

COMMUNICATION TURNS GREEN CONSTRUCTION PLANNING INTO REALITY

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ABSTRACT

Green planning is critically important during the design phases of construction projects but continually gets less attention during construction. Project owners and planners need to understand how communication influences green implementation. To address a gap in the extant research, this paper presents the evaluation results on how sustainability awareness of field supervision personnel impacts the successful completion of school projects by proving that communicating sustainability goals with them is vital for decision-making during the construction stage of the project. This paper uses data collected from 162 new school construction projects to compare sustainability design goals with their successful incorporation into completed projects. Seventy-one project managers and inspectors were surveyed to assess their awareness of key high-performance sustainability requirements that were built into the designs. The responses from these two groups were compared to examine the positive or negative impacts. The analysis results show that early and continuous communication of sustainability design goals with field supervision personnel has a significant impact on whether those goals are realized when the project is turned over to the owner for occupancy. Successful implementation of sustainability goals not only provides economic benefits from fully exploiting life-cycle costs, but also holds the promise of providing a healthier working environment.

KEYWORDS:

green buildings; building design; school buildings; project management; sustainable development

1. INTRODUCTION

Completing a successful, high-performance sustainable project requires more than a willing owner and a creative design team. A thorough commitment to the design is required by the construction team as well to maximize the potential investment by the stakeholders. The

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pressures associated with completing projects on time and within the budget often marginalize quality sustainable design. Even stakeholders committed to implementing a traditionally high standard of work can lose sight of the broader goals of sustainable design without the proper guidance. For example, the Los Angeles Unified School District (LAUSD) implemented sustainability design as part of their \$20 billion new construction program. The program began in 1998, with sustainable design being formally incorporated in 2003, when LAUSD implemented the Collaboration for High Performance Schools (CHPS) as a metric for sustainable design. CHPS is a point-based evaluation system to measure sustainable designs for K-12 schools. It addresses all aspects of school design, including construction, operation as well as energy efficiency (CHPS 2016). LAUSD is the first district to adopt CHPS. More recently, LAUSD has also used the United States Green Building Council (USGBC)'s Leadership in Energy and Environmental Design (LEED) rating system to build and certify green schools.

For its part, LAUSD is moving forward with its commitment to sustainable construction. The District has enlarged its Sustainability Group, which, in turn, is working to change sustainability standards from optional goals to contractual requirements. New Architectural/Engineering (A/E) contracts are being drafted to make CHPS/LEED certification a contract deliverable, with LEED Silver established as the benchmark for new buildings. The new contracts have language requiring A/E firms to inform the owner if design changes impact CHPS/LEED scores and/or sustainability goals. New contracts for construction management firms furnishing project managers for LAUSD include similar language. Revised contract specifications spell out LEED and commissioning requirements as well.

In introducing the sustainability standards for the new construction program, LAUSD incorporated the requirements that would earn certification credits directly into the LAUSD design standards. For example, rather than requiring designers to meet the general heat island requirements called for in the CHPS standard, the LAUSD design standard includes a requirement for cool roofs by specifically requiring white PVC roofs (or equal) to be used. While standards such as this sought to eliminate decision-making in the field by making the CHPS and LEED prerequisites and credits part of the design basis, it also made the sustainability standards less transparent to the construction team in the field. Therefore, the objective of this paper is to evaluate how sustainability awareness of field supervision personnel impacts the successful completion of school projects in an attempt to prove that communicating sustainability goals with field supervision personnel is vital in the process where communication turns green construction planning into reality.

2. LITERATURE REVIEW

2.1 Arguments for Owner Awareness

One of the major challenges for creating more widespread implementation of sustainable design is to convince owners that it is in their best interests to adopt green design. Changing the cultures of large organizations is not easy, as it requires education of stakeholders at many levels (Vanegas and Pearce 2000). Some sustainable elements are easily justified on a cost basis alone. For example, the installation cost of photo-voltaic arrays can be compared to utility savings. Other benefits are harder to quantify, but nevertheless provide a long-term benefit to the owner. Daylighting measures have been demonstrated to promote higher student productivity, while policy makers often only pay attention to the energy savings realized by turning

off the lights (Kelting and Montoya 2011). Reducing heat island effects by using reflective play surfaces can promote student health, but it is difficult to quantify such a benefit. Many elements of green design can be realized with little up-front cost. The evolution of CHPS/LEED credits recognizes that the process of green building construction can be as important as the design itself (Wu and Low 2010). Processes, such as green building commissioning and quality control, can fit into even modest budgets.

Higher capital costs are cited as reasons for resistance to sustainable design elements (Anchipolovsky and Balaa 2010). When analyzed solely from the perspective of the initial effort required to develop a property, the complexity of different systems in green building can increase construction schedules as well as costs (Shrestha and Pushpala 2012). While the up-front costs may be a legitimate concern for a property developer, school districts are prime candidates for sustainable construction as they have the time to recoup the up-front investment. School buildings are often designed for 70+ years of service and are maintained by the owner. USGBC studies point out that the high-performance buildings can save 8-9% in operating costs, allowing the up-front costs of sustainable design elements to be readily recovered (USGBC 2006a, 2006b).

2.2 Owner Commitment to Sustainability

Suppose the owner has made a commitment to “green” building - what does this mean? Does the commitment fade as the up-front costs rise and budget compromises become necessary? Making sustainable design a reality ultimately requires an owner commitment for the entire construction process. An owner may explicitly or implicitly express the will to complete green projects, but without verification that projects meet the true intent of the owner’s values, projects can easily fall short of expectations. A previous study attempted to create a system that characterizes such values associated with sustainable design to better gauge the needs and motivations of the owner (Jahani and El-Ghohary 2012). The study developed an axiological value assessment model and its integration with Building Information Modeling. Robichaud and Anantatmula (2011) showed that strong owner commitment to integrated project delivery systems can help to ensure that sustainability goals are met. Integrated project delivery should include early involvement by the contractor and ongoing team collaboration. The commitment to a cross-discipline team approach should be met by the owner with a system of awards and bonuses for achieving the established goals. Swarup and Korkmaz (2011) conducted an interview survey with two to three participants, including the owners, construction personnel, and designers for each of 12 office buildings and suggested that a strong owner’s commitment toward sustainability is one of the crucial attributes to meet sustainability goals, in addition to the integration in the delivery process by an early involvement of the construction personnel, and the early inclusion of green strategies.

2.3 Project Delivery Pitfalls and Strategies

Project delivery stakeholders must build consensus to work towards the same goals. Establishing expectations as to what constitutes project success is a key component of that consensus. It is no longer sufficient to bring a project in on-time and within budget while maintaining quality. The nature of that quality must be more carefully defined and managed. The traditional requirements of structural integrity and well-executed architectural finishes must be augmented with “green” quality features and documentation of sustainable construction and commissioning. Owners are increasingly concerned with building performance over many

years, while the more traditional requirements are already anticipated. Team members need to reconcile the additional requirements associated with sustainable construction in order not to marginalize them or, even worse, subject them to value engineering as time and cost pressures begin to mount. A survey showed that project delivery professionals without the proper preparation are not prepared for the added cost, delays, and learning curves associated with green building (Rahman and Sadeghpour 2010).

