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Research Article

The Role of Emotions in Teachers' Professional Development: Attending a Research Experience for Teachers (RET) Program

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The current study investigated teachers' emotions, motivations, and changes to classroom practice as related to their involvement in a 6-week summer professional development (PD) program. Participants ($N = 67$) attended the Research Experience for Teachers (RET) program at a large university in the United States. Overall, study results showed that emotions played an important role in teachers' engagement in the RET program and triggered changes in teachers' thinking and implementation of their science teaching practices. Positive correlations were found among teachers' motivations and emotions about their PD experience, as well as changes to their teaching practices. Interview data provided more depth to understanding participants' views of their RET experiences.

1. Introduction

Professional development (PD) programs provide valuable opportunities to teachers from all grade levels to actively engage in experiences that can help improve their quality of teaching in addition to helping increase students' academic outcomes [1, 2]. Therefore, although PD programs vary to a great extent in terms of format and substance, most share a common goal: to provide or enhance effective teaching practices [3, 4]. As a result, PD programs often focus on changing teachers' practices, usually providing new skills or refining specific skills. With a current focus on students' achievement, PD attempts are explicitly designed to help teachers make specific changes in their classroom behaviour in order to increase student achievement [5, 6].

Recent research in science education has demonstrated that effective PD has a direct impact on teachers' development as well students' development (e.g., [7–9]). These studies also show that teachers who, in particular, participated in inquiry-based PD programs have been shown to effectively increase the quality of their science instruction by implementing practices in ways that are similar to strategies used by scientists in their own research (e.g., asking research questions, formulating hypothesis, conducting repeated observations, and making predictions). However, PD frequently requires teachers to make substantial modifications to their teaching. Consequently, teachers may have strong emotional reactions when their current practices are challenged [10–13]. Teachers may find interest in an educational innovation or conversely may feel incompetence and shame when they have initial difficulty implementing an innovation. Teachers' emotional reactions towards a PD program can impact their motivation to implement strategies learned in the PD they attended [10]. For example, a teacher may feel angry for being asked to provide time and effort to change his/her teaching practices and consequently feel unmotivated to implement the ideas learned during PD. Reciprocally, teachers' motivation can impact their emotions, for example, when teachers feel motivated and excited to try new ideas and then feel pleased as they see students perform positively because their efforts.

Recently, researchers have called for more research on the reciprocal nature of teachers' motivations and emotions that they experienced related to PD [10–12, 14]. In the current study, we investigated teachers' emotions, as related to their motivations and experiences in a mentorship PD program in which teachers worked alongside scientists in a lab for a summer long program. The program Research Experiences for Teachers (RET) was funded through the National Science Foundation (NSF) and has been shown to have an impact on teachers' thinking and teaching of science [15–17].

2. Theoretical Considerations

To investigate teachers' emotions in relationship with their motivation and instructional implementation, we drew upon literature exploring how these concepts relate. Specifically, we used [18, 19] control-value theory (CVT) of educational motivations and emotions, which we described below.

2.1. Teachers' Motivations and Emotions: Control-Value Theory. In CVT, [18, 19] proposed that, within educational settings, one's emotions and motivations are interrelated. In particular, CVT suggests that the specific emotion and motivation that individuals have to perform in academic-related behaviour will depend upon the extent to which they believe they have some amount of *control* and the extent to which they *value* the behaviour (and related outcomes). According to CVT, if teachers perceive they do not have some *control* with respect to the implementation of the PD (e.g., they feel coerced to do so) and/or they do not see some *value* for the innovation, they will experience both negative emotions and low/no motivation to participate. The specific emotions that teachers experience, and their related motivations, will depend on the extent to which they perceive they have control and the extent to which they value the innovation.

The main components of the CVT (see Table 1) describe the types of object focus (i.e., outcome/prospective; outcome/retrospective, and activity), the values associated with outcomes or activities (i.e., positive and negative values), the locus of control (i.e., high, medium, and low), and the type of emotions developed (i.e., positive emotions, such as joy, hope, pride, enjoyment, or negative emotions, such as frustration, anger, sadness, and anxiety).

Research has shown that teachers' emotions, particularly their perceptions of control and value, are related in ways predicted by CVT (e.g., [10, 20]). Additional studies show that teachers and preservice teachers alike, who had perceptions of agency (i.e., control), and who valued an innovation, were more willing to experience vulnerability (an emotional element) to implement reform efforts learned during a new intervention or a PD program [12, 21]. Lasky [12] showed that as teachers gained self-efficacy during the implementation (i.e., they believed they could successfully complete the required behaviours), they valued the reform, and they experienced more positive emotions. Consequently, they were more willing to take risks in implementing changes to their classroom practices. Indeed, teachers were further willing to take risks when they saw the potential positive outcomes (i.e., value) that the reform could provide. In another similar study on reform efforts, Darby [11] found that teachers' feelings of fear were initiated when their professional identities were threatened which triggered perceptions of low control and low value. However, with supportive interactions from coaches and facilitators—in ways that increased their efficacy for performing the required behaviours—teachers were able to change their attitudes more positively toward the reform. When teachers were given opportunities to collaborate (i.e., given control), they were more willing to take on the challenges related to the instructional changes. Consistent with CVT, these cognitive and emotional experiences enhanced teachers' motivation to continue the reform efforts.

2.2. Study Purpose. Research on participants' involvement in an RET or similar programs has suggested that the program greatly influenced teachers' thinking about teaching science and their teaching strategies (i.e., [15, 17, 22–24]. Studies also suggested that participants' choices to implement changes in their teaching practices were related to the novelty of the program (i.e., "interest," an emotion) and how much teachers valued the elements of the program (i.e., [2, 6, 15, 16, 25]).

