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NASA Educator Professional Development Collaborative Impact on Educators' Teaching Practices in Puerto Rico

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The focus on STEM teacher quality to motivate and prepare students for STEM careers have resulted in an increase number of professional development programs. In Puerto Rico, teacher STEM education professional development efforts are becoming a focus of formalized efforts. This mix-methods study looks at 1) the direct impact of NASA professional development training on educator teaching practices in Puerto Rico, and 2) if type of educator, years as educator, mode of professional development training, professional development exposure, and main subject of educators predict NASA professional development impact on educator teaching practices.

Executive Summary

- The categorical regression analysis results with the Teaching Practices Index as the dependent variable showed that type of educator, educators' main teaching subject, professional development exposure and mode of professional development (workshop) were statistically significant predictors of impact on participants' teaching practices.

- 94% of PK-12 educator type respondents reported a moderate or large change specifically in their knowledge and understanding of their main subject.

- Educators teaching mathematics as their main teaching subject were almost twice more likely to self-report a small impact in their classroom management, and knowledge and understanding of instructional practices, than any other educators. Mathematics educators were also almost twice as likely to report a small impact in their knowledge and understanding of their main subject than science teachers.

- Results of the categorical regression with STEM professional development hours (variable PDEX) reported by the participants show a strong positive relationship with a p-value of .003. This result appears to support the claim that continuous participation in PD is needed for direct classroom impact.

Background

STEM Education in a Global Society

It has been well documented that the economic success of any nation is dependent on a skilled, educated workforce (National Science Foundation, 2017; U.S. Department of Education, 2016). To remain competitive in a global economy, nations have invested heavily in educational systems, programs, and models that develop the skills required to meet 21st century demands. Careers in STEM that promote innovation, creativity, and problem-solving skills, have been identified as key levers to support both national economic goals and increase the quality of life for individuals (U.S. Department of Education, 2016). Over the past decade, STEM occupations have risen significantly and this trend is projected to continue into the next decade. According to the U.S. Bureau of Labor Statistics (BLS, 2017), there were nearly 8.6 million STEM jobs in May 2015, which represented 6.2 percent of U.S. employment. Moreover, the BLS (2014) noted that STEM related careers are projected to grow by more than 9 million between 2012 and 2022. Taken together, these indicators have stimulated national, state, and local educational leaders in the U.S. to create policies that improve STEM teaching and learning.

The investment in education reform is rooted in the belief that education is the foundation for cultivating a skilled workforce to meet national 21st century demands. This realization has prompted governments from across the globe to reexamine educational policies and structures and devise novel, effective, and transformational educational reform solutions to respond to global challenges and opportunities. To respond to domestic and international demands, educational systems are dependent on the cultivation of a strong, capable, and effective teaching workforce.

The Need for Quality Professional Development

Research has indicated that teacher quality is one of the most important school-based factors impacting student outcomes (Darling-Hammond & Berry, 2006; Geringer, 2003; Hanushek & Rivkin, 2007; Lasley, Siedentop, & Yinger, 2006). The focus on teacher quality has prompted policy makers, researchers, and practitioners to engage in efforts to improve teaching quality and effectiveness. This has resulted in the increasing number of professional learning activities outside the classroom, most notably in the form of professional development programs in advancing teacher competency, quality, and overall professionalism (Darling-Hammond, Hyler, & Gardner, 2017). The need for professional development programs have grown exponentially over the last decade. The raising of educational standards has driven the necessity of developing effective teachers, incorporating rigorous curricula, and assessing student learning based on standardized exams (Ravitch, 2010).

STEM Education in Puerto Rico

Educating students to be highly knowledgeable, skilled and enthusiastic in mastering subjects in STEM has been a priority in teachers professional development in Puerto Rico. A major challenge in realizing this goal in Puerto Rico is the difficulty in recruiting certified mathematics and science teachers. Contributing to this challenge is the closing of more than 400 schools in Puerto Rico, low percentages of students reaching proficiency in math, and current teacher reallocations and attrition (Mazzei, 2018). The cultivation of a skilled STEM educator workforce in Puerto Rico will require continuous and effective teacher support. To improve teacher recruitment in STEM fields, as well as other academic areas, the PRDE has developed the Teacher Equity Plan. This plan intends to promote teacher access to support systems in teaching all students regardless of socio-economic status, ethnicity, and / or geographic location. The PRDE is in the process of revising its recruitment and retention processes to ensure the equitable distribution and/or designation of highly qualified, certified and experienced teachers to fill vacant positions. Among the strategies that the PRDE (2017) outlines to eliminate the equity gaps are:

- Strategy 1: Ensure effective management of human resources.
- Strategy 2: Strengthen teacher preparation and in-service training programs.
- Strategy 3: Commitment of PRDE staff to the Equal Access Initiative

These initiatives include teacher preparation through professional development for out of field, alternate route, and non-certified teachers. Professional activities will include mentoring, coaching, tuition assistance, workshops, online learning, and job embedded instructional support. In addition, partnerships will be sought with higher education institutions that lead to improved academic achievement by aligning teacher preparation programs and professional development projects with PRDE’s priorities (PRDE 2017).

