

Charting Contractor Performance in Public School Construction: A Longitudinal Case Study

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The public schools system is facing pressure on existing infrastructure to perform better and meet the needs of a growing population, while also decreasing costs and meeting tight deadlines. Public school construction projects present challenges with construction restricted to mostly the summertime, strict funding timelines, and public visibility. However, this area also presents opportunities to improve the students' experience, produce high-performing infrastructure, and impact conditions such as indoor air quality. School construction must be highly efficient and cost effective. A longitudinal study of improvement projects at a Midwestern school district is conducted to analyze project performance and contractor response to a selection and project management initiative. The results of this study indicate that performance was enhanced (change order and schedule delay rates). During this time, competition decreased and a concern was that costs increased. Charting contractor response over time shows that: the number of contractors proposing did not significantly impact costs and contractor hit rate improved by the second project, suggesting a vendor learning curve. Future research will more closely examine this trend within the school district and with individual contractors. Public school districts can use this research as they seek to improve efficiencies through alternative selection and management initiatives.

Key Words: contractor competition, metrics, performance, proposal response, public schools

Introduction

The gap in need and estimated investment to get public schools in the USA upgraded is staggering. According to the National Center for Education Studies (NCES) report (2014a) 53 percent of public schools need to upgrade their buildings by making repairs, renovations, and modernizations, with the estimated cost of these needs totaling $197 billion, or $4.5 million per school. The American Society of Civil Engineers (ASCE) rates the infrastructure of public schools to be a "D" (on a grade scale of A-F) and estimates the investments needed to upgrade and properly maintain public schools is $270 billion or more (2013). With such a large documented need and high associated investment required, public schools face pressure to get their facilities up to the desired level and to conserve resources at the same time. Efficiency and quality are critical to delivering these needed infrastructure improvements, which not only falls on the shoulders of public officials, but also on those that carry out these improvements.

Literature Review

The performance of school infrastructure must not only meet today's needs, but also those of the future. Overall, public elementary and secondary school enrollment is forecasted to increase by 6 percent (from 49.8 million to 52.9 million students), with state-by-state changes ranging from an increase of 26 percent in Nevada to a decrease of 11 percent in West Virginia (NCESb, 2014). Increasing public school enrollments place an added pressure on school's already constrained infrastructure. Many schools have a large amount of tenant improvement and renovation projects that have been previously postponed due to lack of financing (Education Evolving, 2004). Further, projects typically involve some form of board or voter approval which can be a lengthy process. In the state of Minnesota, proposed school construction projects have been historically receiving a declining board approval pass rate of 50-65 percent (Buresh, 2003). In response, some schools apply temporary means to address these needs, such as modular buildings. While response to these needs is critical, a more strategic approach is warranted due to the magnitude of this issue.

The specific areas in poor condition in permanent school structures have been identified as: windows, plumbing, and heating (NCESa, 2014). Special attention is needed to improvements in indoor air quality. In particular, one study found that many schools have very poor indoor air quality and poor air ventilation (Daisey, Angell, & Apte, 2003), with many not meeting ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) recommendations. The Minnesota Department of Health (MDH) has identified indoor air quality (IAQ) issues to be of high importance in the school environment. As a result, Minnesota law mandates that each public school district has a plan for monitoring and improvement of IAQ issues (MDH, 2015). MDH takes a proactive approach to IAQ, realizing that preventative maintenance and repairs to existing buildings can often lead to savings as compared to reacting to issues as they arise.

With such a large documented need, benchmarks and quality measures will be needed to ensure that the added infrastructure is improving performance and meeting the documented needs. A study by Crampton (2009) using state student standardized test data (from reading and math) and capital outlay expenditures (from the US Census Bureau) on school infrastructure revealed that investment in school infrastructure (i.e. new buildings, renovations, maintenance, etc.) is linked to increasing student performance. Current research on public school construction focuses on the involvement of a Construction Manager (CM) to improve construction project performance (Debella & Ries, 2006; Günhan, Arditi, & Doyle, 2007) or alternative delivery systems, which have had varied results (Rojas & Kell, 2008). However, initial factors, such as contractor selection and performance indicators in public school construction projects are not explored. Further, research giving special attention to the areas of renovation needing immediate attention, such as indoor air quality, is needed. Research and initiatives must be measured to determine their impact on meeting the needs of school infrastructure to be efficient and minimize cost.

Research Objectives

A common response to the pressure of decreasing budgets and reduction in resources in public school spending is to eliminate or postpone projects. The burden to get the best "deal" may result in public school decision-makers selecting contractors by using low-bid award criteria. This pressure is felt at the school district level as well as at individual schools that suffer due to incomplete projects. A new initiative to select contractors based on performance and price was undertaken at a public school district as a way to address diminishing resources and a need for infrastructure improvements. The initiative involved both procurement and project management processes. In order to measure the impact of this initiative within the school district, a longitudinal study of contractor performance was conducted. Charting of contractor responses and changes over time would give school districts and public officials the metrics to become more efficient by looking at their projects executed over a period of time and determining the impact of the initiative on project performance. The metrics can also be used in determining the characteristics of the highest performing contractors to execute these constrained projects. On the contractors' side, charting of contractor responses over time may also assist contractors in determining the most successful approach to developing a winning proposal.