We embarked on this study to investigate teachers' emotions about their RET program participation, as well as how their emotions were related to motivation for engaging in the RET program and instructional changes. We investigated teachers from different grade levels (i.e., elementary, middle, and secondary) who participated in an RET program. The following research questions guided our study:

(1) What were teachers' reports of their emotions about the RET program, *before* and *after* attending the RET program? Specifically, we investigate the following:

  (a) What differences were reported between teachers from the elementary school level (EE) and middle & secondary school level (MSE)?

  (b) How do participants' responses about their emotions in the RET program varied based on demographic data such as age, gender, ethnicity, and years of teaching experience?

(2) Generally, to what extent were teachers' emotions correlated to their (a) motivation for attending the RET program and (b) changes to their teaching practices?

(3) Overall, how did teachers perceive their RET experiences, in the context of their emotions, motivations, and instructional practices?

3. Methods

3.1. Study Context. The current study investigated the experiences of teachers attending the Research Experiences for Teachers (RET) program. A total of 90 teachers participated in

Table 1: The Control-Value Theory model (from [19]).

Object focus	Appraisals		
	Value	Control	Emotion
Outcome/prospective	Positive (success)	High Medium Low	Anticipatory joy Hope Hopelessness
	Negative (failure)	High Medium Low	Anticipatory relief Anxiety Hopelessness
Outcome/retrospective	Positive (success)	Irrelevant Self Others	Joy Pride Gratitude
	Negative (failure)	Irrelevant Self Others	Sadness Shame Anger
Activity	Positive Negative Positive/negative None	High Low High/low	Enjoyment Anger Frustration Boredom

the RET summer program at the National High Magnetic Field Laboratory (Magnet Lab) in Florida, United States. The duration of the RET program during the summer was of six weeks. These 90 RET attendees were contacted after their attendance and were invited to take part in the current study. Only 67 teachers responded to the study invitation and thus completed the survey.

3.2. Participants

3.2.1. Survey Participants. Of the 90 RET teachers who attended the program, we had complete data on 67. An analysis of participants' ($N = 67$) demographics indicated that females represented 77.6% ($n = 52$) and males represented 22.4% ($n = 15$). Also, most participants were aged 26–30 years (21%, $n = 14$) or over 46 (37%; $n = 25$), and the range of teaching experience varied from one year to over 30 years, with the vast majority of participants (90%, $n = 60$) indicating that they had 1–10 years of experience in the classrooms. With respect to grade levels, 51% of respondents ($n = 35$) indicated they were elementary school teachers (grade level 1–5). Middle school teachers (grade level 6–8) represented 18% ($n = 12$) of the total participants, and secondary school teachers (grade level 9–12) represented 30% ($n = 20$) of the total study participants. Thus, the combined number of middle and secondary school teachers (MSE) represented 49% ($n = 32$) of the total participants. In our comparative analysis by grade level, we compared two groups: elementary level teachers (EE, $n = 35$) and middle &secondary level teachers (MSE, $n = 32$). The decision to combine middle and secondary level teachers (MSE) in one group is grounded theoretically. Middle school and secondary teachers in the United States teach only science and hold a teaching certificate in one subject area (i.e., which is science, in this case); thus, they are specialized in one subject area. Elementary teachers are generalists; they hold a teaching certificate in elementary education (not in one subject area), and teach science in addition to other subjects (i.e., math, literacy, social studies).

3.2.2. Interview Participants. A total of 12 participants (see Appendix A) were selected from the pool of survey respondents to be interviewed via telephone. Interviewees were selected to represent various demographics, such as grade level, gender, and teaching experience. The diversity of demographics represented by interviewees supported the collection of rich qualitative data.

3.3. Procedures. The study was conducted in two phases. First, online surveys were conducted in phase I, and then, telephone interviews were conducted in phase II with selected participants. Quantitative data from the online surveys were analyzed using the SPSS software package, conducting descriptive analysis, frequencies, comparative analysis (ANOVA), and correlational analysis. Qualitative data from the interviews were analyzed using Nvivo software, coding data for major categories and themes. Subsequently, qualitative analysis from two case studies was analyzed more in-depth to provide a better description of individual case study participants' experiences in the program.

3.3.1. Surveys: Phase I. All participants completed an online survey consisting of demographic items and three additional questionnaires investigating participants' (1) *Emotions* about their program experience, (2) *Motivations* for engaging in the RET program, and (3) *Instructional Changes* due to their RET attendance. The *Emotions* instrument is presented in Appendix B, and the *Motivation* survey along with the *Instructional Changes* survey is published in [16].

3.3.2. Interviews: Phase II. A total of 12 survey respondents were interviewed in the second phase of the study about their program experiences. Sample interview questions are presented in Appendix C, and the entire interview protocol can be found in [16]. All interview participants consented to have their interviews recorded. To protect participants' anonymity pseudonyms were assigned to each teacher. The in-depth, semistructured interviews explored teachers' views about their RET experience with respect to their motivations, emotions, and changes to teaching practices related to PD. Two coders developed a coding scheme, first by independently coding sample

interviews, then comparing notes. Once both coders reached complete agreement on the coding scheme interviews were coded.

3.4. Instruments

3.4.1. Emotions Survey. To indicate emotions about their RET program experiences, participants were asked to rate each of the 10 statements describing an emotion they experienced on a six-point Likert-scale (1 = "Not at all;" 6 = "Extremely") with respect to the extent they described a particular emotion (e.g., excited, confident, and disappointed) *before* and *after* their RET program participation. Four subscales measured participants' emotions for attending the RET program, as follows: (1) *Positive emotions before RET* (e.g., excited, inspired, determined, confident, contented); (2) *Negative emotions before RET* (e.g., disappointed, angry, overwhelmed, reluctant); (3) *Positive emotions after RET* (e.g., excited, inspired, determined, confident, contented); and (4) *Negative emotions after RET* (e.g., disappointed, angry, overwhelmed, reluctant). Internal reliability coefficient calculated for the *Emotions* instrument with the study sample was 0.60, and reliability scores obtained for each of the instrument subscale were: *Positive emotions before RET* (alpha value = 0.72); *Negative emotions before RET* (alpha value = 0.60); *Positive emotions after RET* (alpha value = 0.87); and *Negative emotions after RET* (alpha value = 0.56).

