

**Continuing Professional Development in Sustainability Education for K-12
Teachers – Principles, Program, Applications, Outlook**

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Abstract

The next generation will be better prepared to cope with daunting sustainability challenges if education for sustainable development is being taught and learned across educational sectors. K-12 school education will play a pivotal role in this process; most prominently the teachers serving at these schools. While pre-service teachers' education will contribute to this transition, success will depend on effective professional development in sustainability education to teachers *currently* in service. Arizona State University has pioneered the development and delivery of such a program. We present the design principles, the program, and insights from its initial applications that involved 246 K-12 in-service teachers from across the United States. The evaluation results indicate that due to participation in the program sustainability knowledge, perception of self-efficacy, inclusion of sustainability in the classroom, modelling of sustainable behaviours, and linking action to content all increased. We conclude with recommendations for the widespread adopting of the program.

Keywords

Education for Sustainable Development; Sustainability Education; Teachers; Continuing Professional development; In-service Training

1. Introduction

The lack of capacity to prevent and resolve sustainability challenges, on the one hand, and to create and support sustainable development, on the other hand, is at the root of the sustainability crisis. Primary and secondary schools are formative environments for building such capacity in people from diverse social-cultural and economic backgrounds. K-12 schools in the U.S. not only reach tens of millions of people, but also an increasingly diverse population. A study by the National Center for Education Statistics estimated that as of 2016 the overall number of Latino, African-American, and Asian students in public K-12 schools surpassed the number of non-Hispanic whites in them.

Continuing Professional Development (CPD) programs for teachers are a central mechanism to transform teaching and learning in K-12 schools (Desimone, Porter, Garet, Yoon, & Birman, 2002). Popova et al. (2016) highlight the importance to work with *in-service teachers*, as pre-service teachers often take on the culture of the new school rather than introducing new practices. Research has been conducted on best practices in professional development and agreement is emerging about the key characteristics, including competence-orientation, leadership training, intensive interventions, participation of groups of teachers, and formative evaluations (Desimone et al., 2002; Popova et al., 2016). While CPD programs designed in alignment with these features yield positive results, the promise often remains unfulfilled.

A recent review of 171 CPD programs found that most programs are outdated, overly theoretical and fail to engage teachers in tangible and interactive ways that directly translate to their classroom practice (Popova et al., 2016). Also, a good share of CPD programs focus on number of teachers reached, rather than on capacities built. Numerous studies have shown, just because a program reached thousands of teachers that does not mean the program had a long-lasting impact on teaching or learning practices (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Popova et al., 2016; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). Often, CPD programs rely on information dissemination even though research has shown that providing information has little or no effect on people's actions and behaviour (McKenzie-Mohr, 2000). There is broad agreement of the shortcomings of one-time, stand-alone CPD workshops as they fail in transforming teaching practice and student achievement (Darling-Hammond et al., 2009; Popova et al., 2016; Yoon et al., 2007). Still, more than 90% of CPDs consists of short-term conferences or workshops that yield little improvement in teaching or learning (Darling-Hammond et al., 2009).

Against this background, three research questions were pursued in this study:

1. What is a robust set of design principles for CPD programs in sustainability education for K-12 teachers?
2. What is suitable content and structure of an exemplary CPD program in sustainability education for K-12 teachers, aligned with these design principles?

3. How successful is this exemplary CPD program, based on an initial set of applications with teachers from across the U.S.?

We reviewed various strands of scholarly literature to derive a robust set of design principles; then used these principles to create an exemplary CPD program in sustainability education for K-12 teachers; then delivered the program to teachers from across the U.S. and finally evaluated it. Based on our findings, we offer recommendations for adopting the program across the U.S. and beyond.

2. Design Principles for CPD Programs in Sustainability Education for K-12 Teachers

Drawing on a review of pertinent literature on general education, interactive pedagogy, professional development, continuous learning, and K-12 educational change, we have identified a set of design principles for CPD programs in sustainability education for K-12 teachers. Agreement by scholars and practitioners converges on the following program features:

1. The CPD program should target *key competencies in sustainability*. Sustainability provides a context for real-world, solutions-based learning that enables the learner to connect with class content on a personal level and engages with 21st century challenges. Over the last decade, studies have been converging on what knowledge and skills are necessary to solve complex sustainability challenges (Barth, Godemann, Rieckmann, & Stoltenberg, 2007; Frisk & Larson, 2011; Wiek et al., 2015; Wiek, Withycombe, & Redman, 2011). The emerging set of key competencies in sustainability includes systems thinking, futures thinking, values thinking, strategic thinking, and interpersonal competence (Wiek et al., 2015). All too often sustainability has been viewed as a topical subject connected to recycling or solar energy. With the aforementioned competencies, we present sustainability as a field that is less defined by the topics it addresses (resources, energy, water, food, education, etc.), but rather by the styles of thinking, knowledge, values, attitudes it embraces.