Methodology

This study follows a mixed-methods research design in which qualitative data informs the quantitative findings. The Professional Learning Educator Assessment Survey (PLEAS) tool used in this study was adapted from the Teaching and Learning International Survey (2008). PLEAS was administered with teacher participants at four day-long EPDC professional development events. These events took place at four universities in Puerto Rico each located in a different geographic area of the island.

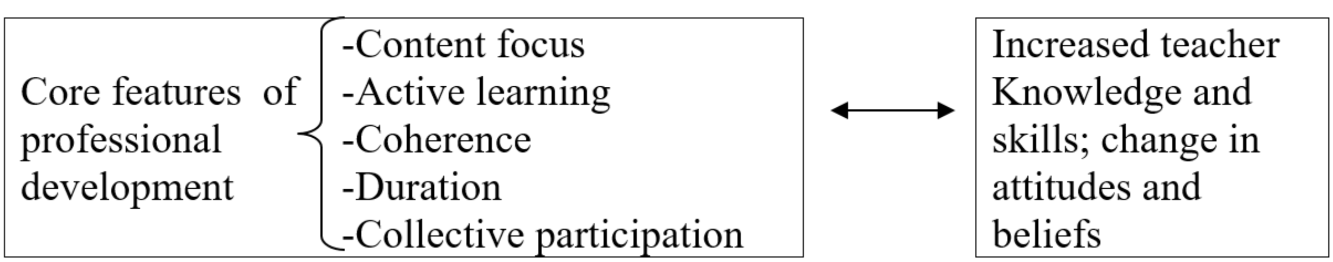
Conceptual Framework

There are certain critical characteristics of professional development that have been identified as leading to positively impacting teachers' self-reported increases in knowledge and skills, and changes in classroom practices (Desimone 2009; Garet et al. 2001). These professional development characteristics have been referred to as core features and they are: (a) content focus, (b) active learning, (c) coherence, (d) duration, and (e) collective participation (Desimone 2009; Garet et al. 2001; Jeanpierre, Oberhauser, & Freeman, 2005; Johnson, Kahle, & Fargo, 2007; Penuel et al., 2007;). The proposed conceptual framework for this study is an adaptation of Desimone (2009) who proposes a non-recursive relationship model (Figure 1). In this conceptual framework, measuring teacher's learning experiences through a core set of features of effective professional development provides the means to assess professional development effectiveness. It is then suggested that this framework can be used as a base to assess the EPDC professional development impact on educators' teaching practices.

Survey Design and Data Collection

Puerto Rico's official languages are English and Spanish, consequently, the administration of the PLEAS questionnaire included a version of the survey in both languages so that participants could select to take the questionnaire in their preferred language. The process of translation verification included several steps. First, a certified bilingual (Spanish/English) educator received the English questionnaire in a digital word processor format and translated the tool into Spanish. Two more educators proficient in English and Spanish,

Figure 1 EPDC Professional Development Non-Recursive Relationship Model



including an educator from Puerto Rico, reviewed the translated questionnaire. Reviewers were asked to 1) check for accuracy of translation paying special attention to the linguistic characteristics of Puerto Rico; 2) ground the questions in the Puerto Rico context to ensure that categories present in the questionnaire were appropriate; and 3) offer an alternative translation when necessary.

Twenty-two items comprised the PLEAS tool including seventeen close-ended and five open-ended questions. Some of the items were adopted and/or modified from the Teaching and Learning International Survey (TALIS) tool, while others were newly created items for this study. Some of the questions were intended to be used as single item analysis, where others needed to be combined as they represent a latent construct. For the latent constructs, indexes and transformations were needed to analyze the data. In some cases, quantitative items intended to be used as a single item analysis also needed to be transformed into categories for deeper analysis. Refer to Table 1 for the list of survey items selected for this study and their transformations.

Sampling

Participants attended a day-long STEM professional development event at one of the four selected sites. Participants registered online for the event with most participants selecting the site for its proximity to their place of residence. The four events followed the same format and covered the same content. At the end of the day-long professional development events teachers volunteered to participate in the survey. A total of 294 educators completed a hard copy of the survey.

