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Practice change in environmental education: lessons from professional development

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ABSTRACT

The field of environmental education (EE) strives to develop innovative practices to address emergent issues such as equity, climate change, and urbanization. Through facilitating workshops and ongoing networks for the exchange of ideas, professional development programs may foster innovation or practice change among environmental educators. This study investigates change in practice among environmental educators who participated in one of three online and face-to-face professional development programs. Drawing from practice theory, we measured elements of EE practice including goals, audiences, settings, activities, resources, and ideas. The results showed that across all three programs participants incorporated new resources and ideas into their practices whereas changes in other practice elements varied among programs. Participants in all three programs produced eBooks or ongoing networks that can be used as indicators of practice innovation. This study suggests that practice theory can be used to inform studies of professional development outcomes and examine EE practice, but that practice innovations may be more readily measured at the group rather than individual level.

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Introduction

Educators need to constantly update their knowledge and practice to address the emergence of unforeseen environmental and social problems (Lum 2014). Nearly, 30 years ago, UNESCO (1990) identified the preparation of environmentally literate teachers as a top priority for improving environmental education (EE). Since then, the United States Environmental Protection Agency (EPA), the North American Association for Environmental Education, national programs like Project Learning Tree, and numerous universities, zoos, botanic gardens, and other actors have developed professional development programs for environmental educators. Given the wealth of professional development programs in the United States and elsewhere, understanding their outcomes is important.

Research on the outcomes of EE professional development programs has focused on educators' confidence, knowledge, and skills acquisition (Dyment et al. 2014); [AQ3] environmental attitudes and behavior (Yavetz, Goldman, and Pe'er 2014); self-efficacy and outcome expectancy (Moseley, Huss, and Utley 2010); and intent to change teaching practice (McConnell and Monroe 2012). Although several authors have focused on teaching practice per se (Bainer, Cantrell, and

Barron 2000; O'Donoghue and Russo 2004; Paul and Volk 2002), the question remains of how to rigorously define change in practice as a result of EE professional development.

Practice theory, which focuses on how professional, consumer, and other practices emerge, evolve, and sustain themselves (Reckwitz 2002; Schatzki 2001), provides a framework to examine EE practice. Research has applied practice theory to conceptualize professional learning in industry (Reich, Rooney, and Boud 2015), teaching (Lampert 2012), and stewardship practice (Krasny et al. 2015). Kemmis and Mutton (2012) applied practice theory to understand EE programs using cultural, discursive, social, and material dimensions of practice but did not examine change in professional practice as a result of professional development.

In this study, we draw on practice theory to define six practice elements (e.g. goals, audiences, settings, activities, resources, and ideas) to assess practice innovation as an outcome of EE professional development. We trace changes in these practice elements among environmental educators participating in three professional development programs varying in their emphasis on online and face-to-face experiences. All three programs incorporated a strong focus on social networking or peer-peer learning, consistent with the notion that sharing resources and ideas will lead to innovations in educational practice. Our specific research question is: How did environmental educators change their EE practice as a result of participating in professional development programs? In addition to furthering understanding of the impact of professional development on practice change in EE, by applying practice theory and defining practice elements, this study provides insights into means for assessing professional development programs.

Literature review

Professional development

Different conceptual models have been used to understand and assess teachers' professional development programs. For example, Bell and Gilbert (1996) viewed teacher development as encompassing personal, social, and professional dimensions that include trying out new activities, developing new ideas and practices, and continuing to develop new activities. Guskey's (2000) model for evaluating professional development of K-12 teachers includes five levels: participant reaction to the training, participant learning, organizational support and learning, participant use of new knowledge and skills, and student learning outcomes. Our focus on educators' practice change through professional development activities reflects the fourth level of Guskey's (2000) model: participants' use of new knowledge and skills in practice.

Professional development in EE is particularly challenging due to the field's interdisciplinary nature, which requires the synthesis of science content, social context, and pedagogical strategies (McDonald and Dominguez 2010). Robottom (1987) proposed five principles for teacher preparation in EE: participatory and practice-based, inquiry-based, involving ideological critique, community-based, and collaborative. Wilke, Peyton, and Hungerford (1987) identified EE competencies including knowledge of environmental issues and concepts, and the ability to infuse EE into multiple disciplines, develop new EE curricula, utilize effective instructional methodologies, and evaluate outcomes. On top of these competence-related elements, few universities offer comprehensive EE coursework and thus preservice teachers have limited access to EE content or teaching methods (McKeown-Ice 2000) or are forced to learn through science or social studies education methods rather than through an interdisciplinary approach (Plevyak et al. 2001). Further, EE is considered by school systems as supplemental to a wide range of school subjects, which makes it hard to garner schools' interest in providing ongoing EE professional development (McDonald and Dominguez 2010).

Studies of professional development in EE have focused on educator confidence and knowledge and skills acquisition. For example, Dymont et al. (2014) found significant positive changes in knowledge, understanding, and confidence among early childhood environmental educators,

whereas George et al. (2009) found that a climate change course helped educators improve their skills and confidence related to developing new climate change courses or incorporating climate in existing courses. Tal (2010) found preservice teachers increased their environmental knowledge and awareness, but not their behaviors, as a result of an introductory EE course.