The focus on sustainability competencies also represents a shift away from the information-deficit model of education (E. Redman, 2013a), in which information dissemination and retention is the primary goal. Rather, the knowledge we focus on is procedural (linked to action) and normative (linked to cultural and social norms), and attainment of the key competencies is represented in the interlinkages between knowledge, skills, and values. The literature on professional development similarly indicates that theory and practice should be linked in order to develop deep understandings about the topic and change practices in ways that flexibly meet the complex demands of teaching (Timperly, 2008).

2. The CPD program should enable teachers to become *sustainability leaders*. Behavioural scholars highlight the role of opinion leaders in creating long-lasting change (Rogers, 2003; Valente & Pumpuang, 2006). One method for identifying opinion leaders prior to the program is through Letters of Recommendation, which ensure that the Principal is supportive of sustainability education and aware of the leadership potential of the nominated teacher(s). Post-program it is

important to position the participating teachers as leaders amongst their peers by supporting school or district level in-service training and conference presentations on implementing sustainability projects in class. These leadership opportunities can yield professional advancement, which serves an additional incentive.

Leadership also pertains to the relationship with the students. Opinion leaders act as role models for behaviour change within the community (Valente & Pumpuang, 2006). Research indicates that educators often have sustainability knowledge but tend to neglect role-modelling sustainability behaviour as a means to educate on sustainability (Frisk & Larson, 2011; Nolet, 2009; Stir, 2006). These skills are best built through participation in sustainability-related behaviours (E. Redman & Redman, 2014). Hence, effective CPD lets teachers partake in sustainable practices in order to become role models. Contrariwise, inconsistency between concepts taught and unsustainable behaviours demonstrated by instructors decreases educational effectiveness (Higgs & McMillan, 2006). In light of role modelling, CPD events should account for sustainability issues in recruitment, decision-making, printing, food services, waste disposal, as well as pedagogy and practices of the CPD implementers.

3. The CPD program should engage *teachers early in their career* and *preferably in groups*. Popova et al. (2016) suggest that teachers see most significant improvements in the first five years of teaching. Leveraging this time early in teachers' careers can be useful in spurring the most significant change. Others suggest a mentoring approach in which beginning teachers are given job support through professional collaboration (Darling-Hammond et al., 2009).

A review of 111 articles published over the last decade on teacher learning found that teachers' co-learning triggered changing teaching practices and improving student learning (Avalos, 2011). Co-learning is here defined as teachers at the same school working collaboratively based on shared values to improve a specific component of student learning. However, in a survey of U.S. teachers, only 17% of teachers reported a great deal of cooperative effort among staff members and only 14% agreed that they have actively collaborated on course content (Darling-Hammond et al., 2009).

4. The CPD program should be *intensive and long-term*. Successful CPD programs offer a high number of contact hours (more than 30) and with continued follow-up support over six to twelve months (Darling-Hammond et al., 2009). Intensive CPD with about 50 hours a year boosts student achievement, while low-intensity and short CPDs show no statistically significant effect on student learning (Yoon et al., 2007). Additionally, longer CPD programs are more likely to provide opportunities for active learning, reflection on students' conceptions and misconceptions, and are more likely to allow teachers to try out new classroom practices (Garet, Porter, Desimone, Birman, & Yoon, 2001).

Research indicates that the time span of the program may be just as important as the number of contact hours (Darling-Hammond et al., 2009; Guskey & Yoon, 2009; Popova et al., 2016). Through sustained contact with the participating teachers, effective CPD includes applications of

knowledge to teachers' planning and instruction. Guskey and Yoon (2009) found effective CPD programs included significant amounts of structured and sustained follow-up after the main activities.

5. The CPD program should be *engaging*. Education scholars have highlighted outdated pedagogical approaches to avoid when creating CPD programs, including instructor-centred ones (Freeman et al., 2014; Sterling, 2004). Appropriate pedagogies include *active learning* and *solutions-oriented learning*. A study that surveyed teachers in the U.S. regarding their CPD experiences found that only a few CPD activities can be categorized as active learning (Garet et al., 2001). Active, experiential learning combines real-world experiences and reflections (Brundiers & Wiek, 2011; Brundiers, Wiek, & Redman, 2010; Duerden & Witt, 2010; Kollmuss & Agyeman, 2002; Obenchain & Ives, 2006).

Shifting from problem-centred to solution-oriented learning does not neglect the understanding of problems, but emphasizes hope and agency (Boone, 2015). Behavioural scholars and sustainability scientists have highlighted the need to focus on solutions and hope, rather than overwhelming the learner with stories of catastrophes (Kollmuss & Agyeman, 2002; Scott, 2002; Wiek & Kay, 2015). Solution-oriented learning, if student-led and collaborative, makes students becoming aware of plurality of perspectives and approaches (Hmelo-Silver, 2004), enhances individual and collective agency for change (Kollmuss & Agyeman, 2002; E. Redman, 2013a).