The Time Location Sampling (TLS) method (also known as venue-based sampling) utilized for the study assumes that the population of interest is the population attending the locations selected. In this study, the population of interest were K-16 educators in Puerto Rico attending a STEM professional development training. The EPDC professional development events selected were a series of four professional development events at four local universities in different geographic areas of the island: Ponce, Mayagüez, Arecibo and Bayamón. Through a partnership with PRDE a permission was granted for the four EPDC professional development events to be part of educators' professional development portfolio. A press release by PRDE communicated this opportunity giving registration information to interested educators. A total of 350 teachers participated, representing 300 schools and 68 municipalities out of 78. Of the 350 teachers participating, 294 completed the survey. Refer to Table 1 for participant demographic information. When utilizing TLS as the sampling method, reports of the TLS data analysis apply only to a population resembling the persons actually sampled, rather than the population from which the sampled persons are drawn (Wejnert, 2014).

Data Analysis

Principal component analysis was chosen to derive the index for the Teaching Practices Impact (TPI) index. First, the five indicators for TPI went through two multivariate analyses: principal component analysis (PCA) and Cronbach's coefficient alpha. For the analysis, the Statistical Package for the Social Sciences (SPSS) categorical principal component analysis (CATPCA) was selected for its suitability to handle different scale levels including ordinal scales. PCA is often used for data reduction. However, in this study, it is used as a tool to assess the reliability of the indicators to measure the same underlying construct and to understand better the dimensionality of the constructs. The goal of principal component analysis (PCA) is to reveal how different variables change in relation to each other and how they are associated (Nardo, Saisana, & Salteilli 2008).

Table 1 *PLEAS Selected Survey Items for this Stud*

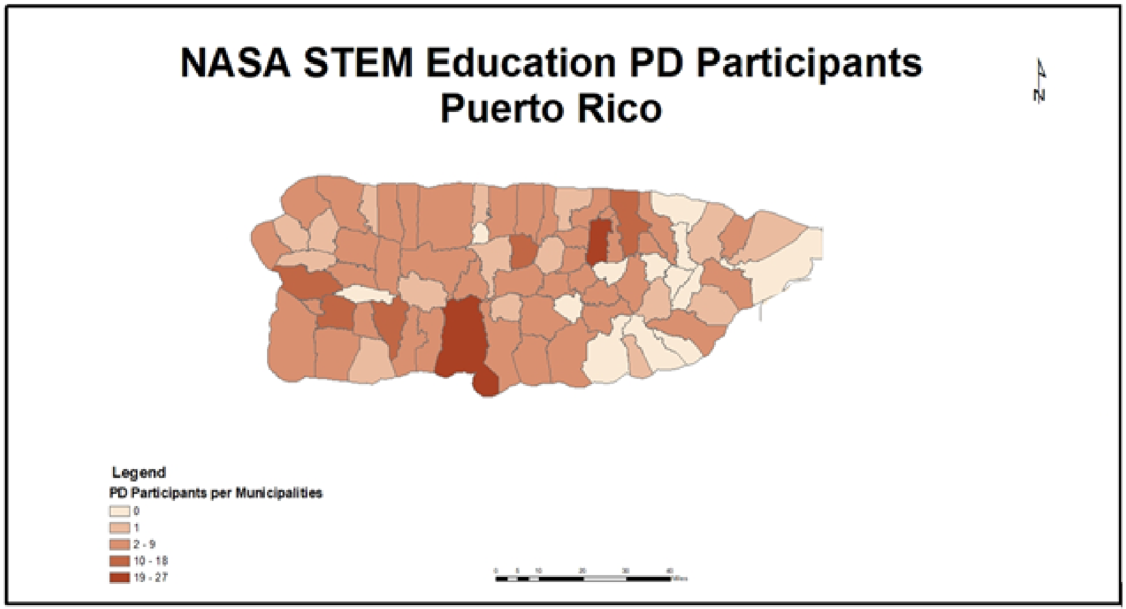
Question	Variable	Original or Collapse Values
PD Experiences: *During the last 18 months, have you participated in any of the following kinds of professional learning activities, including this one, and what was the impact of these activities on your development as an educator?*		
Q1a_Workshops	PDWK	Yes/No
Q1b_Summer Institutes	PDIN	Yes/No
Q1c_Webinars	PDWB	Yes/No
Q1_C: Describe the ways in which you have applied this learning to your teaching	PDQUAL	Open-ended
Teaching Practices: *Concerning the STEM professional development in which you have participated in the past 18 months including this one, to what extent has it directly led to or involved changes in any of the following:*		
Q8a_ Your classroom management practices	CLMNG	None (1); Small (2); Moderate (3); Large (4)
Q8b_Your knowledge and understanding of your main subject field	KUMS	None (1); Small (2); Moderate (3); Large (4)
Q8c_ Your knowledge and understanding of instructional practices (knowledge mediation) in your main subject field(s)	KUIP	None (1); Small (2); Moderate (3); Large (4)
Q8d_ Your teaching of students in a multicultural setting	TEMS	None (1); Small (2); Moderate (3); Large (4)
Q8e_ Cultural responsive/relevant teaching	CRT	None (1); Small (2); Moderate (3); Large (4)
Educator Background		
Q12_Which classification title below best describes you as an Educator in your current and primary role?	EDTY	Higher Education Student
		Higher Education Faculty
		Higher Education Administrator
		PK-12 Teacher
		Other Educator
Q14_How many years have you been working as an educator in your overall career? (count the current year as 1 year)	EDYR	Number of years (numerical entry)
Q17_1_11We would like to ask you about the main subjects that you teach this school year.	EDMS	None; Reading, writing and literature; Mathematics; Science; Social Studies; Multiple; Other
Exposure: *Of the professional development in which you participated in the last 18 months, estimate the total number of professional development hours?*		
Q19_Professional Development Exposure	PDEX	Number of PD hours (numerical entry)
Evaluation		
Q24: *What was the most useful part of this professional development? Describe the elements, information/content, activities, etc. that you believe will impact your teaching practices and explain why.*	EVQUAL	Open-ended