3.4.2. Motivation Survey. Participants were asked to rate each of the 10 questionnaire items about their motivation for participating in the RET program. The four-point Likert-scale (1 = "Strongly disagree;" 4 = "Strongly agree") asked participants to indicate specific reasons for attending the RET program (e.g., to gain science knowledge, to gain new teaching ideas) and report changes to their teaching practices (e.g., including more inquiry-based strategies in their teaching, more experiments). Two subscales measured participants' motivation for attending the RET program: (1) *Intrinsic incentives* (e.g., to gain new ideas for my classroom, to keep myself involved in the professional growth) and (2) *Extrinsic incentives* (e.g., to obtain certification/recertification, was mandated by school/district). Internal reliability coefficient calculated for the *Motivation* instrument with the study sample was 0.73, while reliability scores for the two subscales were *Intrinsic incentives* (alpha value = 0.82), and *Extrinsic incentives* (alpha value = 0.75).

3.4.3. Instructional Changes Survey. Participants were asked to rate each item based on a four-point Likert-scale (1 = "Strongly disagree;" 4 = "Strongly agree") to indicate what specific changes to their teaching practices they made due to the RET program experiences. Three subscales measured participants' reported changes to their teaching practices after attending the RET program: (1) *Changes to teaching style* (e.g., adopted a more student-centered approach in teaching); (2) *Changes to class instruction* (e.g., use of more collaborative activities in teaching); and (3) *Changes to science thinking* (e.g., attending other programs to enhance science expertise). Internal reliability coefficient calculated for the *Instructional Changes* instrument with the study sample was 0.95, while reliability scores for the two subscales were *Changes to teaching style* (alpha value = 0.91), *Change to class instruction* (alpha value = 0.93), and *Changes to science thinking* (alpha value = 0.81). Overall, reliability values for all study instruments and their respective subscales demonstrated good internal consistency (see Miller, 1995).

4. Results

4.1. Teachers' Emotions. Our first research question investigated the types of emotions teachers reported that they experienced *before* and *after* attending the RET program. Overall, survey results indicated that *before* their RET program attendance, most participants felt "excited" ($M = 4.61$; SD = 1.1), "inspired" ($M = 4.12$; SD = 1.2), and "determined" ($M = 4.10$; SD = 1.2). Emotions reported by the survey participants indicated that after the RET program involvement, most participants felt "excited" ($M = 5.01$; SD = 1.1), "inspired" ($M = 4.97$; $SD = 1.0$), "confident" ($M = 4.53$; SD = 1.2), and "determined" ($M = 4.37$; SD = 1.3).

Paired samples T-tests were conducted to see if teachers' emotions changed from one time point to another-such as, *before* their participation to *after* their program participation. Results indicated significant differences between emotions reported by all participants before and after their RET participation. Table 2 summarizes overall and comparative results of participants' reported emotions before and after RET attendance.

Significant differences between emotions felt before and after teachers' RET program participation were found with respect to particular reported emotions such as "excited" ($t = -2.99$, $p < 0.005$), "inspired" ($t = -6.15$, $p < 0.001$), "confident" ($t = -4.71$, $p < 0.001$), and "contented" ($t = -3.29$, $p < 0.005$).

Particularly, significant differences were found with respect to EE teachers reported emotions before and after their RET participation regarding how much they were "inspired" ($t = -4.85$, $p = 0.000$), "confident" ($t = -3.51$, $p = 0.001$), and "excited" ($t = -2.26$, $p = 0.030$) about their RET program participation. Significant differences were found for MSE teachers regarding their emotions before and after their RET participation with respect to being "inspired" ($t = -3.82$, $p = 0.001$), "confident" ($t = -3.09$, $p = 0.004$), and "contented" ($t = -2.92$, $p = 0.006$).

Further comparative analysis for EE and MSE teachers showed that emotions reported by the teachers before their RET participation were described as follows. The EE teachers reported their emotions before the RET as "excited" ($M = 4.57$; SD = 1.9), "inspired" ($M = 4.17$; SD = 1.2), and "determined" ($M = 4.03$; SD = 1.3), and the MSE teachers reported emotions they felt before their RET participation were described as "excited" ($M = 4.66$; SD = 1.0), "confident" ($M = 4.22$; SD = 1.2), and "determined" ($M = 4.19$; SD = 1.2).

Table 2: Teachers' reported emotions (before and after RET attendance).