6. The CPD program should be *practice-oriented*. Teachers are often confronted with multiple and conflicting messages, leaving little time for reflection or change (Kennedy, 2016; E. Redman, 2013b). After conventional CPDs, teachers often have the intention to implement a new practice or lesson but back in their school, they face many obstacles. Therefore, effective CPD needs to include time *within the program* for the teachers to translate their new ideas into their own school system (Kennedy, 2016; Murphy, Smith, Varley, Razi, & Boylan, 2015). During the CPD, action-plan need to be created, which include what they will implement, how, and with whom.

Practice-oriented CPD models require teachers to try out new activities and methods demonstrated during the workshop (Murphy et al., 2015). As the implementation of these activities occurs in between workshop sessions, a reflection session is needed in which teachers share the challenges and opportunities experienced. This requires follow-up after each CPD workshop.

7. The CPD program should include and utilize a *formative evaluation*. One of the critiques of CPD is that evidence of the effectiveness of the programs is limited (Popova et al., 2016). Many CPD educators consider evaluation costly, time-consuming, and outside of their role as CPD implementers (Guskey, 2002). Even when evaluations are done, they often fail to provide details on the actual content or delivery mechanisms and rarely extend to student outcomes (Guskey, 2002; Popova et al., 2016).

To evaluate program outcomes rather than extrapolate from ideals, effective CPD could apply Guskey's five levels of evaluation (Guskey, 2002): 1. Participants reactions, i.e., participants' satisfaction with the quality of presenters, materials, spacing of activities, and organization; 2. Participants' learning, i.e., change in knowledge or skills due to the program; 3. Organization support and change, i.e., alignment with teachers' school cultures and environments and support in creating change; 4. Participants' use of new knowledge and skills, i.e., extent to which teachers implement new ideas and practices in their classrooms; 5. Student learning outcomes, i.e., impact on student learning outcomes and behaviours.

3. Exemplary CPD Program in Sustainability Education for K-12 Teachers

The CPD program for K-12 teachers presented here was developed with the previously described design principles in mind, and with the intention to be able to be applied by CPD program managers worldwide, with adjustments to account for different contexts.

Phase 1. Prior to the CPD workshop(s): Planning & Recruitment. In this CPD program, we make sure that food services offer meat-free, low-fat options, and sugar-free drinks; source organically and locally; and follow inclusive hiring policies (e.g., jobs and job training for homeless people). The food providers are asked to talk to the teachers about their sustainability policies and practices. We work with the facility manager to provide washable mugs/cups instead of single-use disposable cuts as well as composting and recycling bins.

Due to underrepresentation of minorities in STEM fields, recruitment specifically targets teachers from minority-serving or low-income schools (Title 1 schools in the U.S.). Contacting teacher networks—such as the modelling network, STEM networks, and other CPD programs—is the most successful mechanism for recruitment. The recruitment phase begins at least two months prior to the CPD workshop. We indicate a 'close date' for applications as teachers tend to wait until the final submission date to submit. To incentivize participation, the recruitment material includes that there are continuing education units associated with the program, substitute coverage, and/or participation, and project stipends. In order to leverage early career improvements and utilize mentoring approaches, our model uses a team-based approach in which at least two teachers from each school apply. Within the team, at least one has to have served this school for more than three years so as to have some seniority and contextualized experience. When selecting teams of teachers, we give priority to multi-disciplinary teams to encourage an integrative approach to sustainability education. Once the participants have been selected, the teachers sign letters of commitment to participate over the entire course of the program.

Phase 2. The CPD workshop(s). The key components of each workshop include: 1. Introduction to sustainability as a problem-driven and solution-oriented field; 2. Overview of key sustainability competencies and engagement in activities that represent the competencies; 3. Field trips to places that represent sustainability in the real-world; 4. Project development and sustainability action planning. Each of these components includes activities that can be translated into the classroom. For instance, when presenting sustainability as a solutions-oriented field, we ask the teachers to write flash fiction

stories set fifty years in the future. The stories begin with the key sustainability challenges (e.g., poverty, safety, biodiversity loss), then the teachers focus on solutions to these challenges. This activity is based on sustainability research on imagination and storytelling in communicating climate science (Milkoreit, 2016).

A typical day during the CPD workshop starts with a reflection discussion in which we review journal questions and/or 'homework' that the teachers did in between sessions. The journals that teachers are provided with offer questions such as, 'What activities from today would you use in your classroom and how would you adapt them?'. Then we move into a real-world learning component, for instance, a field-trip to a Goodwill facility that sorts unsold items for the next phase (e.g., many broken computers go to Dell) and operates the career training program. The Goodwill facility shows the massive amounts of waste that moves through Goodwill, the strategy they use to divert almost 90% of the waste from landfills, the support they provide to people in need, and collaboration with K-12 schools (e.g., fundraising). The journey continues to lunch at Helpings Café and a tour of their homeless programs and facilities. Next, we return to the classroom to delve into activities such as life cycle assessment or visioning. We conclude with a review of the day, looking at the sustainability competencies conveyed and discuss the next 'homework' assignment. As we get further along in the program, the 'homework' becomes a key method for teachers to translate their knowledge into classroom practices.

