course, methods course, or practicum (5)	❍	❍
Other, please specify: (6)	❍	❍

Q51 Approximately, how many months did you work on the project?

Q14 Did you have a faculty mentor for your research experience?
- ❍ Yes (1)
- ❍ No (2)

Q76 How many other people worked on your research project counting any faculty mentors?

Q16 Which of the following did you do during your research experience? (Check all that apply)
- ❑ Conducted a literary review/background research (1)
- ❑ Generated research question(s) that guided the study (2)
- ❑ Planned data collection methods and/or instruments (3)
- ❑ Collected data (4)
- ❑ Transcribed audio or video recordings (5)
- ❑ Ran statistical tests (6)
- ❑ Coded qualitative data (7)
- ❑ Formulated conclusions from data (or data analysis) (8)
- ❑ Conference presentation/poster (9)
- ❑ Wrote articles for publication (10)
- ❑ Other, please specify: (11) ____________________

Q60 How, if at all, do you think your research experience affected your teaching practice?

Q43 We are going to ask some questions about your teaching practice, but would like to focus on just one of your classes. Of the science courses you are currently teaching at the secondary-level, pick one and write the name of that class below.

Q18 Thinking about last week in the course you just listed, how often did students do the following?

	Zero days (1)	A few days (2)	Most days (3)	Everyday (4)
Discussed what they know about the topic before the beginning of the unit. (3)	❍	❍	❍	❍
Listened to the teacher's presentation of the material. (4)	❍	❍	❍	❍
Took notes. (17)	❍	❍	❍	❍
Participated in a class discussion of the material. (5)	❍	❍	❍	❍
Asked questions to improve their understanding if they were confused. (6)	❍	❍	❍	❍

Wrote down the answer to a question and compared with a neighbor. (1)	❍	❍	❍	❍
Worked in groups on practice problems. (7)	❍	❍	❍	❍
Observed a demonstration. (16)	❍	❍	❍	❍
Asked questions to be investigated or answered. (11)	❍	❍	❍	❍
Designed their own experimental procedure. (8)	❍	❍	❍	❍
Collected data in a lab activity. (9)	❍	❍	❍	❍
Analyzed the data collected in a lab experiment. (10)	❍	❍	❍	❍
Made claims supported by evidence. (18)	❍	❍	❍	❍
Received teacher feedback on their results in lab activities. (14)	❍	❍	❍	❍
Worked on real-life applications to science concepts. (13)	❍	❍	❍	❍
Read from a science textbook to better understand the concepts. (12)	❍	❍	❍	❍
Did Internet/Web research. (19)	❍	❍	❍	❍
Presented a project (group or individual) in front of the class. (2)	❍	❍	❍	❍
Received peer feedback on class work. (15)	❍	❍	❍	❍

Q20 Which of the following teaching tools have you used for the course you listed in the past week, past month, past year, or not at all?

	Week (1)	Month (2)	Year (3)	I don't use this (4)
Bell ringers/Exit slips (1)	❍	❍	❍	❍
Pre/Post tests (3)	❍	❍	❍	❍
Quizzes (4)	❍	❍	❍	❍
Formal end of unit tests (6)	❍	❍	❍	❍
Worksheets (8)	❍	❍	❍	❍
Graded homework (9)	❍	❍	❍	❍
Non-graded homework (10)	❍	❍	❍	❍
Science notebook/Journal (12)	❍	❍	❍	❍
Lab notebook (only used for labs) (13)	❍	❍	❍	❍
Lab reports (14)	❍	❍	❍	❍
Research papers (15)	❍	❍	❍	❍
Portfolios (16)	❍	❍	❍	❍
Small group discussion (17)	❍	❍	❍	❍
Class discussions (18)	❍	❍	❍	❍
Projects (19)	❍	❍	❍	❍
Conferences with you to assess learning (21)	❍	❍	❍	❍
Peer feedback (22)	❍	❍	❍	❍
Whiteboarding (23)	❍	❍	❍	❍
Other, please specify: (24)	❍	❍	❍	❍
Other, please specify: (25)	❍	❍	❍	❍