In addition to helping educators acquire knowledge and skills, professional development can encourage the exchange of ideas and resources among educators who share diverse perspectives, which may lead to the emergence of innovative practices (Biggs, Westley, and Carpenter 2010; O'Donoghue and Russo 2004). Such interactions and collaborations also contribute to educators' social development (Bell and Gilbert 1996) through enabling teachers to develop social relations that support and sustain learning (Chalmers and Keown 2006; Goodyear et al. 2004; Lieberman 2000; Stoll et al. 2006). Further, interactions provide opportunities for feedback that facilitate reflection on one's teaching practice (Akerson, Cullen, and Hanson 2009). Studies also show that interactions can positively impact teaching practice (Grossman, Wineburg, and Woolworth 2001; Vescio, Ross, and Adams 2008) including when nonformal educators partner with school teachers (Bainer, Cantrell, and Barron 2000). Other studies have found that teachers and informal educators adapted or intended to adapt EE curricula and activities that they learned from face-to-face and online professional development programs into their classrooms or youth club programs (McConnell and Monroe 2012; Paul and Volk 2002; Sondergeld, Milner, and Rop 2014). In short, these studies examined practice in general or some components of practice, but none of them have comprehensively investigated individual elements of practice in EE.

Practice theory

Practice theory views professional learning as going beyond knowledge acquisition to encompass change in teaching practice. Professional learning is situated in practices (Boud and Hager 2012; Gherardi 2000) that include social, material, embodied, and other elements (Reich, Rooney, and Boud 2015). By analyzing the practice itself, this socio-cultural theory offers a middle ground between frameworks that emphasize individual agency and those focusing on institutional structures (Reckwitz 2002).

According to (Schatzki 2012, p.13), 'A practice is a social phenomenon in the sense that it embraces multiple people. The activities that compose it, moreover, are organized.' (Reckwitz 2002, p.249) further defined a practice as 'a routinized type of behavior which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, "things" and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge.'

Practice theory has been used in research on organizations (Brown and Duguid 2001; Feldman and Orlikowski 2011; Lounsbury and Crumley 2007; Nicolini, Gherardi, and Yanow 2003), consumer behaviors (Gram-Hanssen 2010; Halkier, Katz-Gerro, and Martens 2011; Warde 2005), environmental behaviors (Hargreaves 2011), outdoor recreation (Pantzar and Shove 2010), and civic ecology practices (Krasny et al. 2015). Additionally, the theory has been applied to studies of professional development in engineering (Reich, Rooney, and Boud 2015; Rooney et al. 2012), human relations (Chudzikowski and Mayrhofer 2011), leadership (Bjørkeng, Clegg, and Pitsis 2009; Carroll, Levy, and Richmond 2008), and policing and medicine (Lindberg and Rantatalo 2014). Most studies focus on the interaction of different practice elements, such as body, mind, material objects, knowledge, discourse, structure/process, and the agent (Reckwitz 2002); materials, meanings, and competencies (Shove and Pantzar 2005); or interactions among understanding, procedures, and engagement (Warde 2005). Higginson et al. (2015) applied social network analysis to visualize and interpret the relationships of practice elements. Although studies have invoked practice theory as a framework for studying teacher professional development (Bacevich 2010; Ball and Cohen 1999; Lampert 2012), they have not specifically mentioned how

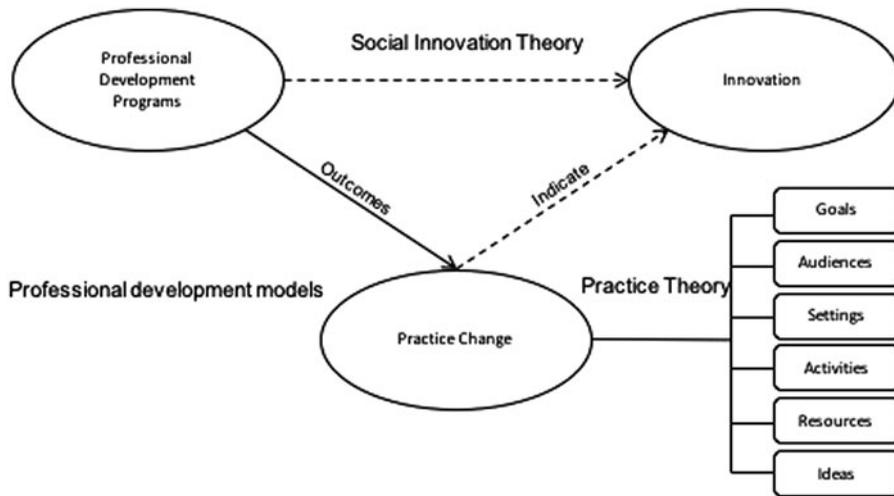


Figure 1 Professional development and practice change framework.

practice theory can help define practice elements or discussed their results within the context of practice theory.