Phase 3. Activities after the CPD workshops. Our CPD model begins with an intensive intervention of more than forty contact hours (as described above), and continues with follow-up support, school visits, implementation support, and seed-funding for projects. The teachers submit project reports, train other teachers, and serve as 'Sustainability Ambassadors.' Ambassadors have opportunities for further project and conference funding, and additional Continuing Education Units. The designation of 'Sustainability Ambassador' as well as the further support can help position teachers as leaders for sustainability in their schools. Many Ambassadors have participated in our 'educator round-table' session during our other CPD workshops, sharing their successes, challenges, and adaptations.

Quality CPD programs should result in strong connections between the CPD implementer and the participants that is beneficial for both parties. The implementer visits participants' schools, co-writes proposals for conferences and co-presents with CPD alumni, writes letters of recommendations for further leadership opportunities, and integrates feedback provided by teachers into updates of sustainability lessons. Long-lasting relationships result in high response and contact rates: teachers submitting and receiving feedback on photos, videos, and/or narratives about their implementation of sustainability projects.

4. Initial Program Applications across the U.S.

The CPD program in sustainability education for K-12 teachers described above was piloted mainly through eight CPD workshops with 246 teachers by Arizona State University faculty and staff in 2015-

16.¹ To support organizational change, the CPD team also provided project seed-funding, visited some of the schools, and conducted sessions to allow for reflecting upon progress. The CPD team also met with teachers over the course of the school year and collected qualitative data regarding implementation and students’ learning outcomes.

The large majority of participants taught in grades 6 through 8 with a few having students a grade older or younger. In the U.S., grades 6 through 8 generally represents middle school with students aged 11-13 years. Each workshop had between 26 and 34 participants. The workshops that are classified as ‘National’ had participants from across the U.S. (e.g., Hawaii, West Virginia, New York, Washington) and those that are classified as ‘Regional’ had teachers only from the state in which they were held (Tab. 1). Teacher participants are not distributed equally across all subjects, rather about half of the participants were science teachers. In advertising the workshops, we asked for teams that represented multiple disciplines, however, the initial applicants were typically science teachers, who then recruited a colleague from another discipline. More participants taught at Title 1 schools² than the U.S. average because we gave priority to Title 1 schools while the large majority of the participants had been teachers for more than three years

Table 1. Demographic data of participating teachers across the eight CPD workshops

	2016 National (3 workshops)	2015 National (2 workshops)	2015-2016 Regional (3 workshops)
# of teachers (N=243)	102	53	88
Science	46%	53%	46%
Math	13%	16%	17%
English	14%	10%	11%
Social Studies	8%	12%	8%
Other	19%	9%	17%
Public (Title 1)	89% (37%)	91% (43%)	93% (63%)
Private	11%	9%	7%
0-3 years	12%	28%	24%
4-8 years	19%	42%	18%
9-15 years	31%	21%	17%
More than 15 years	38%	9%	41%

¹ June 2015: 29 teachers nationwide; July 2015: 26, nationwide; July 2015: 31 in Florida, 32 in Arizona, 34 in California; June 2016: 32, nationwide; July 2016: 32, nationwide; August 2016: 30, nationwide. Total=246.

² Title 1 schools have a large concentration of low-income students, i.e., students from families with incomes at or below 130 percent of the poverty level. enrolled in the free and reduced lunch program. A Title 1 school has at least 40% of low-income students, who are eligible to enroll in the free and reduced lunch program.

5. Evaluation Design

Our third and last research question asked how successful the CPD program was in its initial roll out. While the ultimate goal is to reach students, the scope of this evaluation was to assess the change in the teachers' knowledge, intentions and behaviours with regards to sustainability. Following Garet et al. (2001), we measured changes to the participants' 1) sustainability related knowledge, 2) awareness of key sustainability competencies, 3) perception of self-efficacy, and 4) behavioural intentions. Additionally, we collected 5) feedback related to the process that support transformational change within the CPD in line with the design principles described in section 2, above.

As main evaluation instrument, we constructed and revised a survey that was delivered prior and after the workshop participation. Research shows that enhanced knowledge and skills have a substantial positive influence on change in teaching practice (Garet et al., 2001) and that teacher perception of self-efficacy is associated with successful implementation of innovative practices (Stein & Wang, 1988). Hence, in developing the survey instrument we created multiple questions to assess declarative/content knowledge, intentions to apply their knowledge and skills, and teacher perception of self-efficacy. The CPD program was framed using sustainability competencies (Wiek et al., 2015, 2011), so we also included a set of questions on key competencies and their relation to project development.