Q62 In your opinion, the purpose of each of the following teaching tools is (check all that apply even for tools you do not use):

	A learning tool for students (1)	To allow students to see/understand their learning progress (7)	To guide my teaching (2)	To collect data on the understanding of my students (4)	To assign students a grade (3)	Required by my school/district (6)	I don't know (8)
Bell ringers/Exit slips (1)	❑	❑	❑	❑	❑	❑	❑
Quizzes (3)	❑	❑	❑	❑	❑	❑	❑
Formal end of unit tests (5)	❑	❑	❑	❑	❑	❑	❑
Pre/Post tests (6)	❑	❑	❑	❑	❑	❑	❑
Worksheets (8)	❑	❑	❑	❑	❑	❑	❑
Graded homework (9)	❑	❑	❑	❑	❑	❑	❑
Non-graded homework (10)	❑	❑	❑	❑	❑	❑	❑
Science notebook/Journal (12)	❑	❑	❑	❑	❑	❑	❑
Lab notebook (only used for labs) (13)	❑	❑	❑	❑	❑	❑	❑
Lab reports (14)	❑	❑	❑	❑	❑	❑	❑
Research papers (15)	❑	❑	❑	❑	❑	❑	❑
Portfolios (16)	❑	❑	❑	❑	❑	❑	❑
Small group discussion (17)	❑	❑	❑	❑	❑	❑	❑
Class discussions (18)	❑	❑	❑	❑	❑	❑	❑
Projects (19)	❑	❑	❑	❑	❑	❑	❑
Conferences with you to assess learning (21)	❑	❑	❑	❑	❑	❑	❑
Peer feedback (22)	❑	❑	❑	❑	❑	❑	❑
Whiteboarding (23)	❑	❑	❑	❑	❑	❑	❑
Other, please specify: (24)	❑	❑	❑	❑	❑	❑	❑
Other, please specify: (25)	❑	❑	❑	❑	❑	❑	❑

Q52 The following questions ask you to rank different groups of teaching tools. For each set, regardless of whether or not you use the tool or strategy, please rank them in order from which contributes most significantly to student learning to least significant.

Q22 Please rank by dragging and dropping the following items with the most significant to student learning at the top of your list.
______ Working in groups (1)
______ Creating/Using models or representations (2)
______ Taking notes (3)
______ Teacher-led class discussions (4)
______ Homework (5)
______ Study guides/Reviews (6)
______ Quizzes/Tests (7)
______ Lab experiments (8)
______ Student-led class discussions (9)
______ Real-world applications of content (10)

Q23 Please rank by dragging and dropping the following tools when used as a whole class with the most significant to student learning at the top of your list.
______ Taking handwritten notes (1)
______ Printed lecture slides, but taking notes in the margins (2)
______ Teacher provided notes, but with fill-in-the-blank holes (3)
______ Class discussions over topics (4)
______ Whiteboarding ideas (5)

Q24 Please rank by dragging and dropping the following items about work habits with the most significant to student learning at the top of your list.
______ Working alone (1)
______ Working in groups of 2 (2)
______ Working in groups of 3-5 (3)
______ Working in groups of 6-8 (4)
______ Working together as an entire class (5)

Q25 Please rank by dragging and dropping the following items about student assessment with the most significant to student learning at the top of your list.
______ Regular informal questions during class (1)
______ Bell ringers and/or exit slips (2)
______ Homework (3)
______ Quizzes (4)
______ Unit tests (5)

Q26 Please rank by dragging and dropping the following items about laboratory styles with the most significant to student learning at the top of your list.

______ Experiments in which students use prior knowledge to answer a question or meet a challenge. (1)

______ Experiments in which students are given a specific procedure to review a topic already covered in class. (2)

______ Experiments in which students are given questions to answer using a specific procedure. (3)

______ Experiments in which students are given questions to answer using a general procedure which they might have to modify. (4)

______ Experiments in which students create their own questions to answer using their own procedure possibly given a plan or topic. (5)

Q27 Please choose the one item you feel is the most important for a student's learning of science.

