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Research article

Growth in Elementary Teacher Science Self-Efficacy through Professional Development

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Abstract

The Frameworks for Success in Science Math/Science Partnership (MSP) Title IIB project was designed to increase teacher content knowledge and pedagogical skills in elementary science education. Participants included 43 elementary school teachers from the seven schools that fed into Hilo Intermediate and Hilo High School on Hawaii Island. The MSP project was facilitated by a nationally-recognized, award-winning science teacher who served as the curriculum coordinator. Both qualitative and quantitative findings from the MSP project for Cohort I suggested significant changes in teacher science self-efficacy and improved pedagogy. With the unique T2T professional development model, where teachers, through on-going, grade-level, cross-school meetings, constructed a vertically and horizontally aligned science curriculum, was also facilitated by the curriculum coordinator.

Keywords: elementary science, professional development, teacher self-efficacy

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Introduction

Conderman and Sheldon Woods (2008) suggested that although science plays a central role in our world today, science instruction seems to be minimized particularly at the elementary grade levels. To cultivate higher-order thinking, as well as meet the changing demands of society, it would seem that the quality and quantity of science teaching and learning must be increased in the elementary classroom.

According to Abell and Lee (2008), the most effective professional development in science has: (a) relevant and applicable content directly connected to the classroom, (b) teachers learning in a way similar to the way their students will learn, (c) collaborative teacher relationships, and (d) sustained opportunities to collaborate and reflect over time (p.62).

A professional development model that utilizes a science content expert such as a curriculum coordinator, who is also a classroom teacher, creatively uses existing resources in the school or community. According to Ramey-Gassert et al. (1996), it is “people who ‘move’ people” (p. 294). A science curriculum coordinator would facilitate science content understanding, and is in a position to provide opportunities for teacher sharing and implementation of lessons involving science inquiry skills. Since this person is also a classroom teacher specializing in science, they could stimulate the discussions necessary for elementary teachers to implement lessons that truly address the science standards and benchmarks. This person understands and participates in the daily demands of teaching, has implemented a variety of science lessons and knows what science concepts and skills students need for their future years in school.

Researchers have investigated the construct of efficacy (Bandura, 1977, 1994; Riggs & Enochs, 1990; Ramey-Gassert, Shroyer & Staver, 1996; Tschannen-Moran, Hoy & Hoy, 1998, 2001). Professional and conceptual development in teachers has also been explored (Gordon, 1990; Sheerer, 1997; Skaalvik & Skaalvik, 2007). Supporting science content knowledge development, and effective science teaching, is imperative for elementary school teachers.

The purpose of this research was to describe the changes in efficacy elementary teachers experienced as they participated in science professional development. This study focused on the identification and description of the changes in attitudes, behaviors and skills elementary teachers experienced as they participated in sustained professional development. The Teacher-to-Teacher (T2T) professional development model, which built science content knowledge and teacher confidence in teaching science, as well as supported teachers as they developed science curriculum, was also explored.

Background of the Study

During the four years of the TIR project and the subsequent MSP grant, the T2T model and the grant evaluation findings have shown significant changes in both teacher skills and student classroom science assessment pre/post scores. Utilizing a model that includes a teacher, as facilitator and PLCs composed of teachers who are from different schools seems to have created a pathway for more science teaching across the Hilo Complex Area elementary schools.

Purpose of the Study

The purpose of this research study was to describe how teacher self-efficacy develops as the teachers continue to revise, create new materials and teach the science units that have been developed through participating in the T2T professional development model of the MSP grant.

Research Questions

How does a teacher's sense of self-efficacy (attitude) towards teaching elementary science change over a sustained period of professional development?

Definitions

In 1977, Bandura described teacher efficacy, a type of *self-efficacy*, as a process by which teachers build and reflect upon their beliefs about their ability to do a specific task. Teacher efficacy relates to "teachers' classroom behaviors, their openness to new ideas, and their attitudes towards teaching" (Tschannen-Moran, Hoy, & Hoy, 1998, p. 215). *Attitudes* can be described as the internal perceptions and beliefs that teachers mentally hold about teaching science. The *behaviors* they exhibit due to these beliefs are the visible manifestations of their attitudes toward science as they teach students in the classroom. The *skills* that the teachers develop are the specific physical and observable teaching strategies that they develop and implement in their classrooms. Therefore, "training to enhance self-efficacy with regard to science teaching should deal with improvement of teachers' actual science teaching skills and personal beliefs toward those skills" (Riggs & Enochs, 1990, p. 634). How teachers take their internal beliefs and turn them into viable actions to effectively teach students drives what they do in their classroom and in turn, affects their confidence in their own ability to teach.