The knowledge index comprised five questions that are scored as correct/incorrect. For example, one of the questions was: "Water use is often divided among three sectors: industry, agriculture, and household use. Which of these three sectors uses the most water?" The respondents were asked to select one of the three options using the radial button selection. Teacher perception of self-efficacy was measured by asking six questions on a 5-point Likert scale from Strongly Agree (5) to Strongly Disagree (1). For example, one of the questions was: "I have the knowledge to work towards sustainability." The awareness and inclusion of the key sustainability competencies in project design and development were evaluated through two questions. For example, one of the questions was: "What are key elements of an effective sustainability project?"

For data collection, we used external evaluation teams. In 2015, we had an evaluation team from the education department at Arizona State University collect data on the 54 participants from the first two CPD programs. Data from the 2015 programs are less consistent due to changes in the evaluation team and the need for significant adjustments in the survey and interview instruments used. Some of the results therefore have a smaller N because they do not include the first 54 participants. For the other six workshops, we used the same external evaluation consultancy. All participants were e-mailed out the survey before arriving and again upon completion of the program. As taking it was a required part of participating in the workshop, completion rates were very high with 243 of the 246 participating teachers. Nineteen interviews were conducted by external researchers and transcribed by the evaluation consultancy.

In addition, we collected follow-up reports with photos and videos of sustainability classroom practices and sustainability campus projects 6-8 months after completing the CPD. In 10% of the schools, we did on-site visits.

Descriptive statistics are used to compare the responses of the participants on the survey and look for changes before and after the workshop participation. Inferential statistics were not used due to design limitations of the survey, ethical considerations regarding the data collection, and a decision that they would not contribute meaningfully. The open-ended responses in the surveys and the transcripts of the interviews were reviewed by two raters for key themes and exemplary quotes were pulled from the text. Text mining was carried out using some basic techniques described by Silge and Robinson (2016) to look for frequency which words affiliated with the sustainability competencies were used and to measure the overall sentiment (positive versus negative) of the participants. Finally, the implementation reports, site visits and other various types of content were integrated into the results presented in the following section.

6. Evaluation Results

6.1. Change in teachers' sustainability content knowledge

The knowledge index comprises five questions that are scored as correct/incorrect. Averaging responses of all five knowledge questions, the rate of correct answers improved from 54% pre-program to 92% post-program. In one of the questions we asked about water (Tab. 2). Knowledge was far higher and improved more in teachers from water-scarce states (AZ & CA) compared to those from the national sample of teachers. This difference points to the fact that the perceived relevance of the topic to the teachers and their students is critical for the content of a CPD to resonate with and be absorbed by the participants.

Table 2. Changes in teachers' sustainability content knowledge pre- to post-program

Question(s)	Workshop	% who answered correctly	
		Pre (n)	Post (n)
"Water use is often divided among three sectors: industry, agriculture, and household use. Which of these three sectors uses the most water?"	Regional CA & AZ	77% (66)	98% (64)
	National 2016	53% (95)	69% (100)
Index of 5 knowledge questions	Regional & National 2016	54% (145)	92% (148)

One of the largest improvements in content knowledge was regarding the different dimensions of sustainability (ecological, economic, social, well-being, cultural). In the pre-program survey, 91% percent of respondents thought that 'recycling' was one of the critical dimensions of sustainability. One teacher stated, "I really did not have a proper understanding of sustainability other than recycling so I am thrilled to have this new knowledge." Another teacher commented that, "sometimes I feel like sustainability is about just using less, or reusing what we already have, but this program, especially with the homelessness, going to Goodwill, has forced me to see that it's more about lending a hand, too." These results show a shift from defining sustainability in terms of environmental behaviours to viewing sustainability as a multi-dimensional field that provides a framework for how we interact with people and the world.

6.2. Changes in teachers' awareness of sustainability competencies

The awareness and inclusion of the key sustainability competencies in project design and development was evaluated through two questions (see Tab. 3). The most frequent responses related to the key sustainability competencies in the pre-program survey was 'waste reduction.' In contrast, after the program more than 95% of participants identified systems thinking, stakeholder engagement, and values thinking as key competencies in sustainability.

Table 3. Changes in teachers' awareness of the key sustainability competencies pre- and post-program

Question	% who choose ...	
	Pre	Post
Which of the following are key sustainability competencies? Check 5 of the following boxes (out of 8).	n=170	n=165
Systems thinking	64%	99%
Action orientation	82%	90%
Stakeholder engagement	72%	97%
Future orientation	74%	84%
Values thinking	66%	96%
What are key elements of an effective sustainability project? Check all that apply (out of 6 options).	n=103	n=101
Stakeholder engagement	86%	99%
Inclusion of values thinking	66%	92%
Future visioning	81%	92%
Real-world action	89%	83%

The way that teachers spoke about sustainability after the CPD showed a familiarity and inclusion of sustainability competencies. For instance, one teacher stated that futures thinking is "not just about us protecting what we have now, but preparing for things in the future and how what we do now can affect our future greatly. Before I just thought that sustainability was protecting our environment, the here and now, not in the future." Another said, "you hear sustainability and you think about turning off the water when you brush your teeth. But at the big picture of what one person can do for future generations has just been mind-blowing." The text of the responses from all of the survey and interviews were analyzed for key terms associated with the sustainability competencies. The results show that participants had absorbed the concepts of the key competencies and were using their language to describe sustainability (Fig. 1). The competencies most frequently referred to were the interpersonal (collaborative) and strategic competence.