A collaborative design and good communication establish a solid framework for successful project delivery. To effectively use that framework, milestones and controls should be established to monitor project progress. Previous study has indicated that scoring systems such as CHPS and LEED provide guidelines for charting such milestones (Bosch and Pearce 2003). These tools, however, are not self-explanatory. It has been shown that contractors and other stakeholders are interested in sustainable design, but often lack the training needed to remove their doubts regarding participation in these projects (Bayraktar and Owens 2010). Once initial expectations are established, it is important to maintain communication among team members to manage the project and adapt to unforeseen conditions. Managing knowledge in the project becomes critical so that the proper team member can respond to a developing situation in a timely manner. It has been demonstrated that team members work more effectively together rather than separated. This can apply to the individuals working within a large organization as well (Khalfan and Bouchlaghem 2004). Especially, pre-project planning is a crucial part of project management practices for successful delivery and performance of green construction projects that pursues the building certification such as LEED (Weerasinghe et al. 2007).

2.4 Greening Project Management Practices

Since the green construction industry is growing fast and gaining popularity, a demand for greening project management practices is significantly increasing. Many construction companies have acknowledged that their successful implementation of green construction projects largely depends on a project management team that possesses management knowledge and skills to meet the owners' requirements (Frank 2002). Robichaud and Anantatmula (2010) presented the costs and trends of green building to make recommendations for greening project management practices for the construction industry and showed that greening project management practices can add significant value to a sustainable construction project while delivering it within acceptable cost constraints. Rwelamila et al. (2000) focused mainly on the organization structure and project delivery system and discussed the lack of appropriate focus on sustainable construction in two propositions, such as an inappropriate project organizational structure and a traditional construction procurement system, which causes a poor relationship management system incapable of dealing with sustainability parameters. Tan et al. (2011) reviewed sustainable practice in the construction industry and found a positive relationship between sustainability performance and business competitiveness. Hwang and Ng (2013) identified and discovered 10 essential management knowledge and skills that contemporary project managers require in managing green construction projects and compared their difference between traditional and green construction projects using a survey and an interview with project managers. The study contributes to construction industry knowledge of what attributes a competent project manager should possess with regard to green construction projects. However, this paper is different from the existing studies because it examines how communicating sustainability goals with field supervision personnel such as project managers and inspectors involved in the green building certification process is essential to successfully incorporating these goals into the completed projects.

3. RESEARCH OBJECTIVES AND METHODOLOGY

The research objective of this paper is to evaluate how sustainability awareness and communication with field supervision personnel affects the success of meeting sustainability goals. The success is measured by the positive and/or negative consequence in achieving the sustainability standards elaborated in CHPS criteria through both the analysis of actual CHPS project data and a survey with the professionals who possess the depth and breadth of the experience. CHPS projects are evaluated to consider how implicit versus explicit project requirements affect the ability of the team to meet the design intent. Two strategies were used to collect data for this paper. The first strategy was to collect project data from existing LAUSD databases. The second strategy was to distribute a survey questionnaire to the field supervision personnel such as project managers and project inspectors identified in the databases as they play significant roles in the specific projects. The data collected from the existing LAUSD databases was used to create and filter a list of projects for the focus study group. The list of projects was used, in turn, to identify the members of the survey panel who would receive the survey. Once the survey data was collected, the responses were all associated with specific projects in one large, unified database that would be used for all of the data analysis.

With regard to the data extraction from the LAUSD database, the project data for 162 new school construction projects was cross-referenced with the CHPS scorecard data. Projects were filtered out of the data set if: (1) CHPS data was not available for the project; (2) the project construction cost was less than \$2.5 million or greater than \$153 million, and (3) the project was a special sustainability/green pilot project. Once these group criteria were established, 139 projects remained in the study group. For the purposes of comparing project cost (award amounts), start dates (NTP), and CHPS credits, no duplication of the specific projects was permitted. CHPS design credit data was collected from both CHPS scorecards and summary scorecard data furnished by the LAUSD Sustainability Group. All of the credits for the designs were confirmed by a Global Breen USA associate.

As for the survey with the project managers and inspectors, the survey questionnaire was designed to ask questions in the categories of several parameters, which include general questions regarding the projects to validate and cross-reference the independently collected data such as description, construction cost, and project delivery method, training on CHPS/LEED, knowledge of CHPS/LEED requirements for the project, long-term values of CHPS/LEED, stakeholder involvement in CHPS/LEED verification, commissioning, value engineering, and recommendations for improving CHPS/LEED compliance. The survey was performed using Qualtrics online survey software for the higher response rate and made possible to complete within a very short amount of time.

Non-parametric tests such as chi-squared test, Mann–Whitney test, Wilcoxon signed-rank test, or Kruskal–Wallis test are used in the analysis of Likert scale data. The Mann–Whitney test is one of the nonparametric procedures which compare the population medians, while 2-sample t-test is its alternative parametric test for the difference between two population means based on independent random samples (Meyer and Krueger 2005). A nonparametric procedure has desirable properties that hold under relatively mild assumptions regarding the underlying populations (Hollander and Wolfe 1999). Therefore, the Mann–Whitney test is used for data analysis in this paper.

4. DATA COLLECTION AND CHARACTERISTICS

The authors collected data from a variety of school projects such as elementary schools, middle schools, adult centers, and early education centers. These school facilities are built using a range of project delivery systems such as Design/Bid/Build, 17406 Developers Agreement, and Design/Build. The California Educational Code provides for public contracting using all three of these project delivery systems. The Design/Bid/Build model is the traditional approach, requiring the owner to use the lowest qualified bidder. The 17406 Developers Agreement permits projects to be awarded using additional evaluation criteria such as project team experience and safety records in addition to the bid price. Design/Build project delivery is the most recent model. It permits the owner to pre-screen contractors using a Request for Qualifications (RFQ) process, followed by a weighted selection process using a Request for Proposal (RFP). All of the projects in the study group are part of the \$20 billion bond-funded new construction program with start dates (Notice To Proceed) ranging from 2003 to 2011. Many of the projects were for new school campuses, but projects for building additions and modernizations were included as well if they met the selection criteria as previously described in the Research Objectives and Methodology section. Project managers included in the survey were a mix of district employees and contract professionals, while the project inspectors were all district employees.

