What Building Operators Are Saying about BOC Training

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ABSTRACT

The Building Operator Certification (BOC) training program was developed in the 1990s and now operates in eighteen states. This paper draws on evaluations conducted of the BOC program in California, New England, and the Pacific Northwest. Most certified building operators report they have benefited from the BOC training. Their descriptions of what they have gained from the training align with the instructors' objectives. Participants state they have applied concepts from the training and improved the operation of their buildings, have saved energy and money, and have improved occupant comfort. These statements are substantiated by an examination of specific operation and maintenance (O&M) behaviors. Both when they compare their actions with their behaviors prior to training and when investigators compare their actions with the behaviors of their non-trained peers, building operators conduct more frequent and extensive O&M activities after training.

Introduction

There are many education and training programs intended to promote energy efficiency, yet their success in changing energy behaviors is often not known. The Building Operator Certification (BOC) program has been extensively evaluated from the perspective of BOC students and their supervisors. In addition, comparisons have been made between student and nonparticipant energy behaviors, as reported by the students and nonparticipants themselves. This paper explores what building operators are saying about the BOC training.

Program Description

Program Design

The Building Operator Certification (BOC) training program is an educational course for commercial and institutional building operators and facility maintenance staff. It teaches personnel how to operate and maintain building systems for optimal performance, energy-efficiency, and occupant comfort.

Facility operations and maintenance (O&M) activities have long been identified as critical components for the efficient operation of commercial and industrial buildings. Yet, building O&M personnel are often among the least educated building professionals about energy issues and the least valued of staff in a company. These conditions led energy efficiency professionals to wonder how operations and maintenance staff could receive training and education that would increase their capabilities, improve their estimation of the importance of their work, and raise their valuation by the market. The BOC is one response to this need.

The first of the BOC training and certification series is Level I training, which comprises eight days, typically conducted over a seven-month period. Its seven courses (one of the courses spans two days) include an overview of building systems and how they interact, energy conservation techniques, HVAC systems and controls, lighting and electrical systems, indoor air quality, and environmental, health, and safety regulations.

Level II course series and certification are available for students seeking to further their training. Level I graduates are eligible to enroll in the Level II courses, as are building operators who can demonstrate adequate preparation for the series. Four core courses and two supplemental courses comprise a Level II series. The four core courses address preventive maintenance and troubleshooting, HVAC maintenance, controls, and optimization, and advanced electrical diagnostics. The two supplemental courses are drawn from seven options, including motors, building commissioning, enhanced automation and demand reduction, electric control circuits, and water efficiency. The Northwest Energy Efficiency Council (NEEC), the developer of the program, has continued to expand the curriculum by developing more supplemental courses.

Students receive an instruction manual for each course. Instructors structure their lessons according to the manual. Instructors have been selected from among professionals active in the building trades and they offer their experiences to illustrate the course material. Instructors are encouraged to find opportunities for "hands on" learning and many bring end-use and testing equipment to the classes. Students are also encouraged to share their experiences and ask questions relating to their facilities.

Operators earn certification by attending the training, passing course exams, and conducting project assignments in their facilities. Initial certification lasts for two years. Thereafter, students must accumulate and submit evidence of re-certification hours. A number of activities potentially provide re-certification hours, including: formal classes offered by trade associations, utilities, the federal government, and others; energy efficiency projects conducted by students at their facilities; membership in trade associations and holding officer positions in these organizations; and other activities.[1]

The cost of the training varies by region and ranges from $1,095 to $1,400. In some regions, companies may pay a lower cost if their utility pays a portion or if they are a member of a sponsoring organization.

Program Locations and Evaluations Conducted

NEEC, extending efforts initiated by the Washington State Energy Office and the Idaho Building Operators Association, developed the Building Operator Certification Program for the Northwest Energy Efficiency Alliance (the Alliance) in 1997. The program continues to run in the Northwest.[2]

The BOC was first offered as a California statewide program in 2002. The California investor-owned utilities license the course from NEEC and have contracted with NEEC for its delivery. In addition, in 2001, the Sacramento Municipal Utility District licensed the course and delivers the training to its customers.

[1] For re-certification and other information on the BOC, see www.theboc.info.