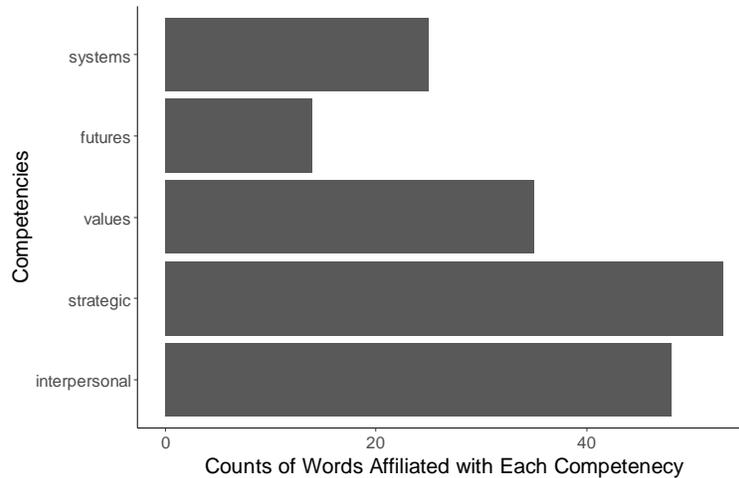


Fig. 1. Counts of words affiliated with the sustainability competencies used by the participants after workshop participation in responding to survey and interview questions.

6.3. Changes in teachers’ perceived self-efficacy

Teacher perception of self-efficacy was measured by asking six questions on a 5-point Likert scale from Strongly Agree (5) to Strongly Disagree (1). Teachers’ perception of their sustainability knowledge, skills, and expertise increased due to participation in the program (Tab. 4). Prior to the program, few teachers felt they had the resources to implement a sustainability project in their school—with only 15% selecting “Strongly Agree”. The post-program survey found a strong improvement in teachers’ self-awareness of resources they possess to implement a sustainability project as well as of the achievability working toward sustainability on a regular basis.

Table 4. Changes in teachers’ perceived self-efficacy pre- and post-program

Question sorted by biggest to least change from pre- to post program	% who choose “Strongly Agree”	
	Pre (n)	Post (n)
I have the knowledge to work toward sustainability.	9% (172)	61% (160)
I feel I have the skills and expertise to teach sustainability.	15% (103)	59% (101)
I have the necessary skills to implement a sustainability project in my school.	11% (171)	54% (165)
I feel I can make a different when it comes to sustainability.	31% (103)	62% (101)
I have the resources to implement a sustainability project in my school.	15% (172)	42% (165)
For me, working toward sustainability on a regular basis is achievable.	32% (172)	55% (165)
Average	18%	55%

6.4. Changes in teachers’ behavioural intentions

We examined behavioural intentions in two key ways: 1. Participants intention to model sustainable behaviours; 2. Participants intention to enact change in their school institutions. Coming into the program nearly 2/3 of the participants strongly agreed that it was important to model sustainable behaviours to their students, but less than 1/3 felt they could (Tab. 5). After participating in the CPD, the

large majority saw the importance of modelling, could see opportunities, and intended to model themselves. In the words of one of the teachers, “as far as modelling the behaviours, I'll definitely do that. And the Sustainability Club that we're creating will be how I model it throughout the school and how I work with students.” The increased importance placed on sustainability behaviours is an important indicator that participants are connecting knowledge to action.

Table 5. Changes in teachers' intention to model sustainable behaviours

Question sorted by biggest to least change from pre- to post program	% who choose “Strongly Agree”	
	Pre (n=172)	Post (n=165)
It is important to model sustainable behaviour for students.	65%	81%
I have the opportunity to model sustainable behaviours for students.	31%	75%
I focus on modelling sustainable behaviours for students.	38%	71%

Teachers reported on their project plans as well as the actual implementation. For instance, one teacher stated, “we have an action plan for a sustainability project in our school which is for a school with 5th and 6th graders with high poverty (90% free and reduced lunch). We will implement composting with cafeteria food waste, worm composting, and chickens; using the compost in a school garden which will eventually be a community garden; implement recycling for plastic and aluminium in addition to the paper and cardboard; implement sustainability education for students and teachers.” The implementation reports from the first 54 teachers that participated in the first workshops revealed that 19 of the teachers led sustainability teacher trainings in their regions, 22 of the teachers implemented sustainability units that ranged from one-week long to one-month long, and all participants implemented at least one sustainability lesson.