Materials and Method

Research Design

This mixed-methods study used two research designs. The quantitative portion of the study used a one-group, post-test design. The qualitative portion of the study used a semi-structured interview protocol with a sub-sample of participants.

Project Participants

There were six elementary and one grade K-8 school within the Hilo Complex Area that have elementary science programs. Five of the six elementary and the K-8 school have teachers that participated in the professional development provided by the T2T model. There were 41 participating teachers; 18 teachers participated in all four years of the project (Cohort I), 21 teachers who participated in at least two years (Cohort II) and two teachers who were new additions to the last year of the MSP grant due to teacher retirement and movement from the school. Over 58% of the participating teachers have taught 11 or more years at the elementary level, with Cohort II having a larger percentage of teachers with this level of experience. However, Cohort II also contains all of the newer teachers in the grant sample (n=6).

Selection of Research Sample—Cohort I

The quantitative data from the entire MSP grant (41 teachers) was reviewed in order to provide a context for the selection of Cohort 1 for this research study. Focusing on Cohort I teachers, who had the most years of participation in the T2T professional development provided an opportunity to take a longitudinal view of the teachers as they developed their science content self-efficacy and pedagogy over several years.

Instrumentation

Several existing surveys, (Bleicher, R.E., 2004; Koehler, J.R., 2006; Tschannen-Moran, Woolfolk Hoy & Hoy, 1998; Woolfolk Hoy, 2000), were utilized as models by the researcher to develop the retrospective self-efficacy questionnaire. Internal consistency reliability was addressed by the fact that all items represent only one construct: self-efficacy. Cronbach's alpha was calculated for the Teacher Retrospective Self-Efficacy Questionnaire for both the pre and post questions; yielding pre 0.921 and post 0.951, indicating very high instrument reliability.

Validity was addressed twofold: (a) content validity, and (b) construct validity. For the Retrospective Self-Efficacy Questionnaire, the items were taken from already established surveys of teacher self-efficacy and adapted to reflect the behaviors and skills of an elementary science teacher. Additionally, construct validity was addressed by including items that specifically described the behaviors and skills of self-efficacy in science teaching.

Interview Protocol

Permission from the superintendent of the complex area to conduct research with the participants of the MSP grant was provided prior to the initial orientation meeting. Goals and objectives, as well as the expectations were covered so that every teacher and administrator was clear as to their role in the *Frameworks for Success in Science* MSP grant. In addition, the letter of consent was issued, questions and answers were addressed and the participating teachers and administrators provided their signature permission to participate in the various evaluation activities associated with both the grant and this research study. Copies of their signed letter were returned to each participant at the end of the orientation meeting.

Each teacher selected for the semi-structured interviews signed a second consent letter that detailed their participation and expectations from their interview for this research study. The interview questions explored the changes that the participating teachers went through because they participated in the professional development model being employed by the *Frameworks for Success in Science* Math/Science Partnership (MSP) grant.

Techniques to Ensure Trustworthiness

Lin (2010) describes four methods of ensuring trustworthiness in qualitative research data analysis. Two of the four were utilized with the interview transcripts: 1) dependability, and 2) credibility.

Lin (2010) describes dependability as similar to reliability in quantitative studies. An external auditor, in this case the project technology assistant, compared the original interview transcripts to the published findings confirming that the published findings were consistent with each other.

Creswell (2008) describes member checking as a "process in which the researcher asks one or more participants in the study to check the accuracy of the account" (p. 267). The respondents were given a copy of the entire interview transcript and the findings and asked to confirm the accuracy of what was presented, specifically addressing the credibility of what was published.

Threats to both descriptive and interpretive validity were also addressed, through the use of an external auditor who checked the answers to the interview questions from the transcript for accuracy. Additionally, the respondents confirmed that the relationships between the categories in the published findings could also be interpreted from the "participants perspective" (Maxwell, 2002, p. 288) including the words and actions within the various situations that the respondents shared with the researcher. Through triangulation, the different interview responses were examined in order to provide evidence to support the emerging themes.