	EE teachers (n = 35)		MSE teachers (n = 32)		Total (N = 67)	
	Emotions *before* RET Mean (SD)	Emotions *after* RET Mean (SD)	Emotions *before* RET Mean (SD)	Emotions *after* RET Mean (SD)	Emotions *before* RET Mean (SD)	Emotions *after* RET Mean (SD)
(1) Excited	4.57 (1.9)	5.00 (1.0)*	4.66 (1.0)	5.03 (1.2)*	4.61 (1.1)	5.01 (1.1)*
(2) Anxious	3.66 (1.4)	2.37 (1.4)	3.13 (1.2)	2.13 (1.4)	3.40 (1.3)	2.25 (1.4)
(3) Inspired	4.17 (1.2)	5.06 (1.0)**	4.06 (1.3)	4.88 (1.1)**	4.12 (1.2)	4.97 (1.0)**
(4) Disappointed	1.14 (0.50)	1.46 (1.0)	1.31 (0.64)	1.34 (0.60)	1.22 (0.57)	1.40 (0.87)
(5) Angry	1.17 (0.51)	1.09 (0.37)	1.13 (4.2)	1.16 (0.62)	1.15 (0.46)	1.12 (0.50)
(6) Overwhelmed	2.17 (1.5)	1.89 (1.1)	1.70 (0.94)	1.66 (0.86)	1.99 (1.06)	1.78 (1.04)
(7) Determined	4.03 (1.3)	4.29 (1.3)	4.19 (1.4)	4.47 (1.3)	4.10 (1.2)	4.37 (1.3)
(8) Reluctant	1.57 (0.91)	1.43 (0.85)	1.38 (0.70)	1.19 (0.47)	1.48 (0.82)	1.31 (0.70)
(9) Confident	3.57 (1.1)	4.37 (1.3)**	4.22 (1.2)	4.91 (1.4)*	3.88 (1.2)	4.63 (1.2)**
(10) Contented	3.86 (1.2)	4.20 (1.4)	3.78 (1.3)	4.47 (1.5)*	3.82 (1.2)	4.33 (1.4)*

Note. $^{*}p < 0.05$, $^{**}p < 0.01$ (paired samples T-test); N = 67.

Also, comparative analysis for the two subgroups showed that emotions reported by the teachers after their RET participation were described by the EE teachers as "excited" ($M = 5.0$; SD = 1.0), "inspired" ($M = 5.06$; SD = 1.0), and "confident" ($M = 4.37$; SD = 1.3), and by the MSE teachers as "exited" ($M = 5.03$; SD = 1.2), "confident" ($M = 4.91$; SD = 1.4), and "inspired" ($M = 4.88$; SD = 1.1).

However, no significant differences were found between emotions reported by the EE and MSE teachers, before and after the RET participation, except "confidence". MSE teachers felt more confident ($M = 4.22$; SD = 1.2) compared to EE teachers ($M = 3.57$; SD = 1.1) *before* the RET program involvement ($p = 0.03$). Such results are in line with most research in the field showing that elementary teachers in general hold less science teaching confidence than their middle and secondary peer teachers (Appleton, 1995; Bryan, 2003). But more interestingly, however, we found no significant difference between emotions reported by the EE ($M = 4.91$; SD = 1.4) and MSE group ($M = 4.37$; SD = 1.3) with respect to confidence, *after* their RET program ($p = 0.08$), which is a surprising result for our study. This finding could lead to the assumption that both EE teachers and MSE teachers from our study felt increased confidence after their RET program attendance, which is encouraging news for teaching research.

Comparative analysis (one-way ANOVA procedures) showed no significant differences with respect to emotions (i.e., *before* and *after* their RET program attendance) and participants' demographic data such as age, gender, ethnicity, years of teaching experience, and which year/session they attended the RET program. This finding can suggest that factors external to the emotional component (i.e., demographics) are not related to teachers' changes in emotions, nor affected their emotions about their PD program attendance.

4.2. Teachers' Emotions, Motivation, and Changes to Practices. To answer our second research question, we investigated whether or not teachers' reported emotions (both before and after RET) were associated with their (a) motivation for attending the RET program, and (b) changes to their teaching practices. Results from correlational analysis are presented in Table 3.

4.2.1. Before RET Attendance. Significant differences were found between teachers' ratings of positive emotions *before* RET and their ratings for intrinsic motivation for attending the RET ($r = 0.263$, $p < 0.05$), which could suggest that teachers who felt positive emotions before their RET participation (e.g., excited, inspired, determined) had intrinsic reasons for participating in the RET program (e.g., wanted to gain new ideas for teaching, or keep involved in the professional growth). On the other hand, teachers' ratings of negative emotions *before* their RET participation were positively correlated to ratings of extrinsic motivation ($r = 0.247$, $p < 0.05$), possibly suggesting that teachers who were felt negative emotions about their RET engagement (e.g., overwhelmed, anxious) attended the program for extrinsic incentives (e.g., to obtain certification/recertification, or was mandated by school/district).

4.2.2. After RET Attendance. Furthermore, teachers' positive emotions *after* attending RET were positively related to changes to their (1) teaching style ($r = 0.434$, $p < 0.01$), (2) instructional strategies ($r = 0.371$, $p < 0.01$), and (3) science activities ($r = 0.438$, $p < 0.01$). This suggests that teachers who felt positive emotions before the RET program made changes to their teaching practices after the RET program in areas such as teaching style and instructional strategies, as well as the types of science activities used in the classroom.

Interesting findings were revealed regarding correlations between positive emotions of teachers before and after their RET participation and/or negative emotions of teachers before and after their RET participation. Positive correlations were found between teachers' reports of positive emotions (e.g., excited, inspired) before and after their RET participation ($r = 0.570$, $p < 0.01$), suggesting that those teachers who reported positive emotions about their RET participation before the program involvement

Table 3: Correlations among major study variables.

		1	2	3	4	5	6	7	8	9
1	Intrinsic motivation for RET	1	0.64	0.27*	0.30*	0.25*	0.26*	0.05	0.19	−0.52
2	Extrinsic motivation for RET		1	−0.24*	−0.20	−0.15	−0.12	−0.24*	0.16	0.25
3	Changes to teaching style			1	0.84*	0.87*	0.19	0.10	0.43*	−0.12
4	Changes to class instruction				1	0.82*	0.19	0.15	0.37*	−0.12
5	Changes to science thinking					1	0.23	0.07	0.43*	−0.21
6	Positive emotions before RET						1	−0.19	0.57**	−0.30*
7	Negative emotions before RET							1	−0.12	0.54*
8	Positive emotions after RET								1	−0.40**
9	Negative emotions after RET									1

Note. * $p < 0.05$, ** $p < 0.01$ (2-tailed); $N = 67$.