6.5. Processes that support organizational change

We focused on solutions-oriented, real-world learning that connects knowledge with practice and action. In 18 of the 19 interviews from the summer 2016 programs the respondents described the program as engaging and 16 of the respondents specifically highlighted the positive impact of the field trips. The teachers also highlighted the value of the practice-oriented approach, with 12 of the 19 interviewees specifically mentioning that the lessons and project planning prepared them for implementation after the initial CPD programming. One teacher commented, “I think through our project especially, we are going to start implementing more of a hands-on approach through the students on having them identify ways that they can be more sustainable and then letting them run with that – so not really forcing them into things, but giving them options and letting them kind of create their own path.” This statement demonstrates that through using active, hands-on pedagogy in our CPD and providing support for project planning without being prescriptive, participants translated these pedagogical methods into their plans of action for their schools.

The entire program was designed to leave participants with a positive, hopeful, empowering view of sustainability rather than a negative feeling associated with guilt and large-scale catastrophes. We analyzed the surveys and interviews for positive and negative sentiment using three different

methodologies (Silge & Robinson, 2016). The analysis shows that the participants used positive language to describe their experience in the CPD (Fig. 3). Additionally, we focused in on the question on the interview and survey which asked the participants for critical feedback and ways to improve. For this question, the sentiment was even more positive than it was overall.

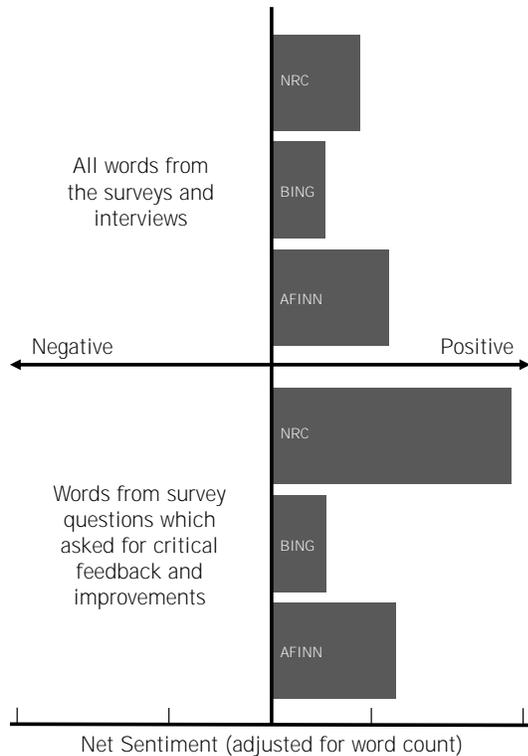


Figure 2. The net sentiment using three different sentiment lexicons (labelled on bars) for the surveys and interviews (on top) and just those in response to requests for critical feedback (bottom)

7. Discussion

The results show that prior to the CPD, teachers associated sustainability with waste issues and environmental/ecological topics. This finding is not too surprising given that other surveys regarding teacher knowledge on sustainability found that few K-12 teachers consider sustainability holistically (ecological, economic, social, well-being, and cultural aspects) (Uitto & Saloranta, 2017) and that the teachers rarely delve beyond surface knowledge (Pepper & Wildy, 2008; Stir, 2006). After participating in the CPD, the participants showed a significant improvement in their sustainability knowledge and demonstrated a shift from viewing sustainability as a content area associated with the environment to viewing it as a process and a way of interacting with people and the world. The broad misconception that sustainability is akin to environmentalism has been found elsewhere (Kagawa, 2007), and highlights the need to engage learners in social, cultural, and economic aspects of sustainability.

We found that real-world, hands-on, solutions-oriented activities were perceived as engaging and practical by participants. Not only did this result in a positive sentiment regarding the program, rather

than negative sentiments like guilt, but it also likely contributed to the significant improvement in knowledge. Other researchers in higher education have found that when students take courses that are community and practice-oriented and focus on active learning, their sustainability knowledge increases (Segalàs, Ferrer-Balas, & Mulder, 2010). The integration of solutions-oriented pedagogy has also been supported by researchers emphasize the need to adopt empowering pedagogies to avoid the sadness and anxiety associated with ecological crisis and to support an increase in confidence to take action (Boone, 2015; Hicks, 2002; Kagawa, 2007; A. Redman & Redman, 2017; Sterling, 2001). The increase in self-efficacy that we saw through the CPD aligns with the research that solutions-oriented pedagogies can increase the learners' confidence to act. The results shown here, as well as the research by Segalàs, Hicks, and others, demonstrates that the process of *how* we teach, not just *what* we teach, impacts program outcomes.