[2] NEEC delivers the BOC in Washington, Lane Community College delivers it in Oregon, and the International Building Operators Association (formerly the Idaho Building Operators Association) offers in Idaho and Montana the training and certification curriculum it had developed. NEEC certifies all students successfully completing the BOC in every state except Idaho and Montana, where IBOA issues the certification.

In 2001, utilities belonging to the Northeast Energy Efficiency Partnership (NEEP) licensed the curriculum from NEEC. NEEP began conducting the training program in the eight-state Northeast region on behalf of its utilities in 2002. In the Midwest, the Midwest Energy Efficiency Alliance offers the BOC in four states (since 2002), and Wisconsin Focus on Energy offers it in Wisconsin (since 2001), for a total of eighteen states nationwide.

Detailed participant satisfaction studies have been conducted in three regions—the Pacific Northwest, the Northeast, and California (satisfaction study only)—and two of these regions have conducted impact studies. During the period in which it was funding the BOC as an efficiency venture, the Alliance conducted seven market progress evaluations, which are available on its website.[3] NEEP has conducted two evaluations of its BOC program.[4] Pacific Gas and Electric (PG&E), on behalf of the California utilities, is currently conducting its third evaluation of the BOC.[5] This paper draws from these studies' findings. The Midwest Energy Efficiency Alliance has produced four case studies highlighting the BOC, but has not conducted a program evaluation. The Energy Center of Wisconsin tracked student satisfaction and student comments on the course's impact, yet did not publish these findings.

Instructors' Objectives

The BOC curriculum aims to provide students with an understanding of how a facility functions as an integrated system. The training starts with a "building systems overview" to acquaint students with basic properties of energy and energy transfer and with how a facility's shell and electro-mechanical equipment function and interact to provide comfort and services to the occupants. After providing a framework for understanding a building as a whole, the series moves into an exploration of each of the component parts.

In describing what they hope students learn from their classes, BOC instructors commonly say they hope to teach students to "think differently" about their buildings, to increase their understanding and, as a consequence, change their behaviors in ways small and large. The BOC curriculum is not a checklist of operations and maintenance activities. It is designed to provide students with the understanding necessary to operate the equipment in their specific facility for optimal performance, occupant comfort, and energy efficiency.

Students learn how to calculate an energy use index (EUI) and how to benchmark their facility against other similar buildings. Working with the EUI and tracking consumption over time, students can begin identifying and prioritizing the systems that have the highest potential for savings.

An instructor of *Efficient Lighting Fundamentals* described how the course goes beyond teaching students to retrofit their facility lighting: "Lighting certainly has some immediate energy efficiency possibilities. We tell them up front you could go out tomorrow and reduce your

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[3] See http://www.nwalliance.org/projects/projectdetail.asp?PID=41#evaluations for the BOC market progress evaluation reports, which were prepared for the Alliance by Research Into Action, Inc. The final report includes an estimation of per-student kWh savings.

[4] NEEP's evaluation of their 2003 BOC program, conducted by RLW Analytics, is available through a link on http://www.efficiencymaine.com/pdf/BOCfinalreportdelivered.pdfl. The evaluation of their 2002 program is available on request from Research Into Action. Both studies include estimates of per-student kWh savings.

[5] The first two studies of the California Statewide BOC Program are available on the website of the California Measurement Advisory Council (www.calmac.org). The third California evaluation was underway at the time this paper was written. Research Into Action conducted all three studies; the PG&E author of this paper directed the second and third studies.

costs if you want to. But primarily, the time in class is spent making them aware that they can investigate their own situations and make a difference."

One instructor of several course topics offered the following: "The more students understand the operation of the equipment and their systems, the better they can make O&M decisions. You'd be surprised at the number of operators who know they need to change the filter, but do not understand the role the filter plays or what else they need to do."

An instructor of the energy conservation course summarized the value of the BOC: "I believe the number-one improved behavior of the class is confidence in the ability to do their job. With this instilled confidence comes a newfound opportunity to search for energy improvements in their operational routine. I have seen this extensively occur through responses from students that have kept up with me by e-mail. Before the class, the students would take for granted the recommendations of their peers or consulting engineers. After the class, they have a perspective that allows them to question, if not challenge, the logic of the problem."

