Kim, Y.W, Azari , R., and Angeley, J. (2016). “Benchmarking in Integrated Design Process: UW-ARCF Case Study ” In: *Proc. 24th Ann. Conf. of the Int’l. Group for Lean Construction*, Boston, MA, USA,sect.4 pp. 103–112. Available at: <www.iglc.net>.

BENCHMARKING IN INTEGRATED DESIGN PROCESS: UW-ARCF CASE STUDY

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ABSTRACT

Integrated Design (ID) process has been recognized as an integrated approach to design process and prevailed in sustainable high performance building design. Though prevailing assumption is that a more integrated design process yields better performance results, measurement of integration is a largely unexplored area of research which can help participants in the ID process assess their integrated performance. In a previous publication, the authors investigated the relationship between the level of integration in the ID process and project performances using data from 55 LEED projects in which ID was employed. In this paper, the database and the assessment framework are used as a benchmarking tool to assess the ID process of ARCF (Animal Research Care Facility) project at the University of Washington Seattle campus.

We expect that the research would contribute to the domain of ID process by providing an assessment tool to be used by project owners and service providers to evaluate their ID processes.

KEYWORDS

Integrated design; benchmarking; Sustainable High-Performance (SHP) building

INTRODUCTION

In recent years, the growth in Sustainable High-Performance (SHP) building development has increased significantly due to the industry’s rapid response to environmental challenges. In order to design a successful SHP building, Integrated Design (ID) process is applied (Azari and Kim 2015) which recognizes interdependency of various aspects of sustainability in a building, and their complex interactions over the complete life-cycle of the building (Azari and Kim 2015). In addition, ID process maximizes the SHP building’s performance in terms of cost, energy consumption, and sustainability (7Group and Reed 2009). The success of ID process depends on the early involvement of project stakeholders and implementation of extensive technical knowledge and systems-thinking during the design phase (Azari and Kim 2015).

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Azari and Kim (2015) created a systematic evaluation framework that was designed to assess the level of team integration in the Integrated Design Process of Sustainable High-Performance buildings. Azari and Kim proposed that with the increase in level of integration in the design process, the achievement of outcomes can also be improved (Azari and Kim 2015). Their evaluation framework was developed based on the Context, Input, Process, and Product (CIPP) evaluation model (Stufflebeam 2003) that is widely applied in the business and educational contexts. Their evaluation framework consists of four components, which include evaluation model, evaluation factors, evaluation items, and a measurement format. In addition, the existing framework was validated with a quantitative methodology that uses a survey with 79 survey responses. With this framework, Azari and Kim (2015) expect that owners and architects can use the tool to evaluate and diagnose the performance quality of the ID process in respect to SHP building projects.

Functioning as a performance measurement system, the evaluation framework also allows companies and organizations to conduct benchmarking in the area of ID process of SHP building projects. With benchmarking, companies will be able to identify key strengths and weaknesses, and to implement necessary improvement strategies. This paper aims to show a case of benchmarking on UW's ARCF (Animal Research and Care Facility) project using Azari and Kim (2015)'s proposed evaluation framework.

ID (INTEGRATED DESIGN) EVALUATION FRAMEWORK

Azari and Kim (2015) proposed an integration evaluation framework for the ID teams of SHP projects. Figure 1 illustrates this framework which consists of four major components: a) CIPP evaluation model/categories, b) 20 evaluation factors, and c) 65 evaluation items.

Evaluation Factors (20 factors)

The evaluation factors refer to macro-level areas which need to be evaluated, under each and all four categories of the CIPP model, in order to assess the integration level of the ID teams in SHP projects. 20 factors were identified through qualitative research (Azari and Kim 2015). 'Collaboration', as one of the evaluation factors, was a broad concept and was broken into seven sub-factors, as shown in Figure 1.