The CPD changed teachers' perception regarding modelling sustainability to their students. The increase in behavioural intention, at least in part, can be attributed to engaging teachers' whole personality (e.g., personal, social, and professional). Relevant for teaching students (Sipos, Battisti, & Grimm, 2008), it seems similarly relevant for CPD for teachers. We presented sustainability not just as what we teach and how we teach, but also as a framework for personal and professional decision-making. Research on pedagogical content knowledge for sustainability education suggests that, "teachers are not only regarded as professionals, but also as individuals with civic responsibilities and as role models with a public education function" (Bertschy, Künzli, & Lehmann, 2013, p. 5069). However, the focus of CPD should be on preparing the teacher for integrating sustainability in the school context, not on prescriptive behavioural outcomes (Bertschy et al., 2013). In the CPD, we only briefly covered (approx. 30 minutes) theories on social change, such as 'Diffusion of Innovations' (Rogers, 2003) and 'Community-Based Social Marketing' (McKenzie-Mohr, 2011), so in the instructional context there was little emphasis on behaviours. However, the teachers mirrored our approach to sustainability education—we modelled sustainability in our food, waste, transportation, and community-driven decisions for the workshop, and they saw that the modelling of these behaviours was impactful on the learners (themselves). We did not significantly change whether teachers felt modelling sustainability behaviours was important—two-thirds of teachers felt modelling behaviours was important before attending the CPD. However, through modelling sustainability ourselves, they experienced different ways and opportunities for modelling sustainable behaviours and a renewed focus on making a conscious effort to model sustainable behaviours to their students. These results show the importance of taking a whole program and whole person approach, rather than viewing the content and curricular instruction as separate from the operational decisions.

8. Synthesis

The design principles presented in section 2, above, informed the development of the CPD program, which in turn impacted the evaluation results (Fig. 3). For instance, to support co-learning, we asked teachers to apply in teams, then throughout the program they collaborated to co-generate a plan for

sustainability at their institution. As a result of the co-learning team approach, the evaluation showed that participants most frequently referred to interpersonal competence particularly with regard to collaborating with their colleagues. In terms of engaging pedagogy, we focused on solutions-oriented and real-world learning and the field trips were the activity that was mentioned most frequently as participants favourite part of the program. Self-efficacy refers to teachers' perception of whether they have the knowledge, skills, and resources to educate for sustainability and through taking a practice-oriented approach and providing resources through seed-funding for sustainability projects, we saw a significant increase in self-efficacy.



Figure 3. Interlinkages between CPD design principles, CPD program features, and evaluation results

9. Conclusions

In many ways, the presented CPD program is like other CPD programs—it is more effective when there is an initial intense intervention with long-term follow-up; collective learning improves outcomes; and providing practical resources, rather than over-theoretical content, supports the teachers turning their knowledge into practice. All education programs should be shifting to more engaging pedagogy, so this is not unique to sustainability. However, the focus on *empowering solutions* is a defining component of sustainability pedagogy (Wiek & Kay, 2015). Similarly, all CPD programs should be evaluating outcomes rather than inputs and processes; key is the attainment of sustainability competencies.

The presented CPD program diverges from more traditional CPD (e.g., Biology or Math CPD) in that every decision should reflect sustainability principles. CPD participants should not simply discuss stakeholder engagement or read case-studies where stakeholder engagement is critical to sustainability problem-solving. Rather, the participants should engage with key stakeholders in sustainability education during the program. Sustainability is a framework for decision-making, and successful

sustainability CPD programs are led by people that embrace and understand this as well as use sustainability to guide decision-making throughout the program. Through modelling sustainability actions within the CPD, we are reflecting what we hope the teachers do—which is lead for sustainability not just through curriculum but also through becoming a role model for sustainability personally, in society, and professionally.

The presented CPD program was designed based on best practices in professional development, sustainability education, and pedagogical development. We intended to launch a CPD model that equips teachers with the knowledge, skills, and motivation to create positive change. Initial success seems to be indicated as teachers strengthened their intention to become a role model inside and outside of the classroom, as well as significant changes in sustainability knowledge, sustainability competencies awareness and self-efficacy occurred.

While our initial applications show promising results, there are certainly areas for improvement. Our evaluation did not include assessing student learning outcomes nor did we assess the attainment of key sustainability competencies; rather we asked the teachers to report how they translated their knowledge and skills into practice and to reflect on their changing view of sustainability. Currently, we are working with researchers and educators through the Global Consortium for Sustainability Outcomes (GCSO) to transfer this program to other locations internationally, including Ireland, Germany, and Mexico, and develop tools to assess student learning outcomes and the acquisition of sustainability competencies. The difficulty in scaling this approach globally is that it is not a one-size fits all CPD model. Instead, it relies on local sustainability leaders sharing their passion for sustainable food, composting, reducing homelessness, improving walkability, and connecting mindfulness and well-being with sustainability, to name a few. Each place has unique strengths and weaknesses and its own stories of sustainability heroes to tell. However, if we can transfer a successful sustainability CPD model to diverse locations around the globe, there is the potential of impacting a large number of learners through leveraging the impact teachers have upon shaping the future.

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