(e.g., being excited, inspired to participate in the RET program) also reported positive emotions about their RET experiences after the program participation as well. Likewise, teachers' ratings of negative emotions before their RET participation were positively correlated to ratings of negative emotions after their RET participation ($r = 0.548$, $p < 0.01$), suggesting that negative emotions (e.g., overwhelmed, anxious) reported before the RET by teachers were persistently reported by these teachers after the program participation as well.

4.3. Teachers' Perceptions of Their Emotional Experiences. To answer our third research question, we drew upon results from participants' interviews to investigate and explored how teachers' emotions were related to their RET experiences. First, we describe general themes from the interviews reflecting all participants' views, followed by two case study illustrations, each case from a different grade level to describe similarities, but differences as well in teachers' perceived program experiences and emotions.

4.4. General Themes. Across participants' interviews, three interrelated key themes (Appendix D) appeared to be common to all participants and were labeled as (1) *Positive emotions*, (2) *Negative Emotions*, and (3) *Social values*.

4.4.1. Positive Emotions. Participants' generally expressed positive views about their overall experiences in the summer PD program and positive emotions associated with their experiences. When talking about their emotions *before* starting the program, the general feeling mentioned by the majority of participants was 'excitement'. Teachers were excited about the opportunity to work with a scientist in a lab and to be able to learn research science by conducting themselves a research project. When participants talked about their emotions as related to program attendance, *after* the program (postprogram), most described feelings of satisfaction, excitement, and confidence. Participants generally felt confident that they can teach science better after attending the RET program and after learning about science research. Also, they felt a high degree of satisfaction that they were able to complete successfully this challenging program and are able to take back to classroom valuable experiences.

4.4.2. Negative Emotions. When describing negative emotions, all participants mentioned that they experienced negative emotions mainly *before* the program, prior to starting the RET program. Only one negative emotion—feeling 'overwhelmed'—was mentioned by some participants in reference to their PD experiences, in their postprogram interview. Being overwhelmed was in fact an almost constant state during their PD program attendance, because the program was challenging due to its complex content and structure and because participants realized how much is out there and they still lack a great deal of science knowledge. When talking about negative emotions *before* the RET program, participants reflected on their general state of anxiety about the program's expectations. The majority of participants did not have similar professional development experiences; hence, their engagement in a summer long PD program with scientists as their mentors was a perceived as a challenge, especially for the elementary teachers since they do not have such a rigorous and strong science preparation as their peer teachers from middle and high-school grade levels. Most elementary teachers used strong words to describe their negative emotions *before* the start of their PD program, such as 'scared', 'overwhelmed', 'intimidated', and 'lack of confidence'.

4.4.3. Social Values. One emerging theme related to emotions was about participants' social values. In their interviews, all participants felt a sense of belonging and satisfaction due to the fact that they were provided with opportunities to network. This made their program experiences more engaging and elicited positive feelings about the program and their learning. Teachers were provided with opportunities for networking, both inside and outside the program. By engaging participants during the program in collaborative activities with peer teachers and allowing them to work in pairs in a research project, allowed them to develop strong connections with all program peers. And consequently, after the program ended, teachers continued to communicate and collaborate with their former peers, but moreover, the program created avenues for teachers to engage with other teachers outside the program, by

providing opportunities to engage in professional events in science teaching organizations, at their host schools, or school district level professional events.

4.5. Case Study Illustrations. Further, in addition to general themes from the interviews, we present two case studies, namely, one from the elementary group (EE) and one from middle &secondary group (MSE). Nina (from the EE group) and John (from the MSE group) are illustrative stories, chosen in the current study for the purpose to exemplify how RET experiences were influential in different individual cases. Nina, an elementary school teacher, recalls mainly negative emotions about her RET experiences, while John, a middle school teacher, recalls mainly positive emotions about his RET involvement.

4.6. Elementary School Teacher Case Report: Nina. Nina was a 5th grade teacher at the time she attended the RET program. She illustrates the desire to learn science with a scientist in the lab—a very new experience to her, but felt negative emotions about such experience. She described her RET experiences as connected to negative emotions, like lack of confidence and how negative emotions played an important role in her learning. In her interview, Nina stated that she wanted to attend the RET program so she would to be able to learn new things that would allow her to take back to classroom something valuable, such as the knowledge and skills learned in the program. However, learning new knowledge and skills would come to a certain cost for her; the program expectations and expertise level were overwhelming for her. As she explained,

> I knew I'm going to learn a lot of science, get experience working with scientists, you guys told us what we would do; it was going to be fun, take all these back to our classrooms. I wasn't expecting how hard it was at that time, and the scientist level was so way out there. There was no pity on us.

Nina was one of the teachers who greatly emphasized her desire to learn (from the scientists and her peers) and saw herself as a life-long learner. Her description of emotions about the program involvement is extremely powerful. The intensity of the emotions and the range of emotions and behaviours she experienced show how new learning environments can be intimidating for individuals. She felt 'very scared', afraid that she'll never 'get it', and cried for the first week:

> In the beginning of the [RET] program, it was very scary, very scary; it was way, way over my head, and I think that's because the M. Lab, had that program the first time. I was among the first ones... I cried, I think for the first week or so and I thought, 'O my God, what are they talking about? 'I don't understand a thing. . .. I thought, 'I will never, ever get it.' My partner and I did a lot of research on our own, we would look up online about M. Lab, and just magnets and magnets, and that was very helpful. So, I learned a great deal.