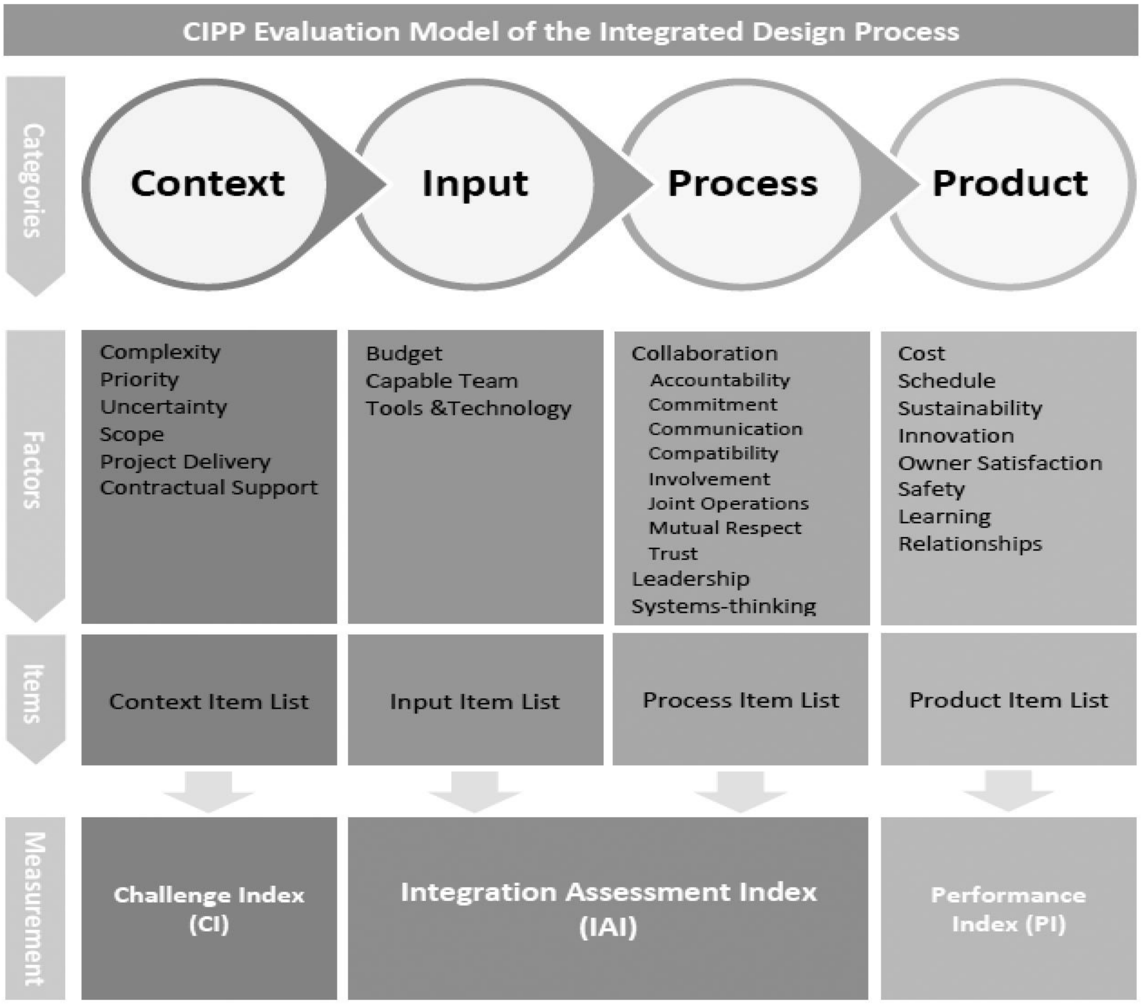

Figure 1. CIPP integration evaluation model for the ID teams of SHP projects (Azari and Kim 2015)

Evaluation Items (65 items)

To facilitate integration evaluation, evaluation factors were operationalized (i.e. specified) into 65 specific evaluation items – indicators - in order to provide tangible and measurable criteria for evaluation of the factors. These evaluation items were identified based on the interviews with industry experts as well as previous studies in the field. Some important issues considered in generating evaluation items included: reflection of the purpose, level of needed specificity or generality, clarity, validity, reliability, etc. (DeVellis 2003). The resultant final list of evaluation items included 65 items. Table 1 shows a random example of evaluation items that were specified to capture the presence of 'systems-thinking', as an evaluation factor, in the ID team environment.

Table 1. Four (4) evaluation items were specified to capture 'systems-thinking' (Azari and Kim 2015)

Systems-thinking	The ID team thoroughly discussed in the joint meetings the tradeoffs and synergies of the following major sustainability elements before making design decisions: (form and energy use, site potentials and energy use, site potentials and daylighting, site potentials and ventilation, daylighting and energy use, ventilation and energy use, etc.)
	The ID team thoroughly discussed in the joint meetings the impacts of design decisions across '*relevant disciplines'* before making design decisions.
	The ID team thoroughly discussed in the joint meetings the impacts of design decisions over the '*project lifecycle*' before making design decisions.
	The team as a whole is motivated to achieve sustainable design and followed opportunities for that through exploration and discussions rather than mere pursuit of green building rating systems.