A semi-structured interview protocol was used to gather the opinions, feelings, and experiences of the teachers in an attempt to add depth and breadth to the learning described in their reflection log entries.

Data Analysis

Retrospective Self-Efficacy Questionnaire

The Retrospective Self-Efficacy Questionnaire was given in the summer to all MSP grant participants. At this time, Cohort I had already received two or more years of sustained professional development in the T2T model. The sample size for Cohort I was 18 teachers; therefore both non-parametric and parametric tests were used to determine the significance of the results.

Retrospective Self-Efficacy Questionnaire Pre/Post Total Scores

Since the sample size for Cohort I (n=18) was smaller than the recommended size for parametric tests, a Wilcoxon signed-ranks test was first conducted on the total pre and post scores for the Retrospective Self-Efficacy Questionnaire.

Table 1: Wilcoxon Signed-Ranks Pre/Post Retrospective Self-Efficacy Questionnaire

	RpostTotal - RpreTotal
Z	-3.726[a]
Asymp. Sig. (2-tailed)	.000

Table 1 revealed a statistically significant increase in the total score on the Retrospective Self-Efficacy Questionnaire following the T2T experience, z= 3.726 p < .001, with a medium effect size (r=.621). The median score increased from the pre-survey scores based on experience prior to the MSP professional development (*Mdn*=23) to the post score based on their perceptions after completing two years of T2T professional development (*Mdn*=39.5).

In order to confirm the non-parametric results, a more robust paired samples t test was conducted with the totals for the pre and post responses (*M*pre=25.22, *SD*=6.5, *M*post=40.4, *SD*=4.97).

Table 2: Paired Samples t Test – Pre/Post Retrospective Self-Efficacy Questionnaire

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
RpstTotal - RpreTotal	15.222	6.093	1.436	12.192	18.252	10.600	17	.000

Since the obtained value for $t_{(17)}$= 10.6, p<.01 (two-tailed), was well above the critical value of t=2.898, showed that there was a significant increase in the total scores for Cohort I pre Retrospective Self-Efficacy Questionnaire score (M=25.2, SD=6.5) and post score (M=40.4, SD=4.9) conditions t =10.6, p<.01.

Interestingly, both the median and the mean for the totals on this questionnaire were close, indicating that there was a lack of outliers and the results of significance from both the non-parametric and parametric tests supported the idea that a teacher's sense of self-efficacy (attitude) towards teaching elementary science does change over a sustained period of professional development.

Retrospective Self-Efficacy Questionnaire Pre/Post Individual Question Scores

Table 3 compares the responses on the pre versus post set of questions associated with efficacy for the 18 participants in the Cohort I sample. The pre-prompt stated "Prior to starting the professional development with the MSP grant, I felt I was able to…" and the post-prompt states "After participating in the professional development with the MSP grant, I now feel that I am able to… The questions are the same for both pre/post sections and were selectively written to closely align with the behaviors and skills that are directly connected to the development of self-efficacy in science teaching.

An analysis of the means data for each question shows a range of means for the "pre" questions from a low of 2.28 for question 8 (student self-assessment in science) to a high of 2.72 for question 2 (differentiating). The response of "2" falls into the "very little" choice on the Likert scale provided, which seems to indicate that the teachers reported

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having very little confidence in doing the science skills listed in the questionnaire prior to their T2T experience. There was a larger range of means for the "post" questions from a low of 3.72 "sometimes" (answering student questions outside of what is provided in the textbook) to a high of 4.28 "quite a bit" (providing materials and supplies to do science safely).