4.1 Data for Existing School Projects

Several data sources were used and assimilated into one large database that was then organized by associating all of the data with specific projects. The LAUSD project database, which is maintained by both the Inspection Department and the Project Execution branch, provided data for project descriptions, start dates, and award (contract) amounts. These databases also provided the contact information for the inspectors and project managers that would be contacted for the survey described below. Data was collected for 162 projects ranging in contract amounts between \$800,000 and \$300,000,000. A separate database furnished by the LAUSD Sustainability Group provided both CHPS scorecards and summary data for the scorecards. While LAUSD has begun to use LEED as a standard for some of its newer projects, it never dropped the requirement to meet the minimum standards defined by the CHPS system. The CHPS scorecards used by LAUSD assign both prerequisites and points for various sustainable construction goals. Prerequisites include meeting minimum regulatory requirements for site abatement, implementing best practices for stormwater management (SWPPP, Stormwater Pollution Prevention Plan), creating a water use budget, meeting minimum energy efficiency standards, meeting minimum requirements for commissioning and verification, meeting minimum recycling standards, providing minimum daylighting in classrooms, providing outside air to meet minimum air quality standards, meeting minimum acoustic performance (maximum noise level) in classrooms, and meeting thermal comfort standards. In addition to the minimum requirements, a total of 81 points can be earned from the categories of Site, Water, Energy, Materials, Indoor Environmental Quality, and District Resolutions. To become CHPS certified, a project must meet all of the prerequisites and earn a minimum of 28 of the 81 possible points. The CHPS scorecard data includes data from Design scorecards and Construction scorecards. As the titles imply, Design scorecards measure how the 100% construction documents meet the CHPS standards, while Construction scorecards measure the “as-built” conformance to the standards. Since the new projects have data for both LEED and CHPS, but the older projects have only CHPS data, the LEED data was not used for this

study to provide a larger and more consistent data set. Data for 135 Design scorecards and 31 Construction scorecards were collected out of 162 projects. The Construction scorecard may vary from the Design scorecard for a number of reasons, including value engineering of sustainability components (positive or negative), construction deficiencies, or missing documentation required for certification.

4.2 Survey Data with Field Supervision Personnel

A new survey was designed for this study to evaluate how field supervision personnel addressed issues regarding sustainable construction during the construction phase of the projects. Project managers (Owner's Authorized Representatives – OARs) and LAUSD project inspectors (Inspectors of Record – IORs) were asked a series of questions keyed to specific projects to incorporate their responses to the data collected from the existing databases. Where possible, the questions used a 7-point Likert scale to quantitatively measure response options such as "Strongly Disagree," "Disagree," "Somewhat Disagree," "Neither Agree nor Disagree," "Somewhat Agree," "Agree," and "Strongly Agree" to more effectively analyze the results. Other questions used "Yes/No" response options or had open-ended text responses that required categorization to be analyzed. After thorough investigation of the database, 149 OARs and IORs were identified from the LAUSD database and filtered to remove 61 people who did not work on projects that met group criteria. The survey was distributed to 88 professionals who were actually working on either CHPS or LEED projects at LAUSD. Of the remaining 88 people on the panel, a total of 30 OARs and 41 IORs completed the survey; 17 people did not respond to the survey, resulting in an 81% response rate.

5. COMPARATIVE ANALYSIS AND FINDINGS

5.1 Analysis on CHPS Credits

While the focus of this paper is to analyze data during the construction phase of the projects, it is worthwhile to point out some general trends exhibited by data that are driven by the design phase. The total CHPS score for the designs of projects at LAUSD has risen over the course of the bond-funded new construction program. A wide range of design scores were achieved early in the program, with many projects failing to achieve the minimum 28-point certification requirement. As the program matured, CHPS design goals were more standardized and incorporated further into project specifications. The variation in later years is less pronounced, but still substantial. The variation can be attributed in part to the different design goals for different projects. While LAUSD maintains a uniform design standard to be used as a baseline for all projects, the standards are edited to fit the specific needs of each school site.

A total of 31 projects have been identified as valid CHPS scorecard data where both Design and Construction scores are available. To summarize the CHPS scorecard data, the scores for the Design credits were subtracted from the scores for the Construction credits. The delta values obtained from the 31 projects were then tabulated and analyzed to determine if any patterns were present in the data. Analysis showed that there was a significant variability in the Construction credit data to be able to elicit any meaningful trends in the data, which doesn't provide a sound basis for a discussion of inferential statistics. The Construction credit data was accompanied by comments on the status of the scorecards. Nearly every comment was centered on the need to substantiate construction data. It became apparent that there

would be no way to distinguish whether the sustainability goals were being met but not completely documented, or whether they were not being met at all. The difficulties encountered in establishing predictive data, notwithstanding some comments, were found to be more prevalent than others. A common example of unverified data was the construction requirement to document site waste management. Another common way that points were lost during construction was the elimination of bike lanes or bike racks. A third common way that points were lost involves a conflict between the CHPS requirements for daylighting in the classrooms and a LAUSD resolution for security screens on the exterior windows.

5.2 Analysis on Survey Data with Field Supervision Personnel

Since it has been established that the available CHPS scorecard data was insufficient to be used as a metric for gauging the success of projects in the study group for meeting sustainability goals, focus was shifted to analyze the survey data. Responses from the survey were analyzed as positive or negative impacts. In addition, OAR (Project Manager) responses were compared to IOR (Inspector) responses. We chose the nonparametric procedure because all the observations from both OAR and IOR groups are independent of each other and the responses are ordinal, although nonparametric tests are usually less powerful than their corresponding tests. The test is used to determine whether one population median is shifted to the right or left of another population median. The number of responses for each of the questions in the categories varies because a few of survey takers did not answer the specific questions.