Despite the fact that she experienced negative emotions before and during her RET involvement (i.e., anxiety, fear, low confidence), she placed a high value on her learning. After the RET attendance, she felt positive emotions (i.e., joy) that she was able to have the opportunity to learn and challenge herself to a higher level. The positive values she associated with her learning allowed her to make changes in her classroom after the RET attendance. In her interview, talking about the types of changes in teaching practices, Nina described that she was trying to use the same approach in her teaching science to elementary students as she witnessed in the lab. Also, Nina mentioned that as a result of her RET experiences, she incorporated more research into her teaching, used more technology in class, and included more interactive activities (hands-on) and journal writings (similar to the RET daily program activities for teachers).

> I tend to come back to how scientists do it at the M. Lab. I do take a lot of the things I saw, heard, experienced there; make sure kids know more; I give it back to them. I definitely try to research more, use technology more. I incorporate hands-on a lot, do hands-on, the book gives us some ideas, but I try to do more. There's also a "journal in" that I learned at the M. Lab, they're doing it at the Brogan museum. I try to encourage my kids to keep their journal as much as possible.

4.7. Middle School Teacher Case Report: John. John, a middle school teacher, taught science to 6th and 7th grade students at the time he attended the RET program. Dan illustrates the case of teachers who felt mostly positive emotions before RET and made significant changes in their professional advancement due to PD involvement. John mentioned in his interview that he felt confident about science teaching before and after the RET program, and as a result, he became involved in other professional development programs making major progress in his professional growth. His primary reasons for attending the RET program were the desire to stay engaged in his professional growth, to gain more content knowledge, and mainly to work with a scientist in an authentic laboratory setting. He explained,

> In terms of summer opportunities, it looked like the most interesting one, worthwhile. The other ones seemed just a one [or] two-day workshop. I was always interested in interacting with scientists as opposed to programs that were run by people who weren't educators, or who weren't scientists. I don't know what they were. . .. But it just seemed to be a science [education]-type program. They would tell people how to teach, but yet, they weren't teachers themselves. . .this seemed to be not valid to me but [the RET] was more authentic.

One of the most valuable experiences for John (and for most MSE teachers) in the RET program was the fact that he learned science in a laboratory, an authentic setting, side-

by-side with a scientist. The professional growth and the unique experience of being able to work in a laboratory with a scientist, was expressed by John in his interview as follows:

> [The] most valuable [experience to me], honestly was the professional growth since I've been involved in it. After 2 years of RET, I started to feel like [I was] heading in a different direction, doing something a little more unique, and I liked it. I started to become more involved in PD, helping in curriculum writing . . . I coordinated some workshops being delivered. I become more involved in teaching, not just classroom [teaching] but networking with other people and doing more than just teaching.

Emotions expressed by John were mainly positive about his overall RET experiences, reporting feeling confidence before and after the RET program, having feelings of professional fulfillment, and feeling inspired by the program. As a result of his RET experience, after attending the program, John continued to stay connected with the lab's educational programs and got involved in various other science projects. He explained,

> It's hard for me to isolate the RET experience by itself, I did it for two years, but then I've been involved with [the] Lab for 5-6 years, so for me it's all wrapped up—professional growth, fulfillment, and professional satisfactions. . .These feelings probably pertain to '[after] my RET involvement' versus comparing to 'in my RET involvement.' To me it has been a great experience and provided me with a lot of opportunities that I didn't have before. I definitely feel like a more accomplished teacher now than I was before the RET—that's for sure.

In fact, an extremely valuable experience for John when talking about his RET participation was the association of his RET experience with positive emotions (i.e., satisfaction, inspiration). Positive values associated by John to his RET attendance were as well his engagements in other PD opportunities and networking. The positive emotions and values associated with his RET experience brought changes not just at a microlevel (i.e., science classroom teaching), but at a macrolevel, such as expending his professional network and professional leadership engagement:

> I was excited about this program because several opportunities that have come up since the RET program are related to my RET involvement. A couple of years after [the RET], I helped and have done some work with several people out of the M. Lab to put together this workshop that was delivered in San Francisco. And then, through that workshop, I met some people who applied and ended up being one of the four teachers in the US funded to go to a similar type of workshop in Vienna, Austria. And then through that workshop, I met other people, other opportunities that have become available.

5. Discussion

Our study findings generally suggest that RET participants' experiences in the program and changes they made after the program attendance to their teaching practices were greatly influenced by the types of emotions and motives associated with their RET program involvement. Our study results suggest that teachers' emotions and values about their RET experiences greatly influenced their learning of new knowledge and triggered positive changes in their classroom teaching.

Quantitative results indicated interesting results about confidence related to the two groups of teachers (EE and MSE). The MSE teachers felt significantly more confident before the RET program compared to EE teachers. No significant differences between MSE teachers and EE teachers in their confidence were reported after the RET, possibly suggesting that they equally felt confident after the RET program attendance. Teachers' gains in science knowledge triggered positive emotions and later fostered changes in their teaching practices. Inspecting the mean score results showed that EE teachers increased their confidence to the level of the MSE teachers. Such findings are affirming for science teacher PD programs and encourage the inclusion of EE teachers in the RET and RET-like programs which commonly attract more middle and secondary teachers due to high science expertise these programs request. Research in the field shows that many elementary teachers held negative attitudes toward science because they lack science knowledge and confidence [26].

Moreover, quantitative analysis demonstrated that teachers' reports of positive emotions about the RET program, such as feeling excited and inspired, were correlated to changes in their teaching practices. Changes made by all teachers were related to their thinking about science teaching along with changes to their science instructional strategies. Therefore, what participants felt about the program, especially the novelty of the program, along with how much they valued the novelty of the RET program elements, may indicate to which extent teachers made changes to their teaching practice.