Table 3: Mean Ratings by Item for the Retrospective Self-Efficacy Questionnaire

Questions **(Scale Key: 1=Nothing/Not at all, 2=Very little, 3=Some, 4=Quite a bit, 5=A great deal)**	**PRE** ***n*= 18** **Mean (*SD*)**	**POST** ***n*= 18** **Mean (*SD*)**
1. Clearly explain the content for my science lesson, even if it was relatively new to me.	2.56 (.86)	4.06 (.64)
2. Adapt my instruction to address student learning differences.	2.72 (.58)	3.89 (.47)
3. Get students to thoughtfully discuss with their peers what they are learning in the science lesson.	2.50 (.71)	3.94 (.64)
4. Provide materials and equipment that support safety in science.	2.39 (.92)	4.28 (.67)
5. Use student real-life experiences and interests to help promote understanding of science concepts.	2.61 (.85)	4.22 (.73)
6. Identify and address student misconceptions in science.	2.61 (.78)	3.89 (.58)
7. Answer student's science questions even if they were not addressed by the teacher notes, textbook or worksheets?	2.39 (.70)	3.72 (.67)
8. Provide opportunities for students to assess their own science performance (writing/orally).	2.28(.75)	3.89 (.76)
9. Comfortably assess prior knowledge and student understanding to inform and make instructional decisions.	2.61 (.61)	4.17 (.62)
10. Do more than just textbook and simple "cookbook" type science learning activities?	2.56 (.92)	4.28 (.75)

Again, due to the small sample size (n=18), a non-parametric Wilcoxon signed-ranks test was first conducted to determine whether each question pair's pre/post scores were statistically significant.

Table 4: Wilcoxon Signed-Ranks by Item for the Retrospective Self-Efficacy Questionnaire

Question pair	*Z*	Rho	Asymp Sig (2-tailed)
RpreQ9-RpostQ9	-3.695	.62	0.000
RpreQ8-RpostQ8	-3.727	.62	0.000
RpreQ7-RpostQ7	-3.750	.63	0.000
RpreQ6-RpostQ6	-3.493	.58	0.000
RpreQ5-RpostQ5	-3.573	.60	0.000
RpreQ4-RpostQ4	-3.743	.62	0.000
RpreQ3-RpostQ3	-3.714	.62	0.000
RpreQ2-RpostQ2	-3.520	.59	0.000
RpreQ10-RpostQ10	-3.562	.59	0.000
RpreQ1-RpostQ1	-3.739	.62	0.000
Averages	3.65	.61	

Table 4 revealed a statistically significant increase on each question pair for the Retrospective Self-Efficacy Questionnaire following the T2T experience, z= 3.65, p <.001 with a medium effect size (r=.61).

In order to validate these findings, Table 5 provides the data from a matched-pairs t test for each of the 10 questions on the Retroactive Self-Efficacy Questionnaire. Since the critical value (t=2.898, p<.01 two-tailed) was

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well below the obtained values for $t_{(17)}$ which range from 6.48 to 10.57, $p<.01$ (two-tailed), it indicated there was a significant increase between the pre and post score for each of the questions on the Retrospective Self-Efficacy Questionnaire.

Table 5: Paired Samples *t* Test by Item for the Retrospective Self-Efficacy Questionnaire

		Paired Differences					
		Mean	Std. Deviation	Std. Error Mean	*t*	*df*	Sig. (2-tailed)
Pair 1	RpostQ1 - RpreQ1	1.500	.618	.146	10.292	17	.000
Pair 2	RpostQ2 - RpreQ2	1.167	.707	.167	7.000	17	.000
Pair 3	RpostQ3 - RpreQ3	1.444	.705	.166	8.695	17	.000
Pair 4	RpostQ4 - RpreQ4	1.889	.758	.179	10.567	17	.000
Pair 5	RpostQ5 - RpreQ5	1.611	.916	.216	7.459	17	.000
Pair 6	RpostQ6 - RpreQ6	1.278	.826	.195	6.560	17	.000
Pair 7	RpostQ7 - RpreQ7	1.333	.686	.162	8.246	17	.000
Pair 8	RpostQ8 - RpreQ8	1.611	.698	.164	9.796	17	.000
Pair 9	RpostQ9 - RpreQ9	1.556	.784	.185	8.420	17	.000
Pair 10	RpostQ10 - RpreQ10	1.722	1.127	.266	6.481	17	.000

Semi-Structured Interview

A purposeful sampling strategy was used to select "information rich cases" (Patton, 2002, p.243) that provide a detailed description of the insights and experiences each teacher had as they participated in the T2T professional development model. According to Erlandson, Harris, Skipper, and Allen (1993), purposeful sampling in "naturalistic research seeks to maximize the range of specific information that can be obtained from and about that context. This requires a sampling procedure that is governed by emerging insights about what is relevant to the study and purposively seeks both the typical and divergent data that these insights suggest" (p.33).