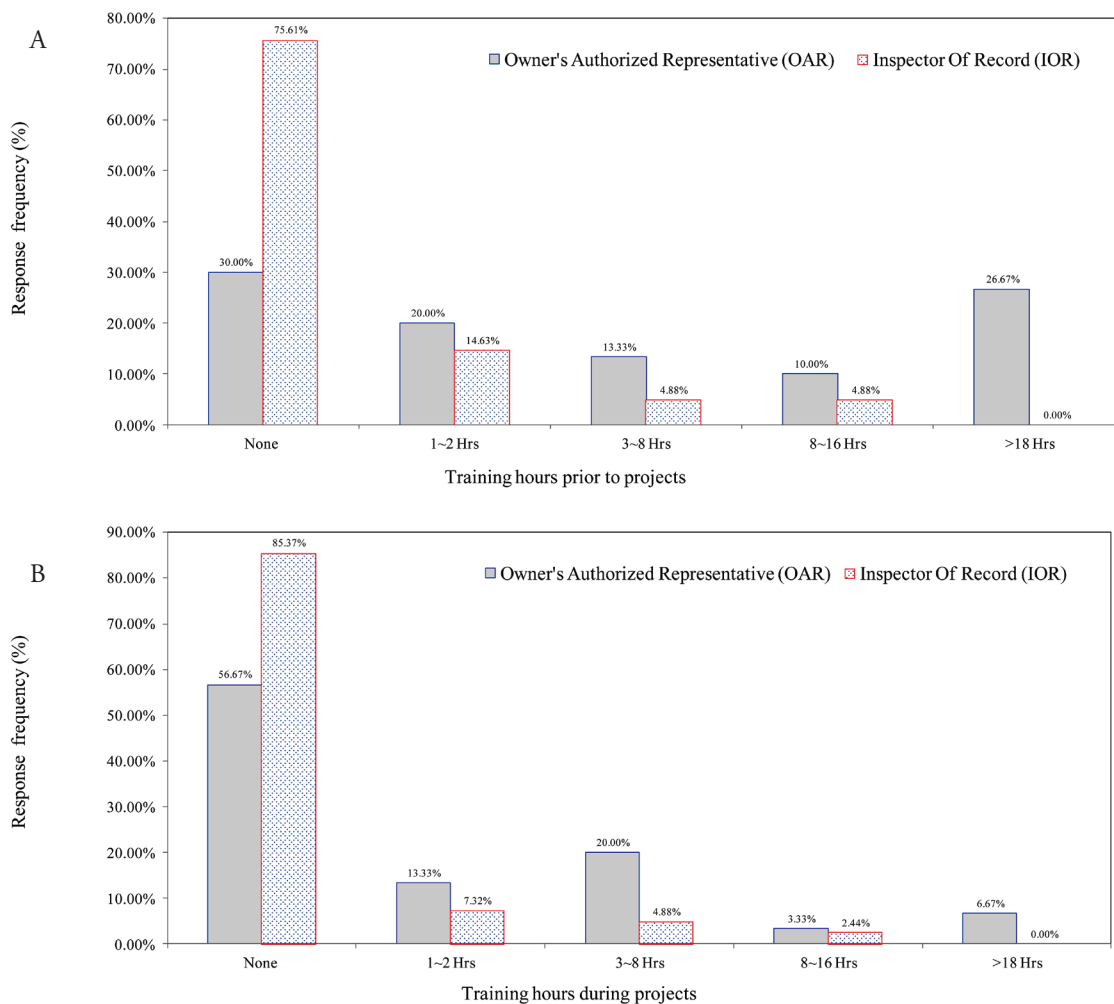
5.2.1 Training on CHPS/LEED

OARs and IORs were asked to indicate how much training in CHPS or LEED certification they had received prior to and during the involvement in the project. Figure 1 shows the comparison results of training hours between OARs and IORs prior to projects and during projects, respectively. Seventy percent of OARs surveyed indicated that they received more than 1 hour training in CHPS or LEED prior to projects, while 43.33% of them indicated that they received more than 1 hour training during projects. On the other hand, IORs indicated that they received more than 1 hour training of 24.39% and 14.63% prior to projects and during projects, respectively. The results indicate a greater degree of awareness of sustainability issues on behalf of the OARs prior to beginning a project, with the gap in training closing during the course of the construction phase.

The authors compared the training hours using the Mann-Whitney test to examine if the median value of training hours for OARs exceeds the median for those of IORs prior to projects and during projects, respectively. For the training hours prior to projects, the hypotheses are *Ho: The medians for OARs and IORs are equal* and *Ha: The median for OARs exceeds the median for IORs*. We reject the null hypothesis because the observed significance level of *p*-value of 0.0001 (Test statistic, $W = 1357$), which is less than $\alpha = 0.05$. Therefore, there is sufficient evidence to conclude that the median value for OARs exceed the IORs' median value for prior to projects. For the training hours during projects, we also reject the null hypothesis because of the *p*-value of 0.0190 (Test statistic, $W = 1222$). Therefore, there is sufficient evidence to conclude that the median value for OARs exceed the IORs' median value for during projects, as well. The results support that OARs receive more training hours than IORs for both prior to projects and during projects in CHPS or LEED certification process. This is consistent with the role that each group plays. OARs are involved from the beginning of the design development process to ensure project scope, budget, bidding process, risk management, construction

activities, and project close-out and occupancy to reflect the client's interests in both design and construction processes in CHPS or LEED certification process, while IORs start their inspection work once the general contractor mobilizes a project. Traditionally, the IORs at LAUSD would only become familiar with a specific project after the design was complete and the contract let. At this time they would join the project team and be party to the review of submittals and change documents that could affect the quality and service life of the facility. The training that they receive during construction is generally limited to understanding the existing approved design in order to ensure that proper installation and commissioning is achieved.

FIGURE 1. Comparison of training hours between OARs and IORs: (a) Prior to projects and (b) During projects



5.2.2 Knowledge of CHPS/LEED as Regulatory Requirements

The survey panel was asked to indicate that CHPS or LEED certification is a requirement for project closeout, Division of the State Architect (DSA) certification (permit sign-off), or receiving matching funds. State matching funds are state bonds approved through statewide ballot initiatives and used in construction, tests, inspections, sites, plans, and nonreimbursable

costs for new construction and modernization of schools (LAUSD 2010). Table 1 presents the survey responses and statistical results. For the responses in the categories of strongly agree and agree that the CHPS or LEED certification is required as regulatory requirement, OARs indicated 65%, 14%, and 69%, and IORs expressed 19%, 6%, and 56%, for project closeout, DSA Certification, and matching funds, respectively. The results mean that OARs pay more attention to the regulatory requirements than IORs, especially for project closeout and matching funds. CHPS standards are buried in the LAUSD project specifications and start as contract requirements. However, nothing prevents a project manager from later writing a change order to release a contractor from the items that contribute to the CHPS score. A final settlement for the release of retention can achieve the same result. DSA certification follows the same logic as project closeout. If LAUSD inspectors have signed off a punch list and DSA field engineers concur that no Fire/Life/Safety, Americans with Disabilities Act (ADA), or structural requirements of the approved plans and subsequent change orders are outstanding, contractual issues are not an impediment to state certification. Aside from some related Title-24 energy requirements, the state has traditionally been silent on sustainability issues. California Code of Regulations (CCR), Title 24, serves as building standards for the design and construction of buildings in California for improved safety, sustainability, maintaining consistency, new technology and construction methods, and reliability (CBSC 2016). Recent changes to the building code will change the state's oversight of "green building," but these changes do not impact the projects included in the study group. Matching funds follow the same logic as DSA certification, since matching funds are realized once certification is complete. CHPS requirements do not come into play from a legal point of view.

TABLE 1. Statistical Results of Knowledge on Regulatory Requirements*.

Response	Project Closeout		DSA Certification		Matching Funds	
	OAR n(%)	IOR n(%)	OAR n(%)	IOR n(%)	OAR n(%)	IOR n(%)
7=Strongly Agree	10(36)	3(8)	2(7)	1(3)	8(28)	11(31)
6=Agree	8(29)	4(11)	2(7)	1(3)	12(41)	9(25)
5=Somewhat Agree	2(7)	6(16)	2(7)	4(11)	1(3)	4(11)
4=Neither Agree Nor Disagree	4(14)	12(32)	6(21)	11(31)	3(10)	8(22)
3=Somewhat Disagree	0(0)	2(5)	1(4)	2(6)	0(0)	1(3)
2=Disagree	2(7)	5(14)	7(25)	10(28)	1(3)	3(8)
1=Strongly Disagree	2(7)	5(14)	8(29)	7(19)	4(14)	0(0)
Total	28	37	28	36	29	36
Statistics: Mode	7	4	1	4	6	7
Median	6	4	2	3	6	6
Mean	5.36	3.89	3.04	3.06	5.21	5.33
Std. Dev.	1.91	1.79	1.95	1.60	2.06	1.59
<i>p</i> -value (<i>W</i> , test statistic)	0.0016 (1163)		0.7607 (887)		0.9264 (964)	

* Note that AOR and IOR stand for Owner's Authorized Representatives and Inspectors of Record, respectively.