The primary research objectives of this study were to:

1. Identify the impact of project performance (cost and schedule) information, especially in project scenarios with a limited construction season.
2. Understand the dynamics of contractor responses and competitive factors in a "measured environment".

Method

A longitudinal study of a large public school district (PSD) in the State of Minnesota was carried out to chart contractor and project performance. A total of 39 construction projects at 11 different schools were completed during the PSD's longitudinal study across 6 years. A majority of the work (62 percent) was mechanical work primarily in Indoor Air Quality (IAQ) improvements. The other work, in General Construction and Electrical, were other improvements made at the schools while the IAQ renovations were taking place. Due to the district's school calendar, all projects were given an average of three-month timeframe to complete construction (during the summer vacation months). During the period of the longitudinal study, there were no changes to project management personnel at the PSD, minimizing confounding variables.

As part of a new initiative, the PSD utilized a project selection and management initiative (PSMI) with the goal to create an overall measured environment (with price representing 30 percent weight and performance representing 70 percent weight) and also required the awarded contractor to track their performance (cost, schedule, and satisfaction) on a weekly basis. During the project management or execution stage, the PSMI does require additional marginal effort on behalf of the awarded contractors. However, the increased levels of transparency and subsequent public accountability is a primary benefit of having this measured environment (Dicke & Ott, 1999; Mosher, 1980). The researchers wanted to understand what impact, if any, these increased levels of transparency had on project performance and contractor response.

To fully understand project performance (research objective one) due to implementation of the PSMI, change order rates and schedule delay rates were measured and charted across the life of the PSD's program (2008 – 2014). To measure contractors' responses and competitive factors (research objective two), the following measurements were calculated by contractor: contractor hit rate (ratio of projects awarded divided by the number of projects proposed on), percent proposal cost is above/below budget, percent proposal cost is above/below average proposal cost, percent proposal cost is above/below awarded contractor's proposal cost, and percentage of evaluation points is above/below evaluation points of awarded vendor.

Data Collection

In order to chart project performance and contractor response to the new initiative over time, data was gathered by both the procurement department and project management department of the PSD. In procurement, PSD personnel tracked the following measures on all projects and all contractor proposals: contractor name, proposed cost, average proposal cost, proposed project duration, proposal score, ranking, and name of awarded vendor. In project management, PSD personnel tracked the following on all projects: budget, date of project start, final cost, and final duration (calendar days). All charting over time utilized the date of project start to indicate timing.

As part of the PSMI, the school district instituted a formal performance measurement system for the projects in this study that was managed by the project management department. The system required contractors to record any changes or risks to the awarded cost, duration, and the clients' satisfaction with the contractor. The contractor emailed the risk reports to the key stakeholders (owner, purchasing, architects, facilities, and other interested parties) on a weekly basis. The reports included a summary report on the project's overall status. While the performance data was not publically provided, each project's procurement results were posted on a public website. Informal interviews with various contractors revealed that this data was commonly referenced and considered in their future proposals. The change order rates and schedule delay rates were calculated from the performance measurement system and validated against the project management department's financial records/invoices.

Results and Data Analysis

Below, the researchers address project performance and contractor response factors in the measured environment.

Project Performance

The performance data was classified by project type (Mechanical, General Construction, and Electrical) and overall in order to see if any major differences exist. The mean awarded cost per project was $977,749 and the total cost of all 39 projects was $38,132,214. Note that while the mean awarded schedule is 203 calendar days (about 6.5 months), many of the projects were split between two summers – all projects still had the short summer construction schedule constraint. The Overall Cost Changes (or change order rate) are calculated by summing the total cost increase or decreases, and dividing this by the awarded contract value. The Overall Schedule Changes (or schedule delay rate) was similarly calculated. Negative values indicate a cost or schedule savings.

The researchers only had performance data on the projects measured in the system – data from the PSD's other traditional or "low bid" projects was not available. A similar study estimated the traditional change order rate for a public school district (in an undisclosed location) to be 12 percent (Günhan et al., 2007). No similar studies in public school districts that investigated schedule delay rate were found. In general, the PSD appeared to experience exceptional results on projects studied herein. Across the 39 projects, the overall cost change was 4.7 percent and overall schedule change was 1.5 percent (Table 1). At the PSD, the primary driver of all cost and schedule changes were non-contractor items, specifically the owner. By project type, the electrical project type appeared to have the highest change order rate and general construction project type to have the highest delay rate.