Table 2 EPDC Participants' Demographic Information

Participants Demographics	Frequency	Percent
Educator Type		
Higher Education Student	1	.03
Higher Education Faculty	21	7.1
Higher Education Administrator	1	0.3
PK-12 Teacher	203	69.0
Other Educator	48	16.3
Non-Response	20	6.8
Total	294	100.0
Discipline Content Area		
None	8	2.7
Reading, writing and literature	2	0.7
Mathematics	13	4.4
Science	128	43.5
Multiple	131	44.6
Others	7	2.4
Non-response	5	1.7
Total	294	100.0
EPDC Site		
Arecibo	81	27.6
Bayamón	58	19.7
Mayagüez	78	26.5
Ponce	77	26.2
Total	294	100.0

Second, the use of Cronbach coefficient alpha (hereafter referred to as c-alpha) acted as an alternative way to investigate the degree of correlation among the set of indicators, which is the most common estimate of internal consistency of items in a model or survey (Nardo et al., 2008). Normality on data distribution is not generally an assumption needed when running c-alpha. C-alpha is not a statistical test, but a coefficient of reliability based on the correlation between individual indicators. If the correlation is high, there is evidence that the individual indicators are measuring the same underlying construct. Therefore, a high c-alpha (or equivalently a high "reliability") indicates that the individual indicators measure the latent phenomenon well (Nardo et al., 2008).

After assessing the reliability of the indicators and the internal consistency for the TPI, a composite score was created. The method used was a sum score of the five indicators that measured the TPI. The composite scores of the TPI became the dependent variable in the regression models. The response or independent variables were self-reported: type of educator (EDTY); number of years as educator (EDYR); educator main subject taught (EDMS); the different types of STEM professional development reported to have participated in the last 18 months (PDWK; PDIN; PDWB); and the STEM professional development exposure in total hours in the past 18 months (PDEX).



Source: Author

A series of categorical regression models were conducted with the aforementioned dependent and independent variables. The categorical regression model selected for this study is the SPSS CATREG approach, which incorporates optimal scaling and can be used when the independent(s) and dependent variables are any combination of numeric, ordinal or nominal. This type of regression with optimal scaling offers three scaling levels for each variable. Combinations of these levels can account for a wide range of nonlinear relationships and offers greater flexibility than other standard approaches such as analysis of variance or logistic regression. A p-value of 0.05 or less was sought to report statistically significance for this study.

Results of the CATREG analysis led to the use of crosstabs when the relationship among dependent and independent variables showed either statistical significance or a high beta value. The Crosstabs procedure forms a two-way table and provides a variety of tests and measures of association. The structure of the table, and whether categories are ordered, determines what test or measure to use. Spearman's Rank Correlation Coefficient is a non-parametric measure of association between the rankings of two variables measured on N cases appropriate for the data structure for this study.

Qualitative Methodology

The PLEAS survey included qualitative questions that sought to gauge the impact of STEM professional development on educators' teaching practices. Survey responses were organized and transcribed verbatim into a Microsoft Excel spreadsheet. Several rounds of data checking were conducted to assess and ensure the accuracy of the data. The data was then imported into MaxQDA, a qualitative data analysis software, to manage 294 surveys and assist in the data analysis phase. After being imported into MaxQDA, the data was organized according to the question and then analyzed by a systematic process of coding, thematic categorization, and interpretation. The analysis of participant responses employed an inductive approach (Patton, 2014) and utilized Saldaña's (2015) first and second coding method. The first phase of data analysis consisted of coding the data using the In vivo coding technique to highlight key responses by the participants. This approach to coding was employed to enhance the voices of Puerto Rico teachers and offer a deeper understanding about their unique insights related to past and current professional development experiences (Saldaña, 2015). A significant number of participants often shared comparable responses to the questions which assisted in the coding process. Specific words and/or phrases used by survey respondents were coded and tallied appropriately. The second level coding stage utilized a thematic coding process that combined codes to identify patterns and create emerging categories and themes related to their professional development experiences.