First, the authors compared the knowledge levels that CHPS or LEED certification is required for project closeout by examining if the median value for OARs is equal to the median value for IORs. For the response of the project closeout, the hypotheses are *H₀*: *The medians for OARs and IORs are equal* and *H_a*: *The median for OARs exceeds the median for IORs*.

We reject the null hypothesis because the observed significance level of p -value of 0.0016 (Test statistic, $W = 1163$), which is less than $\alpha = 0.05$. Therefore, we found that there is sufficient evidence to conclude that the median value for OARs is not equal to the IORs' median value. The results explain that OARs agree that the impact of CHPS or LEED certification impacted project closeout, but that IORs neither agree nor disagree about the impact. Secondly, for the response of the DSA certification requirement, the hypotheses are *Ho: The medians for OARs and IORs are equal* and *Ha: The median for OARs exceeds the median for IORs*. We do not reject the null hypothesis because the observed significance level of p -value of 0.7607 (Test statistic, $W = 887$), which is greater than $\alpha = 0.05$. Therefore, it was shown that the median value for OARs is equal to the IORs' median value. The results support that both OARs and IORs do not have any different views on the DSA certification requirement and both parties disagree that CHPS or LEED certification impacted DSA certification. Lastly, for the response of the matching fund requirement, the hypotheses are *Ho: The medians for OARs and IORs are equal* and *Ha: The median for OARs exceeds the median for IORs*. We reject the null hypothesis because the observed significance level of p -value of 0.9264 (Test statistic, $W = 964$), which is greater than $\alpha = 0.05$. Therefore, it was found that there is sufficient evidence to conclude that the median value for OARs is equal to the IORs' median value. The results indicate that both OARs and IORs agree that CHPS/LEED certification impacted matching funds.

The comparison results between OARs and IORs revealed the different viewpoints due to the matter of the responsibility of each group for project closeout however, each party is in agreement on the positive impact of DSA and matching funds. The differences in the responses can be attributed in part to previous training. While IORs saw CHPS as an abstract metric, OARs were told by LAUSD senior management that the projects could not be closed out without resolving the prerequisite requirements at minimum. The IORs were instructed by their superiors that these requirements were not a Code requirement and could be settled with a simple change document rather than a physical correction. Both OARs and IORs understood that Code was not impacted and that failure to meet CHPS goals would not affect DSA Certification. Neither the OARs nor the IORs recognized that CHPS certification had no impact on matching funds, unlike DSA Certification which ties to matching funds. The LAUSD prioritization of CHPS metrics may have led both groups to believe that there would be financial repercussions for failing to meet the standards.

5.2.3 Long-Term Value of CHPS/LEED

The survey panel was asked questions related to the long-term value of incorporating sustainable design into school projects. The long-term values of CHPS or LEED are broken into four questions such as cost value, environmental value, realistic value given duration and budget, and public relations. Table 2 presents the survey responses and statistical results. For the responses in the categories of strongly agree and agree that the cost and environmental aspects of incorporating sustainable design into school projects have long-term values, OARs indicated 64% and 83%, and IORs expressed 55% and 68%, respectively. OARs' responses indicated 72% of the long term value of the realistic impact given duration and budget, compared to 33% of the responses from IORs. Both OARs and IORs have indicated that the long-term value of public relations are not positive, revealing 18% and 19% for OARs and IORs in the categories of strongly agree and agree. These responses indicate a generally positive

TABLE 2. Statistical Results of Long-term Value of CHPS/LEED*.

Response	Cost Value		Environmental Value		Realistic given duration and budget		Public Relations	
	OAR n (%)	IOR n (%)	OAR n (%)	IOR n (%)	OAR n (%)	IOR n (%)	OAR n (%)	IOR n (%)
7 = Strongly Agree	9 (32%)	6 (16%)	11 (38%)	8 (22%)	8 (29%)	5 (14%)	1 (4%)	3 (8%)
6 = Agree	9 (32%)	15 (39%)	13 (45%)	17 (46%)	12 (43%)	7 (19%)	4 (14%)	4 (11%)
5 = Somewhat Agree	4 (14%)	8 (21%)	0 (0%)	7 (19%)	3 (11%)	13 (35%)	4 (14%)	7 (19%)
4 = Neither Agree Nor Disagree	4 (14%)	6 (16%)	3 (10%)	3 (8%)	4 (14%)	9 (24%)	4 (14%)	11(30%)
3 = Somewhat Disagree	0 (0%)	1 (3%)	0 (0%)	1 (3%)	0 (0%)	2 (5%)	3 (11%)	3 (8%)
2 = Disagree	1 (4%)	1 (3%)	2 (7%)	1 (3%)	1 (4%)	1 (3%)	5 (18%)	6 (16%)
1 = Strongly Disagree	1 (4%)	1 (3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	7 (25%)	3 (8%)
Total	28	38	29	37	28	37	28	37
Statistics: Mode	7	6	6	6	6	5	1	4
Median	6	6	6	6	6	5	3	4
Mean	5.57	5.32	5.90	5.68	5.75	5.03	3.32	4.00
Std. Dev.	1.55	1.38	1.40	1.16	1.24	1.21	1.94	1.70
p-value (<i>W</i> , test statistic)	0.2933 (1019)		0.1791 (1076)		0.014 (1110)		0.1602 (817)	

* Note that AOR and IOR stand for Owner's Authorized Representatives and Inspectors of Record, respectively.

attitude among field supervision personnel regarding the value of sustainable construction to both LAUSD and the environment, except for the public relations. Most responses found the values in LAUSD's commitment to green building.

The differences of both cost and environmental values are examined between two groups if the median values for OARs are equal to the median values for IORs. For the response of these two long-term values, the hypotheses are *Ho: The medians for OARs and IORs are equal* and *Ha: The median for OARs exceeds the median for IORs*. We reject the null hypothesis because the observed significance levels of *p*-values of 0.2933 (Test statistic, *W* = 1019) and 0.1791 (Test statistic, *W* = 1076) for cost values and environmental values, respectively, which are greater than $\alpha = 0.05$. Therefore, it was shown that the median values for OARs are equal to the IORs' median values. The results support that both OARs and IORs agree with the long-term values of CHPS or LEED certification. The studies cited in the background sections of this study point to the economic value of sustainable construction, and it appears the message is not lost on this survey panel. Secondly, for the long-term realistic value given duration and budget, the hypotheses are *Ho: The medians for OARs and IORs are equal* and *Ha: The median for OARs exceeds the median for IORs*. We reject the null hypothesis because the observed significance level of *p*-value of 0.014 (Test statistic, *W* = 1110), which is less than $\alpha = 0.05$. Therefore, we found that there is sufficient evidence to conclude that the median value for OARs is not equal to the IORs' median value. The results indicate that OARs agree about the long-term realistic value given duration and budget, while IORs somewhat agree with this. Lastly, for the response of the public relations, the hypotheses are *Ho: The medians for OARs and IORs are equal* and *Ha: The median for OARs exceeds the median for IORs*. We do not reject the null hypothesis because the observed significance level of *p*-value of 0.1602 (Test statistic, *W* = 817), which is greater than $\alpha = 0.05$. Therefore, it was shown that there is sufficient evidence to conclude that the median value for OARs is equal to the IORs' median value. The results support that OARs somewhat disagree about the long-term value of public relations, while IORs neither agree nor disagree it.