In addition to understanding practice change, practice theory has been used to understand educational and other social innovations that do not lead to quantifiable outcomes like number of patents (Seyfang and Smith 2007; Shove and Pantzar 2005). As an ongoing and often incremental improvement to existing ideas, products, or processes (McKeown 2008), practice innovation can occur through integrating new elements into existing practice or new combinations of existing symbolic (meanings, competences) and material elements (Pantzar and Shove 2010). In addition to studying individual-level practice innovation, researchers have explored how group-level innovation occurs through developing networks and exchanging ideas (Seyfang and Haxeltine 2012).

Integrating literature on practice theory, social innovation theory, and EE program design, we define practice innovation in EE as a process whereby educators and organizations add new elements (goals, audiences, settings, activities, ideas and resources) to their EE practice. To understand how innovation emerges from professional development programs, we measure changes in these elements following professional development programs (Figure 1). Relative to broader elements used in much practice theory research, the elements in this study are applied and more easily measured, and reflect characteristics of EE practice. For example, the element program *goals* is an EE characteristic examined in formal school settings (Eames, Cowie, and Bolstad 2008), whereas the elements *audiences* and *settings* correspond to program relevance and outdoor context (Hogan 2002; Simmons 1998; Sondergeld, Milner, and Rop 2014). The element *activities* includes investigation, hands-on observation and discovery, cooperative learning, and play-based learning (Stern, Powell, and Hill 2013). The element *resources* can include material, human, and social aspects (Ashmann and Franzen 2015), whereas the element *ideas* reflects constructivist learning approaches whereby environmental educators adapt or intend to adapt ideas learned from an online professional development course into their practice (Li, Krasny, and Russ 2014).

Methodology and methods

We used a mixed methods research approach (Creswell 2013) to measure change in practice elements among environmental educators in three professional development interventions. We conducted pre-post (two programs) and retrospective (one program) surveys including Likert-scale,

checkbox, and open-ended questions to determine any changes in environmental educators' goals, audiences, settings, educational activities, and use of resources and ideas, and conducted semi-structured interviews and analyzed participants' project reports to gain a deeper understanding of practice change (cf. Bogdan and Biklen 2007; Denzin and Lincoln 2005).

Professional development programs and participants

The three programs that are the focus of (Marianne et al. 2017) this study were carried out as part of the five-year, Expanding Capacity in EE (EECapacity) professional development program conducted in the United States, Canada, and Mexico. In addition to continuing traditional US professional development activities (e.g. Guidelines for Excellence trainings), EECapacity used a social innovation approach to expanding ethnic and practice diversity in EE. In particular, the program sought to create platforms for the exchange of ideas and resources among EE professionals and professionals working in youth development who use EE activities to build youth assets (Marianne et al. 2017). The goal of these exchange platforms, and of the professional development activities described below, was to enable innovative practices to emerge that would expand diversity in EE by drawing from participant expertise in EE and in youth development in urban, ethnically diverse neighborhoods. In short, the program was based on social innovation theory, which suggests that innovations in educational practice will emerge by creating platforms for exchanging ideas and resources among professionals holding different perspectives and practices (Biggs, Westley, and Carpenter 2010; Mulgan et al. 2007).

The three professional development programs used a combination of online and face-to-face workshops, research-based resources, and ongoing interactions among a diverse group of EE, youth development, and related professionals to foster idea exchange and EE practice innovation. Below we describe each of the three programs.

Pennsylvania State Consortium (PASC). From March 2014 to December 2014, PASC conducted face-to-face workshops, monthly webinars, and Facebook discussions for 27 educators and youth development professionals (21 females and 6 males) from nature centers, state agencies, schools, parks, youth development organizations, professional associations, and other organizations in Pennsylvania. Two co-leaders, one from EE and the other from youth development, co-wrote a grant for EECapacity to fund their professional development activities and recruited three additional leadership team members and 22 consortium members. PASC's goal was to expand statewide EE leadership to include youth development professionals. PASC members did not have structured assignments or collaborative projects. PASC co-leaders and participants were treated similarly in the surveys and interviews.

Urban Environmental Education Project-based Online Learning Community (PLC). From April 2014 to December 2014, PLC members used online resources, webinars, and a Facebook group to gain capacity in urban EE. Of 94 environmental educators and community leaders initially registered, 43 (32 females and 11 males) worked in small groups to write chapters for an urban EE book that was published online (Russ 2015). Participants worked in urban K-12 schools, after-school programs, community and youth development organizations, faith-based groups, zoos, and informal education programs. We also invited 16 scholars and practitioners outside of the PLC to contribute to several chapters; they were not included in this study as they did not participate in the ongoing PLC discussions and were recruited solely to enhance the eBook.

Community Climate Change Fellowship (CCC). From June 2014 to December 2014, 26 educators and community leaders (17 females and 9 males) participated in two multi-day, face-to-face workshops and a Facebook group, with the goal of fostering leadership, networking, innovation, and strategies for reaching new and under-represented audiences in climate change education. Participants conducted climate change education programs in schools, aquariums, community

Table 1. The checkbox choices for the environmental education practice elements.