Due to time constraints, this research project described interviews from 5 cases that highlight what the Teacher-to-Teacher (T2T) professional development model from the MSP grant has brought to the teaching of science. These five cases were purposively selected from the 18 participants of Cohort I. Teachers were selected from different grade levels (grades K-6), with at least one teacher selected from each of the three participating schools. In addition, a balanced representation of ethnicities and years of experience within the case studies were selected in order to represent the diversity of the Cohort I teachers. The teachers were identified with pseudonyms and the blind code numbers used for the quantitative measures.

The average interview took 30 minutes with a range of 20-35 minutes. Each interview was conducted in person in either the teacher's classroom or the MSP grant classroom. Interviews were audiotaped and transcribed for analysis. Respondents were each given a copy of the transcript to check for accuracy and an external auditor verified the transcripts with the audiotapes.

Coding Scheme

"Developing some manageable classification or coding scheme is the first step of analysis" (Patton, 2002, p. 462). Content analysis was completed to determine the predominant categories that emerged from the transcribed interviews (Patton, 2002). Initially, categories were identified and then descriptive findings or units were selected to illustrate the identified categories. Three broad categories of questions were explored through the interview. They were: (a) efficacy and attitude towards teaching science, (b) the skills and behaviors needed to plan and teach science lessons, and (c) feelings about the PLCs.

First Phase of Analysis: Transcription and Unitizing

The first stage of analysis occurred as all interview audiotapes were transcribed to electronic documents. Then a coding scheme was developed in order to analyze the interviews. Each respondent was placed in order on a table by their self-reported pre/post Retrospective Efficacy Questionnaire ratings from the lowest score for Anela through to the highest score for Ekela.

After a second read-through of the interviews, the interview data was unitized. As described by Erlandson, Harris, Skipper, and Allen (1993), units are the smallest pieces of information that can "stand alone". The researcher then takes the units and sorts "them into categories of ideas" (p.118).

Through content analysis of the interview transcripts, subcategories emerged. They included: (a) educational background, (b) prior science experiences, (c) current science experiences, (d) feelings about current science lessons, (e) feelings about the grade-level PLC, (f) lesson prep skills, (g) lesson "habits of mind," (h) science lesson examples, (i) changes to lesson examples, (j) success of lessons, (k) PLC configuration, and (l) feelings about peers.

Each category was determined to be complete when both "internal homogeneity and external heterogeneity" criteria were met (Patton, 2002, p. 465). In other words, categories became complete when they were considered to be unique compared to the other categories and the items that were within all connected together to produce the one category. Words and phrases that were repeated were counted and recorded in parentheses as part of the frequency analysis of the interview data. This data was also part of the unitizing process.

Second Phase of Analysis: Saliency

After reviewing and placing all units within categories, the process of saliency analysis was completed. Buetow (2010) defines saliency analysis as identifying and keeping at the forefront the data that is important: that which is useful in developing new understandings, advancing current understanding, and/or describing real world problems or issues. The first step required a review and placement of units and codes from the initial coding scheme into one of four quadrants: (1) highly important and recurrent, (2) highly important but not recurrent, (3) not highly important but recurrent, and (4) neither highly important nor recurrent. Table 6: Saliency Analysis of Cohort I Interviews shows the codes and units that were used in this analysis.

The next step was to identify themes within the quadrants. Quadrant 1 contained the highly important, major themes and quadrant 3 contained "minor themes that clarify and emphasize major themes" (Buetow, 2010, p.125). Quadrant 2 provided units and codes that were not recurrent and did not fit into the themes described in the former quadrants, but were highly important and should not be lost in the discussion of the overall picture from the qualitative data.

Table 6: Saliency Analysis of Cohort I Interviews

(1) Highly important and recurrent **Science Experiences*** **PLC Support*** **Time to prepare/understand lesson*** **Student Engagement***	(2) highly important but not recurrent **Professional growth*** teacher learning the science first Reflection after lessons Teachers teaching teachers Older teachers learning new tricks
(3) not highly important but recurrent Organization- binders, prep of materials Confidence Collaboration/sharing Revisions/Extensions of lessons Cooperative Learning "hands-on" Differentiation Integration Science tools/materials used	(4) not highly important or recurrent Educational Background Use of Smartboard

***Bold terms** are identified as the major themes for this study.

Third Phase of Analysis: Thematizing

Once the saliency analysis was completed, major themes were identified. The highly important and recurrent themes that emerged included: (1) impact of science experiences, (2) impact of grade-level PLCs, (3) time, and (4) student engagement. Each of the items in quadrant three supported the four major themes described above and thus did not provide any additional themes. It became apparent that much of what was placed in quadrant 2 could also be categorized within the themes developed above, except "professional growth" which became the 5th major theme.