- Working in groups (1)
- Creating/Using models or representations (2)
- Teacher-led class discussions (3)
- Homework (4)
- Student-led class discussions (5)
- Real-world applications of content (6)
- Taking notes (7)
- Whiteboarding ideas (9)
- Regular informal questions during class (10)
- Quizzes (11)
- Unit tests (12)
- Lab experiments (17)

Q29 Do you collect data on your students?

- Yes (1)
- No (2)

Q28 Are you required to collect data as part of your job requirements?

- Yes (1)
- No (2)

Q46 What data do you collect?

Q48 Why do you collect data?

Q47 In your own words, please define the phrase, "data-driven instruction."

Q31 Professional development (PD) is defined here as the process to acquire more skills and knowledge for personal development and to advance professionally. Please keep that definition in mind for the following questions.

Q33 Do you participate in professional development?
- Yes (1)
- No (2)

Q32 Are you required by your school/district to participate in professional development?
- Yes (1)
- No (2)

Q49 Which of the following do you participate in:
- School/District sponsored professional development during work hours (1)
- Professional development on my own time (2)
- Both (3)

Q51 For professional development on your own time, please indicate whether or not you participate in the type of professional development described and then indicate if you think they are useful in achieving your professional goals.

	Participation			Usefulness	
	Have participated in (1)	Plan to participate in (2)	Have not participated in (3)	Useful (1)	Not useful (2)
Take graduate classes (1)	❍	❍	❍	❍	❍
Participate in online workshops (2)	❍	❍	❍	❍	❍
Attend workshops (3)	❍	❍	❍	❍	❍
General teaching development (4)	❍	❍	❍	❍	❍
Content knowledge development (5)	❍	❍	❍	❍	❍
Pedagogical content knowledge development (6)	❍	❍	❍	❍	❍
Meetings with colleagues (7)	❍	❍	❍	❍	❍
Professional conferences (8)	❍	❍	❍	❍	❍
Supervising/Mentoring pre-service or novice teachers (9)	❍	❍	❍	❍	❍
Other, please specify: (10)	❍	❍	❍	❍	❍

Q45 Please rank the following options in describing your reasons to participate in professional development on your own time.

Most Influential	Influential	Not Influential
______ To move up the pay gradient (1)	______ To move up the pay gradient (1)	______ To move up the pay gradient (1)
______ To get my graduate degree (2)	______ To get my graduate degree (2)	______ To get my graduate degree (2)
______ To improve my teaching methods (3)	______ To improve my teaching methods (3)	______ To improve my teaching methods (3)
______ To improve content knowledge (4)	______ To improve content knowledge (4)	______ To improve content knowledge (4)
______ To earn additional endorsements (5)	______ To earn additional endorsements (5)	______ To earn additional endorsements (5)
______ To renew/maintain teaching license (6)	______ To renew/maintain teaching license (6)	______ To renew/maintain teaching license (6)
______ Other, please specify: (7)	______ Other, please specify: (7)	______ Other, please specify: (7)

Q50 In your school/district sponsored professional development, please indicate their level of usefulness.

	Useful (1)	Not useful (2)	This type of PD is not sponsored by my school (3)
Content knowledge development (1)	❍	❍	❍
Pedagogical content knowledge development (2)	❍	❍	❍
General teaching development (3)	❍	❍	❍
Skill development (4)	❍	❍	❍
School initiative related (5)	❍	❍	❍
Supervising/Mentoring pre-service or novice teachers (6)	❍	❍	❍
Other, please specify: (7)	❍	❍	❍

Q35 Professional Learning Communities, or PLCs, as defined here are collaborations between fellow teachers and/or administrators to learn together with the goal of enhancing the students' learning experience. Please keep that definition in mind for the following questions.

Q37 Are you a part of a PLC?
- Yes (1)
- No (2)

Q36 Are you required to be a part of a PLC?
- Yes (1)
- No (2)

Q38 What is the focus of the PLC you are involved in?

Q54 Last questions, please take a final moment to answer the following:

Q39 Overall, what do you do to improve your teaching practices?

Q44 Feel free to use the space below to tell us anything else we should know about your teaching, research, or professional development.