Positive emotions such as "excited", "inspired", and "determined" were reported to be the most experienced emotions by all participants before and after their RET involvement. This suggests that (1) teachers had high expectations going into their science-immersion experiences, (2) their expectations were met, and (3) they were looking forward to using the information they had gained. Also, significant increases in teachers' reported positive emotions before and after RET participation such as feeling more "inspired", "confident," and "excited", suggested that the science-immersion program increased their knowledge in perhaps profound ways and increased their efficacy to include science-immersion experiences for their students, and they were enthusiastic about implementing their new-found learning.

Qualitative data from the interviews revealed the role of emotions in teachers' professional development and impact on their PD experiences. Further, the two case study illustrations showed more in-depth how emotions are connected to motivations and outcome activity (i.e., changes to teaching practices). In line with CVT, participants articulated how

Table 4

Pseudonym	Gender	Grade level experience	Grade level teaching experience	Years of teaching experience
Nina	F	Elementary school	5th	8
Daniel	M	High school	$9–12^{th}$	4
Alex	F	Middle school	7th	12
Kelly	F	Elementary and middle school	4th, 5th and 6th	5
Michelle	F	Elementary and middle school	5th, 6th, 7th and 8th	20
John	M	Middle school	6 and 7th	7
Joe	M	Elementary school	4th and 5th	Over 15
Bob	M	High school	$9–12^{th}$	21
Kevin	M	High school	$9–12^{th}$	Over 10
Martin	M	High school	$9–12^{th}$	6
Finn	M	Middle school	8th	12
Maria	F	Middle school	6th	2

positive values they associated with their RET attendance were associated with positive outcomes of their RET involvement (i.e., changes). While John's story illustrates how positive emotions can impact values and outcome activity, Nina's story shows that negative emotions can be a catalyst to positive values and positive outcomes as well. The qualitative data from Nina's case reveled how negative emotions (i.e., frustration, anxiety) played a significant role in motivating her (and similarly, other EE teachers) to overcome her lack of science knowledge, and tenaciously pursue learning. Nina's case study is an illustration of how negative emotions can be a catalyst for change and can lead to positive emotions at the end of the RET program, as well as positive outcomes (i.e., instructional changes in classroom). Negative emotions experienced in the beginning of the RET program amplified Nina's motivation for learning the science content and, by the end of the program, these achievements triggered positive emotions (satisfaction, confidence) and ultimately lead to changes in teaching practices. This is extremely important to become aware of and acknowledge for science education in general and for the PD program trainers. The power and intensity of the negative emotions can be responsible for increasing individuals' motivation to learn and succeed in a program if they have support for their learning. In the long run, participants' negative emotions (such as fear, anxiety) can develop into positive emotions and finally into positive outcomes.

One of the major findings of the study supported by the qualitative data was that the RET program prompted participants' positive values about PD involvement and therefore supported positive changes. Nina's descriptions of changes revolved around how she made instructional changes due to her RET experiences, and John's descriptions of changes revolved around professional growth (i.e., taking leadership in his field) due to his RET involvement. Both, Nina and John suggested that the RET program experience in the laboratory working with a scientist was extremely valuable in support of their own pedagogy and contributed to their change in thinking about science teaching. This may be due to the value of authentic PD experiences as well as the use of research-based PD strategies and techniques which allowed participants to model not just practices used in the lab by the scientist, but also attitudes toward science [1, 27]. Such improvement in teachers' changes to their thinking about science and attitudes to science could be attributed to the duration of the RET program, one of the extremely valuable features of the program. Being involved in an authentic learning environment for a sustained duration allowed teachers to learn and process the new information (i.e., science knowledge, procedures, and relationships) in various ways and make more solid connections to their practices when applied in classroom teaching later. Previous research has shown that longer PD is more effective and results in more in-depth changes to teachers' thinking, planning, and delivering instruction compared to short-term PD of just a few days, which is commonly developed for teachers due to lack of time and resources [2, 6, 15, 16, 27]. Contributions from this study may be considered therefore for teacher education programs and PD programs regarding the role of motivations, emotional involvement, (positive and negative emotions) and changes to teaching practices as related to improving the quality of teaching and consequently student achievement (e.g., [14, 16, 28, 29].

5.1. Limitations and Future Research. Limitations of this study can be due to several factors, such as (1) the relatively small number of participants ($N = 67$), and (2) retrospective accounts of participants. As we explained in the Methods section, the total number of the RET attendees over the seven-year period was in fact relatively small (90 teachers), and thus, had an impact on the size of the study participants ($N = 67$). With respect to retrospective accounts, we consider this as one of the major study limitations. Participants' retrospective accounts could possibly alter their memory of events and feelings and could result in inaccurate reconstructions of their RET experiences. Future research can address these limitations and expand our understanding of the blend of various psychological constructs in a PD program. Findings from this study may lead to further research investigating cultural aspects of such constructs especially in long-term PD programs. Comparative cross-nation or international RET-like programs could investigate cultural aspects of emotions, motivations, and cognition in different contexts. This is of a great importance,

Table 5: Emotions BEFORE attending the program.

1	Excited	0	1	2	3	4	5
2	Anxious	0	1	2	3	4	5
3	Inspired	0	1	2	3	4	5
4	Disappointed	0	1	2	3	4	5
5	Angry	0	1	2	3	4	5
6	Overwhelmed	0	1	2	3	4	5
7	Determined	0	1	2	3	4	5
8	Reluctant	0	1	2	3	4	5
9	Confident	0	1	2	3	4	5
10	Content	0	1	2	3	4	5

0 = Not at all, 1 = a little bit, 2 = Somewhat, 3 = Quite a bit, 4 = Very much, 5 = Extremely.

Table 6: Emotions AFTER attending the program.