Program goals	Settings
Environmental knowledge and attitudes	School
Pro-environmental behavior	Public libraries
Mitigate environmental problems	Museums
Solve social problems	Zoos or aquariums
Urban agriculture	Botanical gardens
Ecosystem stewardship	Urban parks and other green areas
Positive youth development	Community gardens, urban farms, or rooftop farms
Community development, including families, social capital and trust	Green infrastructure
Foster sense of place or connection to nature	Nature centers or ecology centers
Facilitate participation in urban planning	Nature area
Other, please describe.	Other, please describe.
Age groups	Educational activities
<6 years	Lessons indoors
6–12 years	Lessons outdoors
13–19 years	Walking tours, or neighborhood explorations
20–39 years	Creating or using media
40–64 years	Using online technology
64 years	Creating artwork
Race	Camping, or residential programs
African American/Black	Hands-on science activities
Asian/Pacific Islander	Environmental stewardship
Hispanic/Latino	Visits to environmental facilities
Native American/First Nations	Recreation
White (Non-Hispanic)	Other, please describe.
Other, please describe.	

organizations, and other settings, and collaborated on writing an eBook after the formal professional development activities ended (Hauk and Pickett 2017).

Data collection and analysis

To measure practice change in EE, we conducted a retrospective survey (response rate 62%) with PASC participants after the professional development activities and pre-post surveys with PLC (response rate 70%) and CCC (response rate 100%) participants (pre-program data were not available for PASC). In all surveys, we used Likert scale, checkbox, and open-ended questions to assess changes in practice elements including goals, audiences, settings, educational activities, resources and ideas. For the Likert scale questions in the postsurveys, respondents rated the degree to which they had changed each of the practice elements. For example, 'As a result of participation in the PLC, I have revised or added new goals to my programs' (*Not applicable, not at all, a little bit, some, a lot and totally*). For checkbox questions, respondents checked off a series of predetermined categories related to goals, audiences, settings, and educational activities (Table 1). Because it is impossible to quantify ideas and resources, we asked about these two elements in open-ended rather than check-box questions. In the presurveys with PLC and CCC participants, we also asked their years of working experience in environmental education (work year). To enable us to relate any changes in practice to the program intervention, we used a linear mixed-effects models, which examined the practice elements based on checkbox questions with a random intercept of participants and fixed effect of time of survey (before versus after), controlling for participants' demographics (gender, race, age, and work year; for more information on methods, see Li 2017).

To gain a deeper understanding of how participants changed their practice, we conducted semi-structured interviews with five PASC participants and seven PLC participants (two of whom participated in both programs) after the professional development activities, chosen to represent a range of reported practice changes in surveys. We asked participants who indicated practice change to explain how each practice element changed, and we asked participants whose

practice did not change to explain why. For CCC, we analyzed participants' reports describing their climate change education projects and the influence of the training program on their projects. The first author coded all open-ended survey questions, interview transcripts, and project reports using predetermined codes based on the practice elements (Saldaña 2009) and the second author read over the first author's coding. In the case of disagreements, the two authors discussed and made final decisions on codes.

The goal of the professional development programs which we examined was to facilitate diverse groups of educators exchanging ideas in order to create practice innovations that address changing demographics (e.g. more youth living in cities) and environmental issues (e.g. climate change). We used professional development programs as interventions to examine educators' practice change and innovation. An external evaluation team evaluated the effectiveness of the programs in terms of participants' satisfaction and learning experience. In our study, rather than evaluating the effectiveness of the professional development programs, we focused on practice change, which may indicate innovation to address emerging audiences and issues. However, because we cannot judge the quality of the environmental education practice before the program, we do not pass judgment on educators' success or failure by the degree to which they have changed their practice as a result of the professional development programs. In the conclusion, we address some of the limitations of our measures of practice change and innovation.

Validity

Content validity was addressed by reviewing research on practice theory and EE programs, and by asking expert opinions on developing the list of elements (Haynes, Richard, and Kubany 1995). Convergent validity was addressed by triangulation to compare the checkbox and Likert-scale questions in surveys with the interviews, and CCC report results (Carmines and Zeller 1979; Jick 1979).

Results

We report results for each program from the descriptive analysis and linear mixed-effects models based on the surveys, and from the interviews and reports. Across all three programs, participants incorporated new resources and ideas into their practice as indicated by the Likert scale questions, whereas change in other practice elements varied across programs. The number of goals increased only in PASC, the number of educational activities increased in PLC and CCC, and the number of audience age groups and settings increased in CCC. In the interviews, PASC participants elaborated on how they expanded program goals through reaching out to broader audiences and incorporating ideas learned from other participants, whereas PLC participants emphasized that they conducted new activities and that writing the eBook chapters inspired and empowered them to enhance their practice. In open-ended survey questions and reports, CCC participants described how they enhanced their climate change education projects by incorporating ideas from the program and expanding their networks. Participants who did not report change in their practice explained in the interview the constraints limiting their ability to change or how they refined their program rather than changed practice elements.