When conducting cross-cultural studies, it is essential to reproduce the original data source as possible to secure authenticity and meaning (Larson, 1991). Since 292 out of 294 surveys were completed in Spanish, qualitative participant responses were translated into English for reporting purposes. To help preserve the authenticity of the original Spanish source, a professor in the Department of Education at a university in Puerto Rico who is a proficient bilingual expert (and native of Puerto Rico) verified the translated text. The translated text was either approved or revised to ensure linguistic and cultural integrity of the participants' responses.

FINDINGS

The study explores the direct impact on educators' teaching practices of EPDC professional development programs.. As explained in the methods section, a multivariate analysis was performed for the TPI to assess the reliability of the indicators to measure the same construct of teaching practices. The CATPCA and the c-alpha scoring showed a high level of internal consistency. The CATPCA with only one dimension showed high levels of internal consistency with a lowest scoring of .802 (see Table 3). In addition, a c-alpha score of .906 confirms that the items in the model are measuring the same construct of teaching practices.

To answer research question 1: *What is the direct impact of STEM professional development training on educator teaching practices.* A frequency analyses of self-reported data obtained through survey Questions 8a through 8e (refer to Table 1) with a Likert scale of 4 points from "None" to "Large" revealed that educators report a positive impact. At least 87% of all respondents in each of the Likert scale items in Question 8 reported that STEM professional development (PD) training for educators has a moderate or large impact in their teaching practices. In the qualitative data analysis section, a deeper analysis is performed to better understand how these professional development programs are reported to be impacting teaching practices.

Table 3 CATPCA Results for One Dimension

Model Summary		**Components Loadings**				
Cronbach's Alpha	Eigen value	CLMNG	KUMS	KUIP	TEMS	CRT
0.906	3.638	0.802	0.838	0.891	0.868	0.863

To answer research question 2: *Does type of educator, years as educator, mode of professional development training, professional development exposure, and main subject of educators predict STEM professional development impact on educator teaching practices?* A series of categorical regression analyses were conducted that revealed that four out of these five variables are statistically significant predictors.

For the categorical regression analysis, the dependent variable TPI (Teaching Practices Index) and the independent or response variables of type of educator (EDTY), number of years as educator (EDYR), educator main subject taught (EDMS), the different types of EPDC PD reported to have participated in the last 18 months (PDWK; PDIN; and PDWB), and the EPDC PD exposure in total hours in the past 18 months (PDEX) formed the model. When running the categorical regression with all seven independent variables the variables PDIN and PDWB showed no statistical significant results. Given these results and their low variability, the removal of these variables improved the model fit for the regression. Results of the categorical regression model using the five remaining variables show that out of the five independent variables four were statistically significant predictors of impact on teaching practices at least at a p-value of 0.01 (see Table 4 and Table 5).

Table 4 ANOVA Results of the Categorical Regression Model Using the Variables EDMS, EDTY, EDYR, PDWK and PDEX.

		Sum of squares	*df*	Mean Square	F	Sig.
Regression		25.354	11	2.305	2.472	0.006
Residual		184.646	198	0.933		
Total		210.000	209			

Dependent Variable: Teaching Practices Index
Predictors: EDMS EDTY EDYR PDWK PDEX
R_s: 0.121

Table 5 Standardized Coefficients of the Categorical Regression Models using the variables EDMS, EDTY, EDYR, PDWK and PDEX.

COEFFICIENTS						
Variables		Beta	Bootstrap (1000) Estimate of Std. Error	*df*	F	Sig.
EDMS		0.146	0.074	4	3.889	0.005
EDTY		0.134	0.059	3	5.087	0.002
PDWK		-0.163	0.079	2	4.257	0.015
PDEX		0.172	0.057	1	9.297	0.003
EDYR		-0.014	0.072	1	0.039	0.844

To better understand the strength and direction of the relationships uncovered through the regression analysis, a cross-tab analysis and a Spearman's Correlation Coefficient test revealed further promising results.

Type of Educator and Main Teaching Subjects

When looking at the type of educator as a predictor of EPDC PD impact on teaching practices, the categorical regression produced an F-test p-value of .005. The results of the cross-tab examination revealed expected results. At least 89% of respondents that reported a EPDC PD moderate or large impact in the five teaching Q8a through Q8e (see Table 1) were PK-12 teachers. In this study, 77% of the participants that completed the survey were PK-12 teachers. This sampling bias on type of educator surveyed needs consideration in the interpretation of the results. Results show that the greater direct impact of the EPDC PD on PK-12 teachers is in classroom management and, knowledge and understanding of participants' main subject. Refer to Table 7 for more detailed information.