1	Excited	0	1	2	3	4	5
2	Anxious	0	1	2	3	4	5
3	Inspired	0	1	2	3	4	5
4	Disappointed	0	1	2	3	4	5
5	Angry	0	1	2	3	4	5
6	Overwhelmed	0	1	2	3	4	5
7	Determined	0	1	2	3	4	5
8	Reluctant	0	1	2	3	4	5
9	Confident	0	1	2	3	4	5
10	Content	0	1	2	3	4	5

0 = Not at all, 1 = a little bit, 2 = Somewhat, 3 = Quite a bit, 4 = Very much, 5 = Extremely.

Table 7

Theme	Categories	Description
(1) Positive Emotions	(a) Positive Emotions *before* RET	(i) Excited (ex. To learn more in their field, gained specialized science knowledge)
	(b) Positive Emotions *after* RET	(ii) Satisfaction and excited (ex. To have an authentic lab experience and learn research science by working alongside a scientist) (iii) Confident and determined (ex. To bring back to their students and to classroom teaching their newly gained research science knowledge and skills)
(2) Negative Emotions	(a) Negative Emotions *before* RET	(i) Scared, overwhelmed, intimidated, lack of confidence (ex. Not having any similar prior experience to this and not knowing the expectations)
	(b) Negative Emotions *after* RET	(ii) Overwhelmed (ex. To learn a lot, to know that there is more out there)
(3) Social values	(a) Networking inside the PD program	(i) Opportunities provided by the program to network and collaborate with teachers from different schools but enrolled in the same PD program
	(a) Networking outside the PD program	(ii) Opportunities provided via the PD program to continue networking and collaborate with other teachers in professional organizations

considering the scarcity of research in this field, especially comparative studies (e.g., cross-national or international RET-like programs) for teachers of all grade levels.

Appendix

A. Interview Participants' Profiles

The profiles of the interview participants are given in Table 4.

B. Emotions Survey

Table 5 provides a set of items that ask about your *Emotions* related to your RET program attendance. Please rate each emotion-word below by marking the appropriate rating indicating the extent to which you felt that emotion BEFORE attending the RET program.

Table 6 provides a set of items that ask about your *Emotions* related to your RET program attendance. Please

rate each emotion-word below by marking the appropriate rating indicating the extent to which you felt that emotion AFTER attending the RET program.

C. Sample Questions Interview Protocol

(1) Please tell me a little bit about yourself, about your teaching.

(2) You were one of the RET participants. Can you please talk a little bit about your RET experience?

(3) What do you consider to be the most valuable about your participation in the RET program?

(4) Please describe what changes in your teaching practices you made after attending the RET program.

(5) What kind of emotions do you associate with your RET experience?

(6) How do you feel (what emotions you have) about your RET attendance?

D. Major Categories and Themes

The major categories and themes are given in Table 7.

Data Availability

The SPSS data file used to support the findings of this study has not been made available because of confidentiality reasons. For any questions, please contact the corresponding author.

Disclosure

The results and conclusions reported here are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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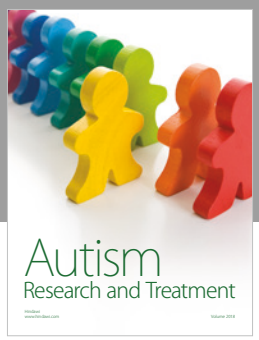

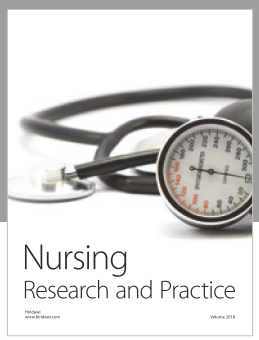

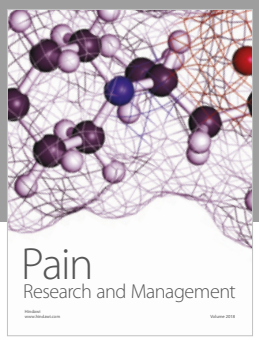

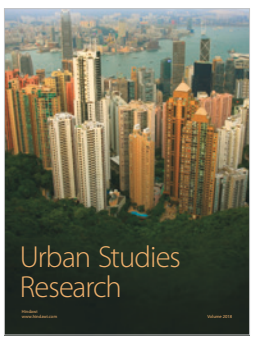

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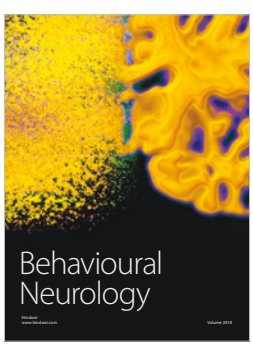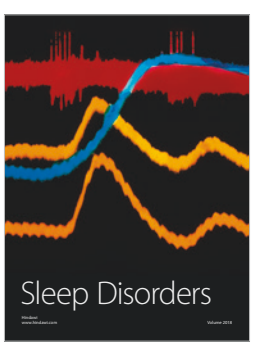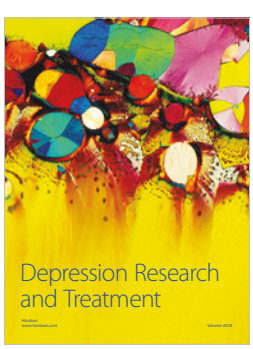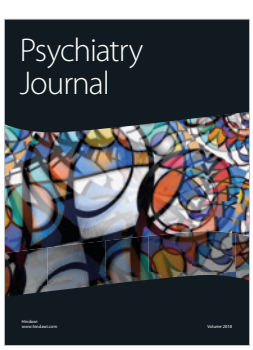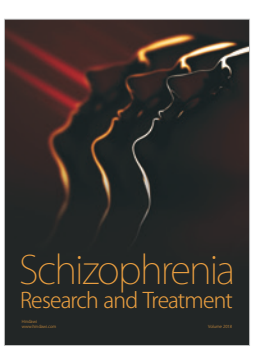
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