PASC

After controlling for gender and race, PASC participants reported significantly more goals on checkbox questions ($F(15) = 10.39, p < 0.01$) but no change in the number of audience race and

Table 2. Change of practice elements based on checkbox questions in each professional development program.

Practice elements	Number of	Before/after Program	PASC <i>N</i> = 16		PLC <i>N</i> = 30		CCC <i>N</i> = 25	
			Mean	SD	Mean	SD	Mean	SD
Goals		Before	6.44	2.34	6.57	2.52	6.44	2.18
		After	7.19	2.07	6.10	2.42	5.92	2.02
Race/ethnicity categories		Before	3.38	1.41	3.57	1.71	3.00	1.61
		After	3.44	1.36	3.71	1.54	2.96	1.62
Age groups		Before	3.82	1.87	3.57	1.91	3.12	1.51
		After	3.69	1.85	3.75	1.99	3.56	1.45
Settings		Before	5.06	2.32	4.14	2.19	3.08	2.38
		After	5.19	2.17	4.46	2.25	3.44	2.22
Activities		Before	8.56	1.93	7.11	2.12	5.28	3.03
		After	8.81	1.76	7.86	2.10	6.12	2.99

Note: One CCC participant who missed checkbox questions in pre- survey was removed from analysis.

ethnicity categories, audience age groups, settings and activities (Tables 2 and 3). Interviewees indicated that they already were using or intended to use new resources and ideas learned from the other participants in their practice.

On the Likert scale questions participants indicated ‘a little’ to ‘some’ change in program goals (Table 4). One PASC leader who did change program goals talked about focusing less on solving problems and more on incorporating diversity and community development.

We have increased community development. I’ve used a lot of activities and sort of knowledge that came through the community of learners in our meetings and webinars and face-to-face meetings to bring those practices into play within the community groups that we work with. That’s built some community development that’s given us more volunteers that increased our capacity to do work.

Other interviewees did not talk about changing their goals but rather about enriching their programs. For example, a participant mentioned, ‘we are expanding our program and adding on more offerings and more options for students. I think that’s what you’re seeing there, but the goals and programs are always sort of the same. It’s more rich I guess ...’

That participants indicated little change in audiences ($M = 2.43$, Table 4) may have been because they lacked control of this practice element in their individual programs. However, a co-leader explained:

Through the community of learners (PASC) we’re going after other grants and things to work with after-school programs and the low-income housing projects that are affiliated with the school districts that we’re serving to get out the students in another way ... that actually increases the diversity.

Whereas participants were unlikely to change settings or activities, they reported higher scores on using new resources ($M = 3.06$, Table 4) and 8 of 15 survey respondents reported having more resources as a result of connecting to others in the program. A participant explained, ‘I now have more resources to contact and network with to obtain my program goals. If I am looking for a particular resource or experience for my students I know where to look.’

Two interviewees reported that their resources did not change, but that they built more connections from which they gained ideas. An interviewee explained, ‘If people are considered a resource, my network of people has expanded. I am able to infuse new ideas and partnerships into our current programming.’ Participants, especially youth development professionals and nontraditional environmental educators, also reported using ideas learned from other participants ($M = 3.50$, Table 4). A community development professional explained how PASC participation impacted her view on EE and motivated her to incorporate EE into her practice:

We are just on a completely different vein ... so meeting [another participant] and others that are involved specifically in [environmental education] I think definitely got my wheels turning ... now this experience has just really put my mind back in the environmental education vein ...

Table 3. Linear mixed-effects models results in each professional development program.

	PASC			PLC					
	Number of goals			Number of activities					
	Den DF	F value	p value	Den DF	F value	p value	Den DF	F value	p value
Time	15	10.38	0.006**	26	9.10	0.006**	22	29.93	0.000***
Gender	13	.01	0.935	22	1.29	0.268	22	1.29	0.268
Race	13	.04	0.845	22	.90	0.354	22	.90	0.354
Age				22	.01	0.909	22	.01	0.909
Work Year				22	4.98	0.036*	22	4.98	0.036*
Time: Gender							22	4.83	0.039*
Time: Race							22	7.69	0.011*
Time: Age							22	11.45	0.003**
Time: Work Year							22	8.07	0.010**

	CCC								
	Number of age groups			Number of settings			Number of activities		
	Den DF	F value	p value	Den DF	F value	p value	Den DF	F value	p value
Time	24	6.40	0.018*	20	1.61	0.219	20	1.21	0.285
Gender	20	1.67	0.211	20	.77	0.390	20	1.07	0.314
Race	20	.17	0.683	20	2.69	0.117	20	2.47	0.131
Age	20	.18	0.674	20	.95	0.341	20	.28	0.605
Work Year	20	.42	0.523	24	4.38	0.047*	24	10.76	0.003**

Note: *** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$. # $p < 0.1$. Den DF: denominator degrees of freedom. In mixed effect models, the degrees of freedom for F test are approximated by using Satterthwaite approximation. So the value of degrees of freedom may vary for different factors. Time = time of survey (pre-/post-program).