Not only is type of educator important when looking at the direct impact of the EPDC PD in educators teaching practices, main teaching subject is also relevant. When looking at the results of the cross-tab analysis of the five teaching practices by teaching main subjects, there is also a clear pattern. Educators teaching mathematics as their main teaching subject were almost twice more likely to self-report a small impact in their classroom management, and knowledge and understanding of instructional practices, than any other educators. Mathematics educators were also almost twice as likely to report a small impact in their knowledge and understanding of their main subject than science teachers. These results might reflect the limited selection of EPDC PD topics directly related to specific practices for teaching mathematic content skills. This doesn't seem to be unique to the EPDC PD experience. In fact, most of the professional development activities that math teachers participate in Puerto Rico are related to curriculum development using current standards and expectations, effective lesson planning, building communities of learning, project or problem-based learning, among others, and not specific content skill development (T. Diaz, personal interview, March 15, 2018). In fact, at Future Leaning Inc., "*less that 10% of the professional development activities that were organized in the past three (3) years were around math content topics*", commented Mr. Tommy Díaz, President of Future Leaning Inc. These results support a previously cited study that found that professional development activities for math teachers that have significant positive effects on teachers' self-reported increases in knowledge and skills, and changes in classroom practice are those that focus on content knowledge (Garet et al. 2001)

Table 6 Type of Educator as a Predictor of EPDC PD Impact on Teaching Practices

Type of Educator	
PK-12 Teacher*Teaching Practices	Percentage of respondents reporting moderate to large Direct change in teaching practices
Classroom management	95%
Main subject	91%
Instructional practices	89%
Multicultural setting	89%
CRT	89%

PD Exposure and Type of PD

Regression results show a statistically significant relationship between the level of exposure of educators to STEM professional development training (measured by PD participation hours in the last 18 months) and the direct impact of EPDC PD on participants' teaching practices. Of interest is that the number of years practicing as a teacher (measured by the variable EDYR) didn't yield either a statistically significant result or strong relationship result. Results of the categorical regression with STEM professional development hours (variable PDEX) reported by the participants show a strong positive relationship with a p-value of .003. This result supports the claim that continuous participation in PD is needed for direct classroom impact.

When conducting the categorical regression analysis with the different EPDC PD modes of delivery (workshop, summer institute and webinars), only the variable PDWK (workshop) showed statistical significance at the 95% confidence level.

STEM education has become more prevalent in teacher professional development efforts in Puerto Rico only in the past few years and its delivery has usually been accomplished through workshops. In fact, STEM education conversations through conferences and workshops in Puerto Rico mostly focus around its conceptualization. There are two important participation challenges for the implementation of online educator professional development: 1) language barriers, and 2) internet access. Although, the official languages in Puerto Rico are English and Spanish, most teachers' preferred language is Spanish, and most people in the Island speak Spanish at home. Teachers in Puerto Rico have requested more Spanish STEM education resources, which are limited right now. Limited or no internet access for many of these teachers also makes it difficult for them to access online professional development opportunities.

The cross-tab analyses of the teaching practice variables CLMNG, KUMS, KUIP, TEMS and CRT, and PDWK revealed promising results (refer to Table 1 for the list of variables). Overall, at least 88% of respondents stated that the STEM workshops they had attended in the past 18 months had resulted in a direct moderate or large change in their teaching practices. Moreover, 94% of PK-12 respondents reported a moderate or large change specifically in their knowledge and understanding of their main subject. Refer to Table 8 for detailed information.

Table 8 STEM Workshops as a Predictor of EPDC PD Impact on Teaching Practices

PK-12 Teacher	
STEM Workshop*Teaching Practices	Percentage of respondents reporting moderate to large Direct change in teaching practices
Classroom management	95.2%
Main subject	94.1%
Instructional practices	89.3%
Multicultural setting	88.7%
CRT	88.2%

Note: Impact reported on EPDC PD participated in the last 18 months.

Teachers Provide Context to Quantitative Analyses

The qualitative analysis results give context to the results obtained through the quantitative analysis and inform its interpretations. Through the qualitative data a deeper analysis is performed to contextualize the quantitative analysis results. Participants provided reflective information through two open-ended questions.

Q1: During the last 18 months, have you participated in any of the following kinds of professional learning activities, including this one, and what was the impact of these activities on your development as an educator? Please indicate 'Yes' or 'No' in part (A) for each of the activities listed below. If 'Yes' in part (A), please specify the number of hours spent on the activity in part (B), and describe the ways in which you have applied this learning to your teaching in part (C).