The instructor gave an example of a former student responsible for overseeing modifications to a thrift store with outlets throughout the country. After taking the course series, the student evaluated the engineering plans and identified significant errors in the original design. He was able to incorporate energy saving features in the resulting modification. Because the stores in the region where he worked all had essentially the same design, the changes he made were also made at several other locations.

Instructors point out that while there may not be much in the BOC that students are hearing for the very first time, nonetheless the coursework presents the information in a way the students usually haven't considered. It reinforces information they may not have thought of in a long time. "Much of the course material goes beyond the operational process and introduces the basic physics of the reasons for the process they are familiar with," continued the instructor whose student influenced his store's design.

"The course presents multiple types of mechanical systems, of which they may have only seen one. They then understand several options of operations from a systems perspective. The result of this type of course—which is presenting the basic physics of HVAC systems, types of mechanical systems, equipment types, and operational procedures—is a new level of ability to reason or problem solve."

Building equipment is changing very rapidly, largely due to advances in controls technology. One instructor characterized the building operations industry as "changing faster than in any other industry except perhaps bio-med. The computerized integration of machinery is creating technology leaps every six months. The operators are exposed to these automation and communication technology quantum jumps in every area of equipment that they are responsible for. And they are given the least amount of training of any trade that I am aware of."

As energy efficiency professionals have recognized, energy-efficient equipment and controls will not, in themselves, generate energy savings. The building operator is the key link in producing the savings. People who spend time in facilities tell stories of staff passing by equipment that is not operating correctly, yet not assuming responsibility for correcting it.[6] For example, variable speed pumps may be operating continuously rather than at a reduction. Motivated by an understanding of the effects of poorly functioning equipment, instructors believe course graduates are more likely to take the initiative and correct problems.

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[6] For example, David Hawk of J.R. Simplot Company told an anecdote of six people in his facility repeatedly passing a steam leak without stopping to fix it. Presentation on March 9, 2006 as part of the Industrial Efficiency Initiative sponsored by the Northwest Food Processors Association.

Instructors hope that firms will increasingly recognize the value of trained building operators. “To really allow this new generation of operating engineers to produce the energy savings that the equipment makes them capable of means allowing them to be more involved in the process of decision-making. They should be involved with the design team from the beginning. They should also be recognized within the facility as the experts of operation and energy savings potential.”

Participants’ Assessments

Interviews with BOC students and their supervisors have confirmed that participants are benefiting from the course, which is consistent with instructors’ hopes and expectations.

Students and supervisors report that the BOC training results in participants having a better overall comprehension of facility operations—it helps them to see things in a new way. “The training tied things together for me,” and “it helped me organize and focus,” said Northwest participants. A New England participant said, “Now I think in terms of the facility. It’s like a super-organism. I’m able to think more developmentally about how various components interact. The training helped me to think in those terms.”

Most students report they learned some information from the series that was completely new to them. As Northwest participants stated: “It increased my knowledge and awareness of energy saving techniques.” “It broadens your range in any type of work. We are involved in all types of systems, so it gives a good overview. I even saved money on my own bill at home.” And from a Midwest participant: “The BOC homework is a very good learning tool. It makes you dig into your building to find the answers.”

Students frequently say the conversations they have with other building operators during the course provides a valued complement to the information provided by the instructors and they appreciate the opportunity the training provides for such discussions.

In California, about three-quarters of Level I students thought the course material was pitched at an appropriate level and about equal proportions (near 13%) thought it was too basic or too advanced (some information was covered to quickly). Similarly, 80% of Level II students thought the overall difficulty was “about right,” while 20% thought it too basic.

It would be a mistake to think the BOC is primarily of value to inexperienced building operators. Certainly, junior staff benefit, but most students enter the BOC having considerable building operations experience, supervisory responsibilities, and formal training in some aspect of building operations and maintenance (such training was reported by 82% of California students). Table 1 illustrates how assessment of the usefulness the BOC varied according to California students’ backgrounds. All interviewed students with less than ten years’ experience found the training to be useful to their jobs. Even half of the students with the highest levels of experience and responsibilities found the training useful. Yet the converse finding—that half of the most experienced staff did not find it useful led to the recommendation that BOC marketing materials clearly state the series is not intended for highly skilled operators.