Scoring

To use the proposed framework, the user will express his agreement with the evaluation item statements based on an equally weighted 5-point Likert scale in which the scores of 1, 2, 3, 4, and 5 reflects 'strongly disagree', 'disagree', 'neutral', 'agree' and 'strongly agree', respectively. Then, three simple indices aggregate the scores based on the equations 1 to 3: 1) Challenge Index (CI) represents challenges arising from the 'context' of a project; 2) Integration Assessment Index (IAI) represents the items in 'input' and 'process' evaluation categories which would indicate the level of integration maturity; and 3) Performance Index (PI) that represents the 'product' category. The following equations were used for building these indices:

Formula 1: $\mathrm{CI} = \sum \mathrm{S_c}$

Formula 2: $\mathrm{IAI} = \sum(\mathrm{S_i} + \mathrm{S_{ps}})$

Formula 3: $\mathrm{PI} = \sum \mathrm{S_{pt}}$

Where,

- CI, IAI, and PI refer to Challenge Index, Integration Assessment Index and Performance Index, respectively;
- S_c, S_i, S_{ps}, and S_{pt} refer to the scores assigned to evaluation items in the context, input, process, and product categories, respectively.

Using this measurement format, the minimum value for each index can be determined by using these formulas and assigning a score of 1, which represents 'strongly disagree', to all evaluation items in the category, or categories, corresponding to that index. Likewise, using a score of 5 (for 'strongly agree') results in the maximum values for CI, IAI, and PI. The performance of a given project on these indices would vary within the range between minimum and maximum values. To rate projects based on their performance on the three constructed indices, the ranges of indices were translated into multiple intervals shown in Table 2 (Azari and Kim 2015).

Table 2. CI, IAI and PI Indices and their Weight Ranges

Challenge Index (CI)		Integration Assessment Index (IAI)		Performance Index (PI)	
Extremely Challenging	29-37	Extremely Integrated	190-225	Extremely Successful	39-45
Moderately Challenging	20-28	Moderately Integrated	154-189	Moderately Successful	32-38
Somewhat Challenging	11-19	Somewhat Integrated	117-153	Somewhat Successful	23-31
Mildly challenging	2-10	Mildly Integrated	81-116	Mildly Successful	16-22
Not challenging	-7 to1	Fragmented	45-80	Unsuccessful	9-15

CASE DESCRIPTION: UW-ARCF PROJECT

The Animal Research and Care Facility (ARCF) is a two-level, 44,900 ASF, below grade animal research facility project on the University of Washington Seattle Campus. The project is intended to centralized and expand the University's animal research and care capacity for the next 10 years. Some of the program includes laboratories, procedure rooms, imaging facilities, cage, and equipment wash facilities; the project requires high flexibility in design. Due to the restriction of being a public project, the project proceeds with a GC/CM contract, however since the project is highly complex, an 'IPD-like' approach of team organization had been chosen.

Benchmarking Survey using IDEF (Integrated Design Evaluation Framework)

To obtain the data for qualitative benchmarking, survey was conducted as the main data collection method. The evaluation items and questionnaires based on the IDEF (Integrated Design Evaluation Framework) are used to assess the performance of the integrated design process. The survey was distributed to all project participants (24) who were involved in the design process through UW campus catalyst. Each project participant could log in and respond to each questionnaire through UW campus catalyst. 18 professionals participated in this survey; a 75% response rate.

Results

As discussed, the survey consists of three categories: context, process, and performance. This section addresses survey results in each section.

Context

The level of context reflects the level of uncertainty, challenges, and contractual structures that may affect the integrated design process. As shown in Table 4.1, ARCF scores 23.3 with benchmarking group averaged 24.1 (max score in this category is 40). ARCF is ranked in 43.89 percentile – which indicates ARCF is almost similar in terms of its context to projects in the existing database.