In short, PASC participants indicated some change in program goals but little change in audiences, settings, and educational activities. In addition, the participants indicated that they already were using or intended to use new resources and ideas learned from other PASC participants in their practice.

PLC

After controlling for gender, race, age, and work year, PLC participants significantly increased their number of educational activities ($F(26) = 9.10$, $p < 0.01$) but reported no change in number of goals, audience race/ethnicity or age categories, and settings (Tables 2 and 3). The change in audience age groups, settings and activities varied depending on PLC participants' age, gender, race and years of working experience (Table 4; for more details, see Li 2017).

Although PLC participants did not report significant change in goals on the checkbox questions, they indicated some degree of change in goals on the Likert scale question ($M = 3.0$, Table 4). A participant who added sense of place and connection to nature as new goals after the PLC explained, 'Definitely it (PLC) made me realize that it's not enough to just take students outside. They have to be taken outside in different places.' Another participant who removed 'mitigate environmental problem' as a goal after the PLC explained, 'So after the class ... my goals and planning, you know that they're taking baby steps, they need to get used to that before they're ready to measure air pollution or something like that.'

Participants reported low scores on changing audiences ($M = 2.17$, Table 4) and program settings ($M = 2.19$, Table 4), which may have been due to participants working at schools or nature centers having little control over these elements. However, a university professor who engaged her students in urban field work for the first time explained:

I realized that I could actually make my plant ecology course instead of having the labs go on field trips ... we would actually do urban plant ecology. And so I focused all my trips in the city. So they (students) will think about using the city in just a different way than I had actually never done before. The students really loved it.

Table 4. Degree to which participants report changing practice elements based on Likert scale survey questions in each professional development program.

	PASC <i>N</i> = 16		PLC <i>N</i> = 30		CCC <i>N</i> = 26	
	Mean	SD	Mean	SD	Mean	SD
Revised or added new goals	2.56	.81	3.00	1.05	3.65	.94
Involved different or more types of audiences	2.43	.94	2.17	1.21	3.08	1.08
Expanded programs to new settings	2.23	1.01	2.19	1.39	2.86	1.28
Revised or developed new educational activities	2.27	1.03	3.04	1.24	3.24	1.13
Used new resources to inform the programs	3.06	1.00	3.04	1.30	3.88	.83
Used ideas learned from other participants	3.50	.89	3.07	1.28	3.84	.90
Used ideas from the eBook			3.00	1.25		

Note: scale: 1 not at all, 2 a little bit, 3 some, 4 a lot, 5 totally.

Another participant who added new settings such as local communities explained, 'We are changing our practice by getting off the campus like blowing into community and helping students and the public enjoy the environment where they live work and play ...'

Participants reported adding educational activities to a greater extent relative to audiences and settings ($M = 3.04$, Table 4). As a participant who added activities explained, the PLC and in particular co-authoring the book chapter gave her different perspectives and changed the way she taught and interacted with kids:

(PLC) gave me a different perspective and a realization that I need to connect to the kids on a different level or the program is not going to succeed... I met the other people who have the urban background. ... writing that chapter and finding that research totally changed the way I interact with them.

A participant who added technology into her teaching explained:

So I am also making myself use much more social media to teach... I make them use Tumblr with focused topics. So as I become more comfortable with my own digital footprint, I will continue to use those media to engage these topics.

Participants reported using new resources ($M = 3.04$, Table 4) and half reported that their resources had expanded in depth and breadth on the open-ended survey question when asked how the resources that they used for their programs changed as a result of participation in the PLC. As a participant wrote, 'I discovered numerous resources and collections shared by other participants on the FB [Facebook] page.'

Participants reported applying ideas and practices learned from other participants ($M = 3.7$), and from the eBook ($M = 3.0$, Table 4) in their programs. A participant explained how writing the eBook chapters reinforced ideas, making her more likely to apply them:

I had to do a ton of research. So seeing data to back up ideas, I think it helps a lot... Now I have that data, it really reinforces some of the ideas that everyone has. So I can put those into the practice...

The eBook itself became a source of ideas and inspiration for practice, as one participant explained:

It [the eBook] really does inform my thinking about where we want to go with our programs and how we can increase both capacity and also to bring deeper content knowledge and information... I mean the case studies are amazing, they really are, and I look through a lot and again just for inspiration to see what people are doing and how they've reached out, in what ways they've incorporated different messages. I mean it's been really helpful; that has been a great resource.

In short, PLC participants significantly increased the number of educational activities and used new resources and ideas learned from other participants in their practice. In addition, writing the eBook inspired and empowered participants to enhance their practice.

CCC

After controlling for gender, race, age, and work year, CCC participants increased the number of age groups (i.e. 13–19 and 20–39-year-olds, $F(24) = 6.40$, $p < 0.05$), settings ($F(24) = 4.38$, $p < 0.05$), and activities ($F(24) = 10.76$, $p < 0.01$) (Tables 2 and 3), but did not significantly change the number of program goals nor ethnic groups.