Table 1. Student Attribution of Positive Influence of Level I BOC Training

BOC Had Positive Effect on On-The-Job Behaviors	Percent of Students
Students with Less than 10 Years O&M Experience (n=21)	100%
Students with 10 or More Years O&M Experience, No Supervisory Responsibility (n=12)	82%
Students with 10+ Years Experience, Supervisory Responsibility, Facilities Less than 1 Million Square Feet (n=21)	86%
Students with 10+ Years Experience, Supervisory Responsibility, Facilities More than 1 Million Square Feet (n=13)	54%
All Students (n=67)	84%

California students taking the Level II series were, on the whole, quite enthusiastic about the training. Several of the students spontaneously asked, "When can I take Level III?" Serendipitously, in the first interview with a Level II student, the student spontaneously said that the course was so useful, he would have been willing to pay for it himself. This comment led to a modification to the survey instrument and a corresponding question was added. Three-quarters (75%) of the 20 interviewed Level II participants said they would be willing to pay for the training themselves and 100% indicated they were "satisfied" or "very satisfied" with the value of the training in light of its cost ($1,095). The evaluation of NEEP's 2003 BOC program found that most students considered the series to be worth its cost ($1,400).[7]

A clear finding from the numerous BOC evaluations is that many students experience increased confidence in their abilities. Representative comments include: "I just feel better about my job. I've been doing this for 13 years and now I know I'm valuable." "The BOC helped my job performance simply by giving me confidence."

With increased confidence, trained operators take more initiative in their facilities and they take a more active role in working with contractors and their management. Said Northwest supervisors of Level II students: "In meetings, he is more informed about preventing problems." "He takes more responsibility. There have been fewer contractor calls. We've done more work in-house. And he is taking the lead on a rigorous energy conservation project for all 22 city buildings." One supervisor light-heartedly noted: "We made a dangerous man out of him by putting him through the training. Now all he wants to do is save money. The BOC gave him a lot of theory. Now he knows what he is talking about with contractors. Seriously, it has been great. Since taking the course, he has put together some nice packages, especially with HVAC."

According to students: "I can converse more effectively with my utility." "I'm more aware of problems and know where to look for them. I can include information in specifications for contractors." "Ninety-percent of the improvement is my new ability to explain to my executive board how energy conservation saves them money." "We used to seek a consultant to back up our ideas, but now the management believes us more."

Thus, BOC-trained operators are better able to advocate for their facilities with management (most importantly) and with contractors. Their concerns and advice are heeded more. This conclusion is supported both by the comments of students and supervisors, and by the job advancement of BOC-trained operators.

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[7] As a point of comparison, one of the authors received marketing materials from American Trainco advertising two-day training courses entitled *Boiler Operation Maintenance and Safety*, *Electrical Troubleshooting and Preventive Maintenance*, and *Understand Air Conditioning and Refrigeration Systems*. Each two-day course cost $790. The BOC comprises seven to eight days of training.

The two studies of NEEP's program asked students whether their job responsibilities, title, or compensation had increased subsequent to the BOC and, if so, whether they credited the BOC with their advancement. Both studies found similar proportions of students attributing advancement to the BOC. About 10% of students reported the BOC contributed to an increase in job title, about 20% credited it with an increase in responsibilities, and about 17% credited it with an increase in compensation, with some overlap among these groups.

The Level I and II students in California's program indicated the BOC training increased the likelihood that their companies would make energy efficiency investments (81% of Level I students, 95% of Level II) and would participate in utility energy-efficiency programs (73% and 90%, respectively). In the Northwest, 59% of Level I students and 71% of their supervisors indicated their firms were participating in utility programs.

Several of the studies sought to assess participant satisfaction with utility involvement in the BOC. Two-thirds of students interviewed in the first Northeast study thought their utility and NEEP were appropriate sponsors for the BOC certification. There was little agreement among the responses the remaining third offered when asked in an open-ended query to indicate a more appropriate sponsor. The first California study used a different line of questioning: Nearly half of students and supervisors would be more satisfied or more likely to send additional staff to the training were their utility more involved. About 30% of students and supervisors would be less satisfied or less likely to send additional staff were their utility less involved. In the second California study, 60% of students preferred that their utility offer the BOC, 10% preferred that it be offered by an educational or professional organization and 10% would like the training offered by both their utility and an organization. (The remaining 15% expressed no preference.)