Limitations

One limitation of this research was the smaller sample size of only 41 teachers being used for the quantitative secondary data analysis and an even smaller sample of 18 for the primary quantitative data analysis. The generalizability of the data to larger populations would be limited. However, the qualitative methods highlighting the identification and description of the personal development of the teachers as they participated in the MSP grant provided support to creating a sustainable science curriculum throughout Hawaii Island using the Teacher-to-Teacher (T2T) professional development model.

Another limitation was the fact that the participating teachers were self-selected for the MSP grant and therefore self-selected for this research study as well. Because Hilo is a small town, the researcher developed personal connections with the participating teachers, so there might have been some concern on the part of the participants about being truly honest on the measures being used for this study. Some may have felt that they did not want to hurt the researcher's feelings if they were truly honest and others may not have been entirely truthful in their reflections because they felt an obligation to the MSP grant itself. Each of these personal concerns were taken into account during the data analysis portion of the study. Finally, this research was not a randomized controlled trial study because the T2T model is still under development and the resources are currently not available for testing effectiveness via a larger experimental study.

Results and Discussion

Quantitative Data

The self-reported Retrospective Self-Efficacy Questionnaire was used to determine how the Cohort I teachers perceived their changes in efficacy over a three-year period of the MSP grant. Half of the 18 Cohort I teachers were also involved in the TIR project the year prior to the funding of the MSP grant. According to the data, there was a statistically significant positive change from the pre to the post total score on the survey. The pre (M=2.5) indicated the average answer choice of "Very Little" to "Some" for the teacher's perceived sense of efficacy prior to participating in the MSP grant. The post (M=40.4) total score indicated an average response of "Quite a Bit" for the survey, with two of the 18 teachers selecting "A Great Deal" as their primary response.

The data from the parametric and non-parametric tests suggest that teachers report they are feeling more confident and doing more science in their classrooms after participating in the MSP grant for the last three years.

Qualitative Data

The differences between how teachers felt before and after participating in the MSP grant were also shared in the interviews. Prior to the MSP grant, three of the five respondents stated that they did not have positive science experiences. Anela shared:

> So one of my experiences prior was taking a science class, it was astronomy – it was astronomy 101 – it was at the University of Hawaii at Manoa and, um, it was just one of my harder classes in my whole educational career. Just taking the class and understanding the concepts and, uh, just struggling with that kind of class.

Keola also did not have positive experiences in science and stated that her one class at UHH "did not prepare" her to teach in her own classroom: "I, uh, never had very good experiences in science…[they] were not positive – they were negative." In addition, her experiences were mostly paper/pencil and "very boring," both to do as a student and to teach her first students.

The current viewpoint that the respondents have towards science showed that they felt more confident in their ability to learn about and teach science; thus their science teaching self-efficacy was greater. The word "confident" appears multiple times in all five interviews, as well as positive descriptors like "supported," "successful," "accomplished," "significant" and "reflective." Both Keola and Waiohi stated that they have "learned a lot" over the last three years in the T2T professional development model. Waiohi shared, "over several years with MSP, I feel really comfortable, I feel prepared, I know I have more knowledge now and when I do science with the kids, they're more excited because I know how to better teach science."

Additionally, teachers shared that they had become more organized, excited, and comfortable with the science content and pedagogy that they developed and are implementing. Keola shared "I've learned a lot and I've also gotten really organized with science" and I feel "like Ms. Frizzle" with lots of growth on doing hands-on science experiences. "I've really had a lot of growth because there's a lot of things I wouldn't have done if I didn't participate – mainly a lot of hands-on, I guess because like I said in college they taught us pencil/paper."

The teachers also emphasized that they enjoy the sharing that occurs in their regular PLC meetings and the support they feel they have received. The word "confident" appears repeatedly throughout both Keola and Waiohi's interviews.