Despite not reporting change in goals on the checkbox questions, participants named several new goals in an open-ended question (e.g. fostering cultural awareness, women's empowerment) and reported relatively high scores on changing goals on the Likert scale question ($M = 3.65$, Table 4). They indicated a moderate degree of change in audiences ($M = 3.08$, Table 4). A participant explained how she recruited more audiences in her practice:

With wind in my sails and inspiration from other Fellowship projects, I was able to keep the fires burning on the project through the program development phase, recruiting over a dozen mentors and some prospective participants, while developing some instruments for running a focus group to tune program recruitment language and materials and begin development of curricula.

Respondents indicated little change in settings on the Likert-scale question ($M = 2.86$, Table 4), but reported adding new settings on the open-ended question including conference venues, community centers, churches, and theaters, as this participant explained, '(The education project) facilitates student coordination and hosting of a community-wide event at the local theater that provides a multi-dimensional series of presentations (art, student skits, local musicians) on local to global climate change causes, impacts, and solutions.'

The CCC participants indicated that they added new educational activities into their practice ($M = 3.24$, Table 4), such as creating artwork, creating and using media, and visits to environmental facilities. A participant who added social media activities explained, 'I'm more open to try new things and adding social media to my work has been both an eye opener and a real challenge, but much needed.'

Participants indicated using CCC resources ($M = 3.88$, Table 4) and ideas ($M = 3.69$, Table 4), including fellow educators and program leaders, 'I have added several new resources including people to bounce ideas off from (CCC participants and leaders), as well as community development materials (via guest speaker) to enhance my programming.'

In short, CCC participants designed and implemented action projects but did not significantly change the number of program goals nor ethnic groups in their practice. However, they significantly engaged more age groups, expanded to more settings, and conducted more educational activities. Several participants expanded their activities to include professional training for other educators. In addition, the participants indicated that they incorporated new resources and ideas into their practice.

Discussion

The key finding of this research is that actual practice change among programs varied although educators in all three programs took advantage of new resources, including lesson plans and fellow educators, and reported applying new ideas into their practice. These results only partially support EECapacity professional development goals and EECapacity's social innovation theory of change, (i.e. to build idea and resource exchange networks among environmental educators and youth development professionals, in order to generate innovative practices that reflect the ethnic diversity of US audiences) (Marianne et al. 2017). Resources and ideas may be easier to incorporate relative to other practice elements such as goals, audiences, settings and educational activities, and may in turn lead to practice change over time. Additionally, the finding of differing types of practice change across programs may be related to variation in the three programs' focus on providing platforms for exchange among EE and youth development professionals (i.e. 'fidelity' to EECapacity program approach) and in other factors such as opportunities for

collaboration in writing eBooks. Below we first discuss our results across the three programs and then reflect on the use of practice theory to understand practice change and innovation in professional development research.

Practice change among three professional development programs

Participants incorporated new resources and ideas into their practices across all three programs. However, changes in other practice elements varied across the three programs. That the number of goals changed significantly only in PASC could be attributed to the fact that this program was specifically designed to bring together environmental educators focused on changing environmental behaviors with youth development professionals who use environmental activities such as community gardening to build youth assets (Delia and Krasny 2018). PASC environmental educators expanded their programs to incorporate community-oriented work, whereas PASC youth development professionals planned to add an EE component to their programs. Although PLC and CCC also brought together professionals with diverse interests, they focused on specific tasks (eBook writing) and topics (climate change), which may explain why participants were less likely to add new program goals.

Variation among programs in changes in activities might also have been due to variation in professional development interventions, while differences in changes in other practice elements, such as audience and settings, might be due to program constraints (e.g. school programs have limited ability to change setting, curriculum, or audience) (Fazio and Karrow 2013). The project-based assignments in PLC (write eBook chapter on urban EE practice) and CCC (implement new climate change project) enabled participants to readily apply new ideas and activities into their practice. Previous studies showed changes in EE practice varied with type of professional development interventions. For example, teachers who attended longer and more workshops were more likely to use an EE curriculum (Paul and Volk 2002) and hands-on activities (Sondergeld, Milner, and Rop 2014) that they learned from the workshops in the classroom. Bainer, Cantrell, and Barron (2000) found that through partnering with school teachers, nonformal environmental educators adopted classroom resources in their practice and adjusted teaching styles. These results suggest that professional development could be designed to change specific practice elements, taking into consideration the potential of and constraints faced by professionals working in different settings.

The number of some practice elements did not change significantly and even decreased. One explanation could be that participants already had comprehensive programs or refocused their existing programs (Bennett 1976). In one case, a participant narrowed down her program goals to make them clear and doable for her students.

The fact that educators in each program applied new ideas and resources to their programs and developed stronger social networks is consistent with other research that has demonstrated professional networks can form through internet-only (Li, Krasny, and Russ 2014) as well as face-to-face interventions (Bainer, Cantrell, and Barron 2000). In the online-only PLC, small groups of co-authors on eBook chapters developed relatively strong ties within the larger social network, suggesting that project-based learning can be used to build ties even in the absence of face-to-face meetings (Spoelstra, Van Rosmalen, and Sloep 2014; Li 2017).