So that's what building operators are saying about the BOC training. What are they saying about the effect of the training on how they operate their buildings?

Participants' Actions

Each study has explored how students believe their work has been affected by the training. Each study used a somewhat different set of questions in an evolving attempt to best capture the various effects that students might perceive as resulting from the BOC.

Table 2. Student Assessment of BOC Impact on Job Activities

BOC Impact	Northwest Study 7 (n=92)	Northeast Study 1 (n=49)	Northeast Study 2 (n=93)	California Study 1 (n=67)	California Study 2 (n=20)[A]
Uses BOC Information	—	90%	—	93%	95%
Improved Job Performance	87%	94%	—	75%	—
Saved Energy	75%	78%	85%	79%	80%
Saved Money[b]	78%	69%	87%	78%	75%
Improved Occupant Comfort	75%	76%	84%	67%	80%
Performs New Activities	—	57%	—	72%	70%
Does Some Activities More Frequently	—	57%	—	61%	55%
Does Some Activities Better/ Faster	—	—	—	—	70%

a. The second California study surveyed Level II participants.

b. The second Northeast study qualified the item "saved money" to read "saved money on labor and materials." The 87% given in the table is the percent of supervisors agreeing. Among students in this second study, the response was 46% agreeing.

Table 2 presents the findings across five studies, including the last study done for the Northwest program and the two studies completed to date for both the Northeast and California programs.

Supervisors interviewed in each study were asked the same or similar questions as were asked of students regarding the influence of the BOC on job activities. The proportion of supervisors in agreement with each statement was roughly similar to that of students, although for many items somewhat lower (ranging from 10 to 20 percentage points). Supervisors are often removed from what the students do on a daily basis and may not be in a position to judge the extent to which the student is applying BOC concepts. This is especially true for BOC students who are themselves supervisors, which was the case for nearly half of students in the first California study (all Level I students; see Table 1). Interviewed supervisors themselves often qualify their comments by saying they don't work closely with the student.

Three of the studies asked building operators about specific on-the-job O&M behaviors. These studies then applied engineering estimates of savings associated with the behaviors to estimate energy savings estimates for the BOC. The seventh Northwest study and the first Northeast study compared the extent and frequency of behaviors among BOC students and among nonparticipating building operators. The second Northeast study did not use a control group methodology, but rather asked participants whether the BOC program had influenced their performance of specific O&M activities.

Table 3 presents the O&M actions investigated by each study and the increase in the frequency or extent of each action estimated as attributable to the BOC. The second Northeast study produced separate estimates for two populations: schools and all other participants.

Table 3. Increase in O&M Activity Attributed to BOC

O&M Activity	Northwest Study 7 (n=92)	Northeast Study 1 (n=49)	Northeast Study 2 Schools (n=45)	Northeast Study 2 Non-Schools (n=48)
Air Handler Door Gasket Maintenance	23%	7%	13%	20%
Air Handler Damper Seal Maintenance	22%	4%	13%	20%
Heating and Cooling Coil Maintenance	3%	—	—	—
Chiller/ Cooling Tower Maintenance	—	7%	2%	27%
Unitary Equipment Maintenance	—	—	16%	24%
Economizer Maintenance	16%	3%	9%	10%
HVAC Controls Maintenance	—	19%	20%	12%
Efficient Lighting Installed	2%	0%	31%	37%
Boiler Maintenance	—	40%	11%	22%
Pipe Insulation	—	—	9%	18%
Motor Maintenance	—	3%	7%	31%
New Motors Installed	—	4%	13%	33%
Variable Frequency Drives Installed	—	21%	9%	18%
Air Compressor Maintenance	—	5%	7%	12%
Water Saving Measures	—	7%	0%	16%

All three studies applied engineering estimates of the average savings achievable from each O&M activity. The Northwest study estimated a *minimum* program impact of 0.14 kWh annually per square foot of facility tended by BOC-trained operators. This value was based on the five O&M behaviors for which the study located impact estimates; the study also determined that BOC-trained operators were more likely than nonparticipant operators to engage in an additional nine specific efficiency actions for which impact estimates were not available in the literature.