> I think for me, my teaching of science changed, is within myself that I feel more comfortable, more knowledgeable and more confident in the science curriculum and when a teacher feels more comfortable and more knowledgeable, students will have an easier time understanding what you're trying to teach them.

When questioned about how she feels about science after participating in the T2T professional development model, Pomai stated that she is better at teaching science. Prior to the grant, she did "activities and fun" but didn't really teach science. Now, she feels that she is able to meet the kids where they are at and take them to the next level by setting the stage and facilitating their science learning. Two key words describe her current feelings towards science: accomplished and significant.

> I really get it in science now that I've been participating in the grant…I can kinda build on what they know and I just, and I understand…meeting the kids where they're at and taking them to the next level.

Ekela's emphatic "I love it" response to how she feels now about teaching science says it all. "I've learned through many different years and different grades and being in MSP…has been huge…um, so the confidence level is so much more, not intimidating"

She is no longer intimidated by the science content and reflects often about her teaching. The re-occurring theme of being "confident" resonated throughout the interview. Again, it was evident that science self-efficacy has improved through the years that the teachers have been participating in the MSP grant.

Overall the interview themes suggest that the teachers believe the T2T professional development model used in their grade-level PLCs has allowed for their substantial professional growth in science teaching and learning. The last section in the "attitudes towards science" section of the interview asked the teachers to relate their feelings about their participation in their grade-level PLC. Every respondent talked about how sharing was key to having comfortable and positive science experiences. Keola states, "We had our meeting today . . . other people are in the same place. I didn't feel too bad because I didn't want to rush!" The feeling that everyone was contributing to the success of the curriculum being developed by the PLC permeated throughout all five interviews. Ekela states, ". . . sharing with other teachers at that grade level…you know you can learn from each other and not have to trail-and-error so much and then build on, you know, each other's strengths and ideas." Sharing, collaborating, and learning from each other were just a few ideas that were shared regarding working with their PLCs.

Finally, the idea of sharing so that everyone can learn from each other was heard in all five interviews. Ekela enthusiastically shared about seeing her colleague who "never did science before but look where she is now…it's HUGE." She also shared about several older colleagues that she has worked with:

> She is an ole timer and so it's really fun to see people who have had their ways all these years come in and try something new and really take it on…there are a couple others in MSP that are closer to retirement and they've been great as far as willing to try and bringing ideas to the plate and um they're really realistic.

Conclusions

This study reinforced the idea that teachers grow and develop over time. The prior literature only described, in a limited way, what efficacy looks like one moment in time, the implications of describing growth of teacher behaviors and skills over a long term, sustained professional development model are important to note. When teachers are supported by the T2T professional development model over several years, they do learn more than basic science content because they begin to internalize and implement science experiences for their students that are deeper and more engaging than those simple activities they have done in the past (if they even taught science). In addition, as they continued to learn and become more confident, they also recognized what they have not quite understood and they move towards trying to improve in that area; they now know what they don't know, so they can learn more about it, which in turn will support their identification and addressing of misconceptions in their student's learning. Finally, as the teachers moved towards a higher sense of efficacy, their feelings towards learning challenging material or experiments changed to a "can do" attitude and they took on the challenge of learning and teaching new skills, some specifically in science, others from other content disciplines.

Although a preliminary description has been developed for the behaviors and skills teachers learn and develop over time through the T2T professional development model, additional data needs to be analyzed from the overall grant. The MSP grant finished a no-cost extension– year with additional teachers, who were not been able to participate in the MSP grant due to the limits of PLC size. The increase in the number of participants to involve most teachers at all seven schools increased the data sample size to one which would be closer to the teacher population of the Big Island of Hawaii.

Another recommendation would be to take the plethora of qualitative data that was collected for the grant and generate further thick descriptions of change that teachers experienced over time. Many of the field notes, classroom observation notes and reflection logs by the teachers are resplendent with anecdotes about how the MSP grant has changed a teacher's way of teaching, as well as the various learning events that have happened to teachers as they taught science and learned alongside their students.

Finally, the ability to take this professional development model and use it to help teachers with the common core standards (CCSS) needs to be explored. The teachers have actually started doing this on their own. They have developed their binders for other subject areas and use the members of their PLC as a sounding board for lesson ideas, even though they are not discussing science. There needs to be a way to continue to support teachers and schools through this model to improve teaching and learning.

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