Table 3. Benchmarking Results: Context Level

Benchmarking Area: Context Level (out of 40)

	ARCF	Benchmarked Group		Percentile
		Average	St. Dev.	
CI	23.3	24.1	5.2	43.89%

Areas in Context Category

In the context category, the scope definition was scored "low" compared to projects in existing database as seen in Table 4. The project was scored only in 29 percentile. The question asked how you could rate the level of scope definition.

Table 4. Score of Scope Definition

Max = 5	ARCF	Benchmarked Group		Percentile
		Average	St. Dev.	
Scope Definition	2.63	3.04	0.74	28.98%

The research further investigated the responses by organizations: which might reveal different perspectives on the same issue. As shown in Table 5, all three stakeholders recognized and agreed that the project was not well defined initially.

Table 5. Score of Scope Definition by each Stakeholder

Max = 5	Group		
	Owner	Contractors	A/E
Scope Definition	2.5	2.25	2.33

Note: 5 = well defined

Process

The level of context reflects the level of integrated design process which includes the following ten factors: Accountability, Commitment, Communication, Compatibility, Involvement, Joint Operations, Mutual Respect, Trust, Leadership, and System-Thinking.

As shown in Table 6, the combined score of process category at ARCF is 164.73 out of 225. Compared to benchmarked projects, the level of integrated design process at ARCF is ranked in 73.31 percentile with average of 141.24. The score suggests that the level of integrated design process at ARCF is better than average of benchmarked group. The scores of each factor will be addressed in the next section with interview results.

Table 6. Benchmarking Results: Context Level

Benchmarking: Process / Integration Level (out of 225)

	ARCF	Benchmarked Group		Percentile
		Average	St. Dev.	
Process-Level	164.73	141.24	37.75	73.31%

Areas in Process Category

The area of mutual respect was scored in 32 percentile compared to projects in existing database as seen in Table 7. The questions asked to measure the level of mutual respect include:

- The team members are sympathetic towards other parties' situation.
- Project team members go beyond their obligations in meeting other parties' request.
- The team members feel valued by other team members.

Table 7 shows responses from each project stakeholder. The score of contractors and designers was lower than that of owners.

Table 7. Score of Mutual Respects by Stakeholders

Max - 5	ARCF	Benchmarked Group		Percentile
		Average	St. Dev.	
Mutual Respect	3.42	3.67	0.55	32.47%

Performance

The level of performance category reflects how well the project achieved project goals. Since the project just began its construction phase, only performances during design phase were evaluated. As shown in Table 8, the combined score of performance category at ARCF is 32.24 out of 40. Compared to benchmarked projects, the level of integrated design process at ARCH is ranked in 69.95 percentile with average of 28.13. The score suggests that the level of integrated design process at ARCF is better than average of benchmarked group. The scores of each factor will be addressed in the next section with interview results.

Table 8. Benchmarking Results: Performance Level

Benchmarking: Design Performance Level (out of 40)

	ARCF	Benchmarked Group		Percentile
		Average	St. Dev.	
Performance-Level	32.24	28.13	7.86	69.95%

Areas in Performance Category

The schedule performance was scored in 21 percentile compared to projects in existing database. All stakeholders agreed that design was significantly delayed.

DISCUSSION AND CONCLUSIONS

This paper shows a systematic benchmarking tool for evaluation of integration in the Integrated Design process. This dimension of contribution to knowledge is of special importance as previous literature (Xue, Shen, & Ren, 2010) highlights the lack of an effective framework to measure collaboration, an integration element, in construction industry. Functioning as a performance measurement system, the proposed evaluation framework of integrated design process allows project stakeholders to perform benchmarking in their integrated design process. With benchmarking, they will be able to identify key strengths and weaknesses as well as to develop necessary improvement strategies.

The research applied the evaluation framework of Integrated Design (ID) process to UW's ARCF (Animal Research and Care Facility) for benchmarking and performance analysis. The research used the survey results for conducting competitive benchmarking against the reference projects. The results showed that the project was highly integrated and expected to reach the goals. Although there were some areas for improvement, the project integration can be still operating effectively.

The benchmarking process is able to assist the project architect or owner in identifying key strengths and weakness in the area of project’s integrated design process. Moreover, the evaluation tool can be used as a reference or guideline to steer a integrated design team’s process.

ACKNOWLEDGMENTS

This research was supported by (1) UW-CPD (Capital Planning and Development)’s research fund and (2) P.D. Koon Endowed Fund of the University of Washington.

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