The first Northeast study estimated a *minimum* program impact of 0.18 kWh annually per square foot of facility tended by BOC-trained operators, based on nine O&M behaviors affecting electricity use for which the study located impact estimates. That study also estimated gas savings of 1.95 MBtu annually per square foot of facility (based on two gas O&M behaviors for which savings estimates were available in the literature) and water savings of 0.16 gallons annually per square foot of facility (based on operators' estimates).

The second Northeast study estimated a *minimum* program savings of 0.26 kWh annually per square foot of school facility tended by BOC-trained operators and 0.40 kWh annually per square foot of non-school facility, based on 13 O&M measures for which impact estimates were available. This study also developed gas, oil, and water savings estimates.

Table 4 compares the findings across the three studies.

Table 4. Estimated Minimum Resource Savings Attributed to a BOC-Trained Operator

Resources	Northwest Study 7 (n=92)	Northeast Study 1 (n=49)	Northeast Study 2 Schools (n=45)	Northeast Study 2 Non-Schools (n=48)
Annual Electricity Savings (kWh/SF)	0.14	0.18	0.26	0.40
Number of O&M Measures Contributing to kWh Estimate	5	9	13	13
Annual Gas Savings (MBtu/SF)	—	1.95	0.41	0.29
Number of O&M Measures Contributing to Gas MBtu Estimate	—	2	3	3
Annual Oil Savings (MBtu/SF)	—	—	0.77	0.14
Number of O&M Measures Contributing to Oil MBtu Estimate	—	—	3	3
Annual Water Savings (gallons/SF) (activities and estimated savings identified by respondents)	—	0.16	0	0.24

Note that all three studies have estimated *minimum* impacts of the BOC training. The estimates of all three studies are constrained by a lack of engineering estimates for a wide range of O&M actions and by limitations on the number of behaviors that can reasonably be explored in a telephone survey without inducing respondent fatigue. Both the Northwest and first Northeast studies concluded these constraints resulted in an underestimate of the impact of the seven-course BOC series. Consequently, these two studies concluded the program planning estimate of 0.5 kWh per square foot of student facility is reasonable. The Northeast study provided as a point of reference estimated savings for building retro-commissioning of 1.2 kWh per square foot.

Fortunately, the BOC training program is inexpensive to implement in relation to the large amount of square footage it affects. The BOC is cost-effective, even at the minimum savings estimated for the program.

Success Elements Evident in the BOC Program

This conference proceedings includes a paper by Tannenbaum et al. (2006) that identifies success elements for training programs, building on work by Anderson (2004). Tannenbaum identifies successful programmatic elements in the areas of program marketing, course design and implementation, and evaluation, many of which are evident in the BOC program. For example, marketing strengths exhibited by the BOC include designing a training for a specific profession or target market, communicating to potential attendees the direct benefits to them from the training, partnering with leading trade groups, and offering training at locations near potential attendees. Design and implementation strengths evident in the BOC include a curriculum structured to be practical and applicable to participants in their jobs, providing opportunities for attendees to participate and exchange ideas, and providing opportunities for post-training reinforcement. Finally, Tannenbaum identified evaluation strengths, several of which apply to the BOC program.

Tannenbaum's work thus provides a framework useful in identifying key elements of the BOC that contribute to its success. Unfortunately, Tannenbaum's work was partially informed by BOC program practices, as the BOC program was one of the training programs that Tannenbaum's sources referred to in their assessment of successful and unsuccessful training efforts.[8] Thus, while Tannenbaum's work provides a good framework for quickly delineating successful elements of the BOC, it is not an independent yardstick by which the BOC can be assessed.

Conclusion

Different studies have estimated differing energy savings estimates for the BOC program. Successive studies have built on their predecessors and energy savings are becoming better understood. Yet whatever the exact resource savings, it is clear that building operators are saying the BOC changes their on-the-job behaviors. Trained building operators report this influence in response to general questions such as "Are you applying the concepts you learned?" "How have you benefited from the training?" and "Are you saving energy? Saving money? Improving occupant comfort?" And trained operators reveal the influence of the program on specific O&M behaviors such as economizer maintenance, both in comparison with their own actions prior to taking the program and in comparison with control groups. Many features of the BOC—spanning marketing, design, implementation, and evaluation—illustrate successful practices for training and education programs.

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[8] Similarly, Anderson's work (2004) on training programs also reflects experience with the BOC.

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