The comparison results between two groups showed almost similar agreement in three of four different long-term values with a little difference in the agreement level, while two groups do not see any long-term value out of the CHPS/LEED certification from the public relations perspective. In general, both OARs and IORs agree that sustainability initiatives have both environmental and financial value. These positive results indicating Cost Value and Realistic given duration and budget are somewhat surprising given the higher initial costs associated with sustainable construction. The fact that both groups acknowledged the initiatives as solely benefitting public relations indicates that some training or public outreach has educated the opinions of the majority of the participants.

5.2.4 Stakeholder Involvement in CHPS/LEED Verification

The survey panel was asked how different members of the field staff were involved in verifying sustainability requirements for the project. Table 3 tabulates the survey responses and statistical results. Fifty seven percent of OARs surveyed indicated that they strongly agree and agree that OARs involve in CHPS or LEED verification, while 23% of IORs indicated that the OARs' involvement from the perspective of OARs. On the other hand, IORs indicated that they strongly agree and agree the stakeholder involvement of 25% and 21% for OARs' and IORs' involvement, respectively, from the perspective of IORs. The nearly symmetrical distribution around the central response indicates that OARs viewed the responsibilities for verifying sustainability requirements as being shared equally.

Additionally, the authors examined the stakeholder involvement in CHPS/LEED verification by comparing the median values between OARs and IORs. It was shown that the median value for OARs is not equal to the IORs' median value. The results support that OARs agree with their involvement in CHPS/LEED verification, but IORs neither agree nor disagree with their involvement. For the IORs, it was shown that the median value for OARs

TABLE 3. Results of Stakeholder Involvement in Verification*.

Response	OAR Involvement		IOR Involvement	
	OAR n (%)	IOR n (%)	OAR n (%)	IOR n (%)
7 = Strongly Agree	7(25)	6(17)	3(11)	6(16)
6 = Agree	9(32)	2(6)	4(14)	2(5)
5 = Somewhat Agree	2(7)	6(17)	3(11)	4(11)
4 = Neither Agree Nor Disagree	5(18)	4(11)	8(29)	6(16)
3 = Somewhat Disagree	2(7)	4(11)	1(4)	2(5)
2 = Disagree	0(0)	5(14)	3(11)	6(16)
1 = Strong Disagree	3(11)	8(23)	6(21)	11(30)
Total	28	35	28	37
Statistics: Mode	6	1	4	1
Median	6	4	4	3
Mean	5.07	3.71	3.82	3.43
Std. Dev.	1.90	2.18	2.04	2.23
<i>p</i> -value (<i>W</i> , test statistic)	0.0184 (1067)		0.4785 (978)	

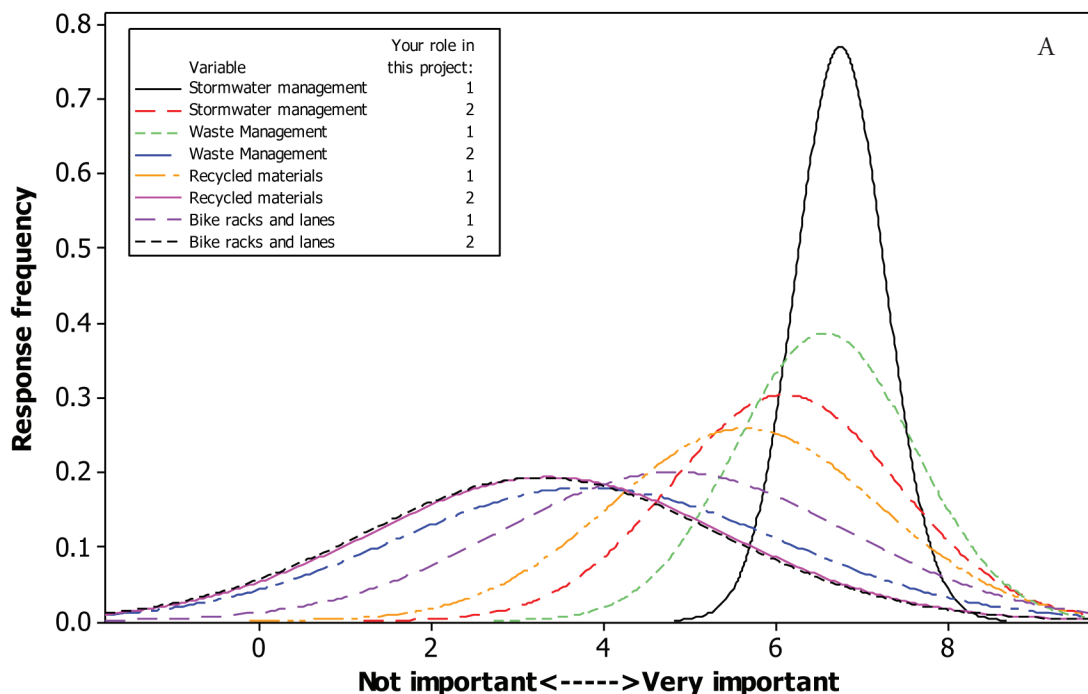
* Note that AOR and IOR stand for Owner's Authorized Representatives and Inspectors of Record, respectively.