Q24: What was the most useful part of this professional development? Describe the elements, information/content, activities, etc. that you believe will impact your teaching practices and explain why.

Teachers Give Voice to Reported Impact

Question 1 above explored the impact of previous workshops on teacher practices. The analysis specifically focused on teachers experiences with STEM workshops and its impact on instructional practice. During the last 18 months, over 50% percent of the participants surveyed in the study reported attending a STEM workshop during this time frame. Participants experienced anywhere from 2-60 hours of STEM professional development during this time. Responses revealed positive impacts supporting content knowledge and pedagogical awareness. STEM related content most notably, earth science, physics, and mathematics, were the most frequently cited responses by the participants. Participants reported that the PD most impacted their teaching and application of STEM resources in the classroom. One teacher noted that, "I apply suggested activities in science classes and I modify them to the needs of the group." STEM related PD also informed pedagogical approaches utilized by the teachers. Participants acknowledged the acquisition of strategies to teach STEM content to their students in relevant ways and incorporate group related activities into their facilitation of student learning. Participants also responded to Question 24 providing insights into how educators participating in the EPDC professional development event just attended planned on applying their learning into their teaching practices.

Instructional Practices

As part of the professional development, educators were exposed to a variety of web-based STEM resources and were provided the opportunity to explore and access on-line educational materials and learning resources. Teachers found the incorporation of these tools and resources particularly useful for enhancing teaching practices and classroom instruction. Of the 294 teachers surveyed in the study, roughly 40% referenced technology-based content, tools, and materials as a meaningful aspect of the PD. The responses ranged from simply mentioning writing 'web link' or internet resources, to a deeper description of how the resources will benefit their instructional practice, such as "[G]aining knowledge of the free, accessible tools for teachers that we can use in the classroom with our students."

A number of teachers referred to the web-based resources as 'technological educational tools,' which will support their teaching practices. After several rounds of thematic coding, the analysis of the data revealed two findings related to the educational tools: 1) the exposure to the myriad of digital resources presented in the professional development was well received due to the practical nature of the tools; and 2) the multidisciplinary nature of the content and exposure to web-based STEM educational resources and use of digital technology increased educators' awareness of readily accessible resources to implement in their classrooms with their students.

Classroom Management

Based on the comments shared by the educators, the new educational tools and resources they acquired during the event will support their instructional and classroom practices. Comments about utilizing and implementing the newly acquired educational materials with students were thematic findings that emerged from the data. The introduction, presentation, and application of on-line digital STEM educational content resulted in a positive learning experience for the teachers according to participants self-reported data. The cost-effective nature of the STEM based tools and resources presented to the teachers were greatly appreciated as evidenced by the responses of numerous educators. Regarding what information was most valuable from the training sessions, one teacher commented, "[I]ntroducing the online links where I can interact with the innovations of STEM and use them in my class." Other comments included: "I really liked the classroom activities that do not require a lot of money to buy…" and "[T]he different web pages because I will be able to work with my students."

Knowledge and Understanding of Main Subject

Based on the qualitative survey responses, teachers generally felt more confident and excited to utilize newly acquired knowledge and resources to boost student interest in STEM. Educators also expressed their desire to utilize the newly acquired resources to facilitate their student learning, and instruction. By doing so, the teachers intend to promote a STEM culture in their school by supporting other teachers and motivating students to engage in STEM. One teacher wrote that by "[U]sing the links to access information from NASA, I will be able to create a page to disseminate material for Kindergarten teachers and create greater awareness in promoting STEM activities in my classroom." Another teacher stated that, "[O]nline educational tools and online resources [were most useful], because I will use it in the classroom to motivate students." Moreover, the learning and acquisition of new content, tools, and resources impacted teachers' drive to learn more about STEM careers and educational related opportunities and to communicate the information to their students: "I just want to acquire the necessary tools so that my students can know the amount of opportunities that exist. What they have available in this century." This sentiment was echoed by another teacher, "I want to raise awareness among students of the opportunities that NASA offers." As such, the responses shared by the teachers reflected a sense of commitment to serve as institutional agents that leverage professional knowledge and institutional resources that are then transmitted to benefit underserved students (Stanton-Salazar, 2010).

Multicultural Settings and Culturally Responsive Teaching

Efforts to address educational disparities in the STEM disciplines have been directed at efforts focused on enhancing the capacity of educators to effectively engage students of color. To achieve this, scholars have conceptualized and advocated for dynamic and culturally responsive methods of engaging students of color in STEM education (Adjapong & Emdin, 2015; Hammond, 2015). To engage in culturally responsive science education, educators must possess critical knowledge about self, sociopolitical, economic, and cultural contexts that impact student learning and achievement (Brown, 2017; Emdin, 2016; Gay, 2010; Ladson-Billings, 1995). As such, educators need opportunities to engage in professional development that depart from the traditional focus on content and inquiry-based instruction, to exploring racial, sociocultural, and political forces that shape and inform STEM instruction (Brown & Crippen, 2016).