Practice theory and social innovations

This study suggests the potential and limitations of practice theory as a means for understanding change in EE practice. Building on practice theory research in consumer studies (Shove and Pantzar 2005); professional learning in industry (Rooney et al. 2012) and environmental stewardship (Krasny et al. 2015); and EE research (Ashmann and Franzen 2015; Eames, Cowie, and Bolstad 2008; Stern, Powell, and Hill 2013), we identified six elements – goals, audiences,

settings, educational activities, resources and ideas – that construct an EE practice. However, the success of an EE practice may also depend on additional practice elements including educator competencies and practice meanings (Gram-Hanssen 2010; Krasny et al. 2015; Shove and Pantzar 2005). Research on tree planting and oyster restoration civic ecology practices demonstrates the importance of meanings attributed to environmental stewardship practice (Tidball 2014; Krasny et al. 2015).

Although we intended to use individual practice change as a measure of practice innovation, one might also consider artifacts collectively produced by the group of educators in any one program as social innovations. PLC members collectively wrote an eBook during the professional development program (Russ 2015) and CCC members collectively wrote an eBook after the program (Hauk and Pickett 2017). Both books currently serve as open-access resources for any interested professional or volunteer. In short, two programs produced new ‘products’ that may be considered as more significant social innovations, defined by the creation or adoption of new ideas, products or processes (Mulgan et al. 2006), compared to the aggregate of changes in individual practice elements in any one program. Although PASC did not produce a similar curriculum resource, it developed a model for state-level professional development that incorporates youth development alongside EE professionals, which could in itself be viewed as an educational innovation. This view is consistent with other group-level practice innovations, such as the emergence of community-based initiatives (Seyfang and Haxeltine 2012) and Nordic walking (Shove and Pantzar 2005).

Although our data do not definitively answer the question of whether EECapacity met its goals of generating innovative practices that reflect the ethnic diversity of US audiences, the eBooks and ongoing networks, along with open-ended interview results, suggest some changes occurred at the group level and among individual educators. For example, environmental educators talked about expanding programs to include urban settings and youth development professionals spoke to adding EE to their programs. Further, the PLC eBook compiled over 30 approaches to EE in ethnically diverse urban neighborhoods (Russ 2015) and two EECapacity generated Facebook groups now include several thousand members from cities and countries around the world who regularly exchange resources.

Limitations

In contrast to previous studies that used qualitative methods to understand practice emergence (Shove and Pantzar 2005; Krasny et al. 2015) and change (Gram-Hanssen 2010), we used a mixed-methods approach to measure practice change including surveys, interviews, and content analysis of reports. The surveys included checkbox and Likert scale questions and quantified specific elements of practice, which enabled us to capture the elements participants felt they had changed; the degree to which participants perceived changing these elements; and what program factors they thought influenced these changes. Elsewhere we have also been able to relate specific changes in practice to other factors such as network formation (Li 2017). However, the choices for the checkbox questions for practice elements may not have covered all possibilities. Further, increasing or decreasing the number of elements, or even making qualitative changes to the elements, does not necessarily indicate positive change in practice as might be implied by the use of social innovation theory to guide professional development in EECapacity. In addition, for participants who do not have control over elements like audiences and settings, measuring changes in these elements may not contribute to understanding their practice. Additional limitations come from using self-report questions rather than actual observation to examine practice change and from the limited time frame in which we examined the innovations and their impacts. These shortcomings could be addressed by a longitudinal study that conducts observation using both treatment and control groups.

Furthermore, by focusing on practice, our study overlooked aspects of personal development (Bell and Gilbert 1996); the importance of educator characteristics, such as knowledge (cf. Booth 2012; Ingvarson, Meiers, and Beavis 2005) and efficacy (Moseley, Huss, and Utley 2010); and the impact professional development on students (Desimone 2009). A more comprehensive study could incorporate all three components – practice, educators, and audiences – to examine professional development outcomes.

Conclusion

We applied practice theory to examine outcomes of three EE professional development programs and found that whereas professionals in all three programs incorporated new resources and ideas into their work, the three programs varied in how much educators changed other practice elements. Whereas we focused largely on individual educator practice change, several group-level innovations emerged from our professional development interventions, including eBooks and a statewide professional network that integrates EE and youth development professionals to meet the needs of diverse audiences. Interestingly, we did not discern greater impacts in face-to-face relative to online forms of professional development, suggesting that both types of interactions, coupled with project-based collaboration, can foster idea and resource exchange among participants and group level innovations.

In applying practice theory, we added a new lens for evaluating the impact of professional development programs and expanded practice theory to encompass EE practice. Practice theory enabled us to understand subtleties of EE practice by identifying practice elements and their changes. However, results varied across the elements and three interventions, and were likely impacted by educators' limited control over some elements (e.g. audiences) and by our failure to include other elements (e.g. competencies, meanings). Thus, future research should be attentive to which practice elements are included and educator control over these elements, the interaction or new combinations of elements, and integrating qualitative methods such as participant observation to better understand the process of practice change and the emergence of educational innovations.

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