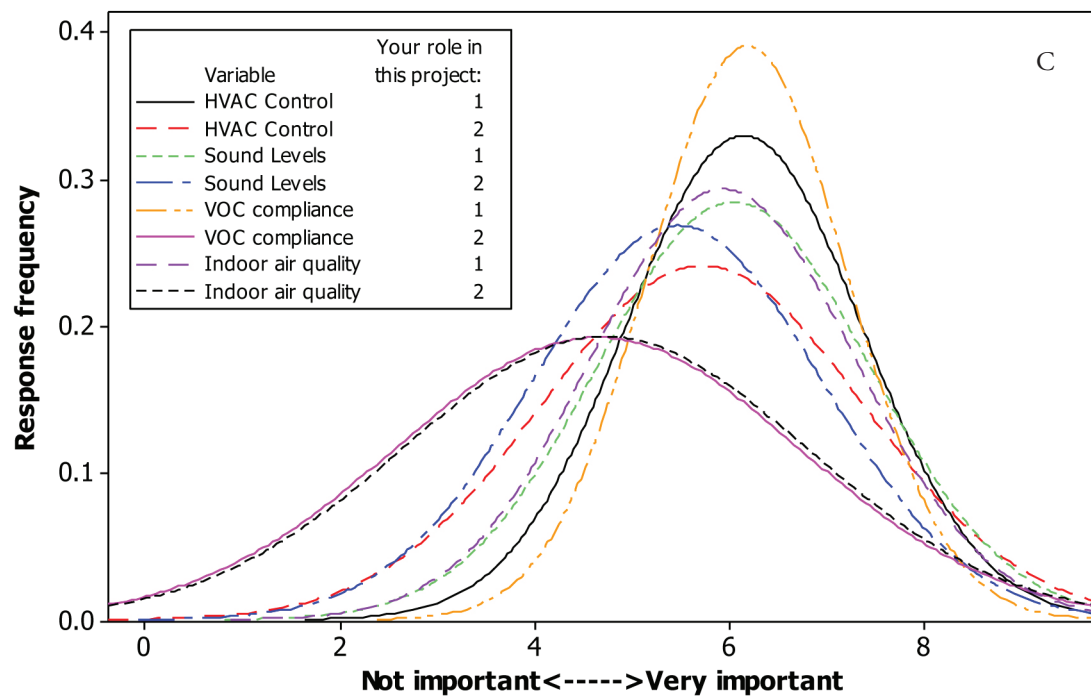
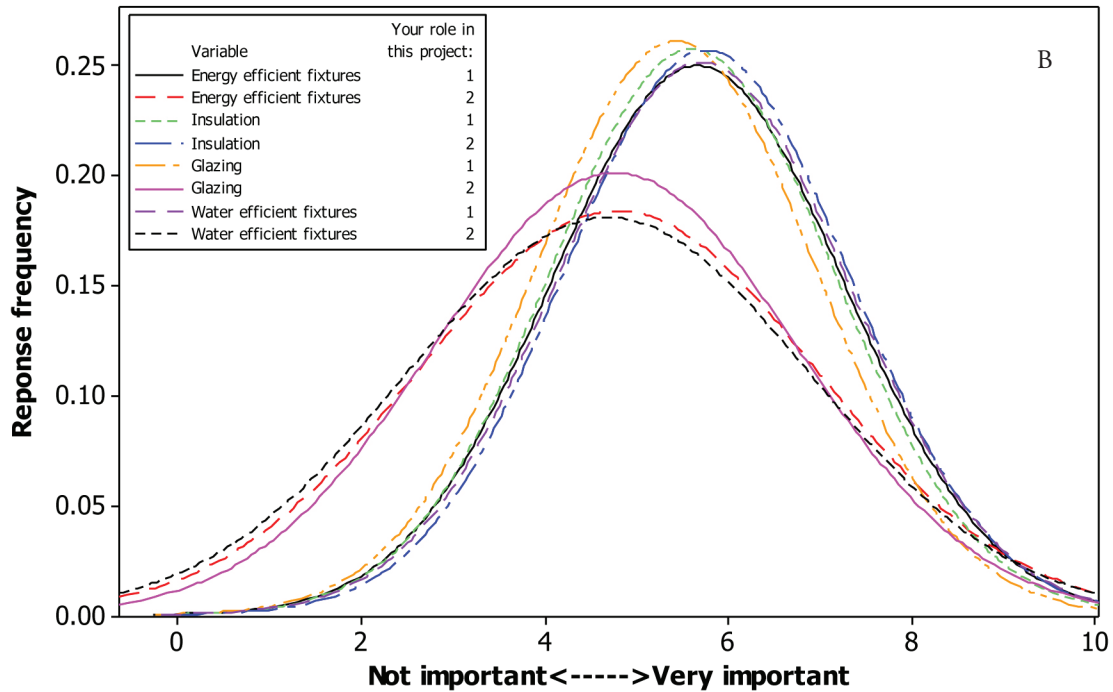
is equal to the IORs' median value. The results support that both OARs and IORs neither agree nor disagree with their involvement.

The survey panel was then asked to see if CHPS or LEED goals were frequently discussed during project meetings. For the responses in the categories of strongly agree and agree that the CHPS or LEED goals were frequently discussed during project meeting, 32% and 11% of survey responses from OARs and IORs, respectively, indicated that they agree the statement, which resulted in negative impacts that reveal the lack of communication during meetings. The authors also compared the CHPS or LEED goal discussion by examining if the median value for OARs is equal to the median value for IORs. We conclude that the median value for OARs is not equal to the IORs' median value, which means that OARs neither agree nor disagree the CHPS or LEED goals discussed during the project meetings, while IORs disagree it. Given that results from Table 2 indicate that both groups felt that CHPS/LEED provides value and that results from Table 3 indicate that all parties felt equally responsible for the outcome of the projects, it seems curious that one group felt sustainability issues were being given more weight at the progress meetings. One possible explanation could be that the OARs are referring to progress meetings with designers that are being held apart from inspection staff.

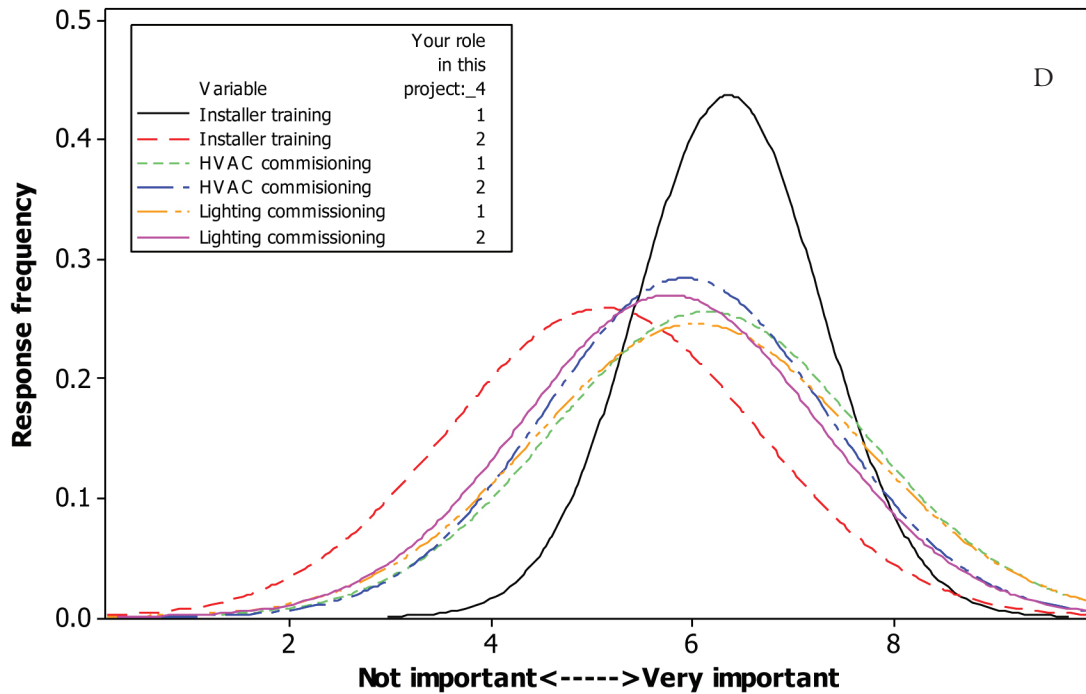
The survey panel was then asked to evaluate how important it was to verify the conformance of 15 different systems that relate to sustainability measures. Figure 2 shows the response results for the various systems, including (a) Site systems, (b) Energy and water systems, (c) Comfort and air quality, and (d) Commissioning and training. Figure 2(a) indicates that both OARs and IORs place a relatively high value on stormwater management. This can be explained by the fact that separation of stormwater systems is regulated by Code