An integral part of the EPDC professional development event was the inclusion of culturally responsive teaching practices and principles. During the sessions, teachers were engaged and exposed to theoretical principles of culturally responsive teaching. Based on participant data, the qualitative analysis revealed diverse and wide-ranging thoughts regarding the culturally responsive component of the professional development experience. The responses stated by workshop participants varied in depth and description. Out of the 294 respondents a total of sixteen respondents positively reported that the session on culturally responsive teaching was meaningful and an integral part of the event. The inclusion of culturally responsive teaching approaches into the EPDC professional development provoked and stimulated the teachers to consider the value of implementing culturally responsive principles into their instructional practices. Statements from participants that responded to the question about describing the most meaningful part of the training included, "[K]nowing about culturally responsive pedagogy helps to improve pedagogy", and "culturally relevant teaching [most useful] because it allows us to approach students accepting their differences, leaving the relevance to exist."

Analysis of data also revealed that a total of twelve participants reported a neutral/negative response regarding the topic of CRT. These responses identified various factors such as the perceived practical benefit of the content to the length and duration of the session. One participant noted that "I did not see the immediate use/benefit from the workshop on culture." The contrasts between participant experiences related to culturally responsive teaching content during the PD are noteworthy and warrant future exploration.

Limitations

Our study sample population consisted of Puerto Rico educators participating in a STEM professional development event. Because of the sampling method used, inherent bias in the characteristics of the participants might be present. Additionally, reports of the TLS data analysis apply only to a population resembling the persons actually sampled, instead of the population from which the sampled persons are drawn. Notwithstanding, 68 out of the 78 municipalities in Puerto Rico were represented in the study sample. It is deemed that given this representation and diverse group of participants in terms of geographic area, main subject taught, years of experience, STEM professional development experience, etc., the population actually sampled is a good representation of PK-12 teachers in Puerto Rico. Another limitation is the bias that might be present in the self-reported data obtained. Challenges to the common notion that self-reported data is less reliable because of the bias that might be present have been raised (Desimone 2009), however, on this debate there are more questions than answers. It is still now well known to what degree observations, interviews, and surveys differ in their ability to capture the effectiveness of professional development experiences.

CONCLUSION

Educational challenges lay ahead for Puerto Rico with school closings and teacher attrition caused by the current economic crisis. The need for an educator workforce that is well prepared to motivate and prepare students for a STEM career is needed in Puerto Rico, as in many other countries around the world, to be competitive in today's global economy. Understanding this imperative, Puerto Rico is in the early stages of implementing a comprehensive

STEM education professional development program for teachers.

Results of this study demonstrate the STEM education professional development programs' positive impact on educator teaching practices, especially on PK-12 teachers. Furthermore, the higher the participation in STEM professional development events the greater the impact in their teaching practices. These findings support the position that attention to educators should include professional development across the professional continuum. Among the greatest impacts reported was PK-12 teachers' class management and, knowledge and understanding of their main teaching subjects. These are promising results, but they also expose pressing challenges to overcome and opportunities to explore in improving professional development efforts for STEM educators.

It is important to reiterate that mathematics teachers were more likely to report lower impacts on their teaching practices than teachers of other subjects. According to the data obtained and comments from teacher professional development leaders in Puerto Rico (T. Diaz, personal interview, March 15, 2018), there is a need to provide professional development activities that are more focused in the development of mathematical content skills (algebra, geometry, statistics, etc.). Additionally, there is an interest from teachers in Puerto Rico to have more STEM resources in Spanish. This will facilitate implementation of resources in the classroom, and a way of engaging families in their students' STEM education experiences in their preferred language. Furthermore, Spanish resources provide an opportunity for teachers to implement some of the culturally relevant teaching strategies learned in the training. If the countries are to stay competitive globally in emerging technologies and STEM workforce needs, it is necessary to prepare large number of students of diverse backgrounds. To do this we need to engage their families since they are a strong influential force in student career decision making (Rodríguez Amaya and Boakye 2015).

STEM education in Puerto Rico, as in many countries in Latin America and around the world, is becoming a focus of formalized efforts. Collaborative partnerships show promising results in providing teachers with the tools and knowledge needed in the 21th century classroom. Although this study gives us an indication on the d impact of STEM professional development programs on teaching practices of participating educators in Puerto Rico, this is self-reported data. Future research should focus on classroom enactment observations of reported impact. In addition, there is a need to explore which modes of professional development delivery are most effective in increasing teacher content knowledge and teaching practices.

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