FIGURE 2. Verification of System conformance: (a) Site systems; (b) Energy and water systems, (c) Comfort and air quality, and (d) Commissioning and training





and well documented by the approved construction documents. While stormwater retention systems may be elective measures, LAUSD has no history of compromising the design of these systems by value engineering. Conformance to standards for both waste management and recycled materials was given greater importance by OARs rather than IORs. While the IORs are generally in a better position to determine conformance, the requirements for



these standards are generally incorporated into the language of the general conditions of the contracts rather than into the construction plans and specifications, the general conditions being the domain of the OARs and the construction documents the domain of the IORs. The importance of verifying bike racks and bike lanes ranked lowest amongst the categories. This result is consistent with the comments for the CHPS Construction credit data where the bike racks/lanes consistently lost points. Figure 2(b) shows that OARs place a higher value on conformance for energy efficient fixtures, glazing, and water efficient fixtures while both OARs and IORs value insulation equally. The increased awareness of OARs may be attributed to greater training, while the relative importance placed by the IORs on insulation may be attributed to wariness related to a history of value engineering, specifically for mechanical insulation.

Figure 2(c) indicates that both OARs and IORs place a relatively high value on the conformance of HVAC controls. In this specialty both groups are well trained, having worked through multiple HVAC replacement programs. The expertise of LAUSD HVAC inspectors often allows the projects to forego third-party commissioning. OARs placed higher value on sound levels, VOCs, and indoor air-quality conformance. As mentioned previously, many of these requirements are reference by contract general conditions and as such are not the focus of the IORs. Indoor air quality testing is often removed from contracts through value engineering. Low sound levels, a CHPS prerequisite, are not necessary for occupancy and use of the facilities. The requirement is often waived if a cost-effective remedy is not available. Figure 2(d) indicates that OARs and IORs value HVAC and lighting commissioning equally, while OARs value installer training more than the IORs. As mentioned previously both groups take an active role in commissioning, but not necessarily third-party commissioning. Installer training is another general condition closeout requirement in which the IORs traditionally had no involvement.

5.2.5 Commissioning

The survey panel was asked to answer whether a third-party commissioning agent was used for their specific projects. The responses of “Yes,” “No,” and “Don’t Know” are 50%, 43%, and 7% from OARs, while those from IORs are 54%, 23%, and 23%, respectively. There is a moderate commitment to providing third-party support for verification of the installation of mechanical systems. Unlike LEED, the CHPS scoring system allows points to be earned for “Commissioning and Verification” by a third-party or by the district. At LAUSD, this may have a lesser impact on the quality of the verification compared with other owners since LAUSD has the resources to maintain a permanent staff of HVAC, electrical, and plumbing inspectors. Not only do the members of this staff have great depth of experience in their trades as they relate to the installations commonly installed at LAUSD, but they are also motivated by proprietary interests of achieving the goal of a long service life since they will be involved in maintaining the very same systems.

Many new construction projects at LAUSD originally had requirements for commissioning in their contracts only to have those requirements removed by the change order process. While this approach may indicate a lack of commitment to the verification process, it could also be construed as an effective cost-saving measure given the ability of the District to perform the work in-house. The areas where bypassing the use of third-party commissioning may not be as effective involve highly technical systems, like modern lighting control and energy management systems. Since LAUSD, as a public agency, cannot usually single-source a proprietary system, the variety and complexity of the new systems make it difficult for District inspectors to understand them in depth. The 7% and 23% of the responses for OARs and IORs indicated that the survey panel did not know whether a commissioning agent was a member of the project team, who expressed a certain lack of transparency in the commissioning process.

The survey respondents recommended that more training for field supervision personnel be the most effective way to improve CHPS/LEED compliance. The overwhelming frequency of this response is significant since the question was open-ended. The response to “incorporate CHPS/LEED into the design” was common among the IORs since the traditional role of the inspectors is to enforce the requirements of the approved design. “Observe and report” is a common phrase often repeated in the Inspection Department. This is essentially the way that CHPS was rolled out at LAUSD.

6. CONCLUSIONS

This paper investigated how LAUSD approached the promotion of new sustainability standards and how the implementation of those standards succeeded in practice. Descriptive data collected from the survey of field supervision personnel provided a good gauge for how the design standards were translated into reality. The findings of this paper demonstrated that most field supervision personnel want to believe that they are contributing to sustainable building, but are not brought into the project management process to feel as if they are part of the solution. The survey panel overwhelmingly confirmed that they need training to effectively contribute to the CHPS/LEED process. One way to better integrate the field supervision personnel into the process would be to have them participate more in the early design-phase activities, such as eco-charrettes and constructability reviews. Taking advantage of the depth and breadth of experience that these field professionals possess could not only increase their

sustainability awareness, but could also promote better design in general. Field supervision personnel could be drivers for a change in culture rather than obstacles to that change. Thus, the authors found out that communication is driving the variance in achieved credits, but not the project goals.

The disconnect between sustainable design and sustainable construction in one way stems from the structure of the CHPS and LEED systems themselves. The systems are set up as architectural tools, and as such focus on rewarding the architects and their design. Most of the points are not gained during construction, but during design, often before breaking ground. Combined with the practice of burying the requirements in the specifications, this “front-loading” of the sustainability credits runs the risk of confirming the doubts of the naysayers who label it as solely a public relations effort. What those naysayers need is to become a more integral part of the process, and, in doing so, learn the underlying value - both environment and economical - of sustainable construction.

Insufficient data related to the completed projects made an objective measure of “success” a difficult target. For instance, CHPS Construction credit data needs to be collected more to infer the meaningful statistical analysis. For future study, additional as-built construction data could allow the successful implementation of sustainability measures to be gauged more accurately. Projects could then be ranked, and the rankings could then be compared to other variables such as construction cost, training, commissioning, etc., to see if any of these variables have the ability to predict success or failure in implementing sustainability goals. Recently LAUSD has stepped up efforts to include more stakeholders in constructability reviews, including IORs. Future study could assess how these constructability reviews approach sustainable design. The success of the new program to meet sustainability standards could then be compared with the results of this study to gauge the effectiveness of these reviews. Lastly, further study may be required to understand how sustainability awareness of other stakeholders such as a public agency that manages huge project management programs for the entire school projects like LAUSD impacts the successful completion of green school projects. It is recommended to properly educate them to change the cultures of such a large organization in school projects to achieve the broader goals of sustainable design and construction.

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