The savings in cost and schedule changes overall was an anticipated outcome of the PSMI, but still a positive result. The overall performance results are similar to those in a separate study done by the researchers (see Lines, Sullivan, Hurtado, & Savicky, 2014). This study analyzed projects in a similar performance selection and management initiative versus those that were primarily low-bid. Results of that study showed that the average overall cost and schedule delay rate of the measured projects was 6.8 percent and 49.2 percent respectively, while the traditional projects was 12.2 percent and 89.3 percent, respectively. Therefore, the researchers surmise that the PSD may have similar performance results on their traditional projects (recognizing, of course, that the differences between the PSD and the federal agency studied could significantly affect the validity of any such inferences).

Table 1

Overall Performance Data by Project Type

Category	**Mechanical**	**General Construction**	**Electrical**	**Total**
Total Number of Projects	13	12	14	39
Total Awarded Cost	$23,752,631	$8,939,019	$5,440,564	$38,132,214
Mean Awarded Cost	$1,827,125	$744,918	$388,612	$977,749
Overall Cost Changes	1.7%	8.4%	11.9%	4.7%
- Overall Cost Changes (Contractor)	0.0%	-0.2%	-0.3%	-0.1%
- Overall Cost Changes (Non-Contractor)	1.6%	8.6%	12.3%	4.8%
Total Awarded Schedule (calendar days)	2931	2247	2743	7921
Mean Awarded Schedule (calendar days)	225	187	196	203
Overall Schedule Changes	0.9%	3.2%	0.5%	1.5%
- Overall Schedule Changes (Contractor)	0.2%	0.0%	0.0%	0.1%
- Overall Schedule Changes (Non-Contractor)	0.8%	3.2%	0.5%	1.4%

Contractor Response

The primary concerns of the PSD remained: efficiency and assurance of getting the best "deal." While the location of the PSD is within a large city, it is geographically separated from other major metropolitan areas. This is important because the loss of a single contractor proposing can be significant when there is only a limited pool of contractors who service the area. The contractor response in terms of competition is measured using the project competition intensity (PCI) over time. The PCI was developed as a means to measure project competition that occurs among contractors and is measured by the number of competitors on a project (Ye, Jiang, & Shen, 2008). Table 2 shows the PCI over time, revealing a decrease.

Table 2

Average Number of Proposals per Project

Year	Mechanical	General Construction	Electrical	Total
2009	6	2	1	3
2010	4	5	4	4
2011	4	4	4	4
2012	2	4	2	3
2013	3	3	2	3
2014	2	3	2	2

With decreasing PCI, a potential concern might be perceived as increasing costs (due to less competition). To better understand what might be driving this change in competition, the researchers analyzed four contractor response metrics across time:

1. Contractor previous hit rate, which is the number of projects a given contractor was awarded (previous to the current project in time) divided by the total number of projects they had proposed on (again, previous to the current project).
2. Proposal performance, which is the owner's evaluation rating of the contractor's proposal (normalized)
3. Difference of contractor's cost proposal compared to the average (normalized)
4. Difference of contractor's cost proposal compared to the budget (normalized)

For these analyses, only contractors that were awarded at least one project were considered (a total of eight contractors). To measure changes in contractors' approach over time with successive projects, the time was represented as "1" meaning a contractor's first project, "2" representing a contractor's second project, and so on. Data were compiled for all contractors. Note that some contractors have different first projects from others. That is, Contractor A's first project could be on School Project ABC, while Contractor B's first project could be on School Project XYZ. Both of these projects (ABC and XYZ) would be included in the Project #1 data point. The four factors analyzed are agnostic of the actual project details and scope (which is why the data used to analyze factors 2 – 4 is normalized). For each Project #, the contractors were grouped into one of two groups: whether they were awarded the contract or not awarded the contract. This helped to highlight trends over time, and therefore yield more useful insights.

The contractor response metrics can be seen in Figure 1 and Table 3. The first charting of contractor response in terms of hit rate over time reveals an interesting comparison. Comparing losing contractors to awarded contractors, a kind of "learning curve" emerges showing an increase in hit rate as awarded contractors performed the work (i.e. after project #2). In comparison, losing contractors did not show a similar curve. This "learning curve" may be due to the learning that comes with each successive project completed, which provides a chance for contractors to become more familiar with the PSD environment, constraints, and general practices, giving a type of competitive advantage.

Comparing proposal performance of awarded contractors against losing contractors shows a narrowing of the gap over time. Initially, awarded contractors' proposal ratings far exceeded losing contractors, but over time there was less differential. A significant negative relationship between awarded contractors' proposal ratings and time was uncovered.

Contractor response in terms of comparing cost vs. average cost or budget over time shows that awarded and losing contractors were not very far from one another, but did not reveal any significant relationships. However, in response to the PSD's concern of getting the best deal, it seems that contractors' cost proposals compared to the average cost proposal were close (within 20%) and similar as compared to the budget.

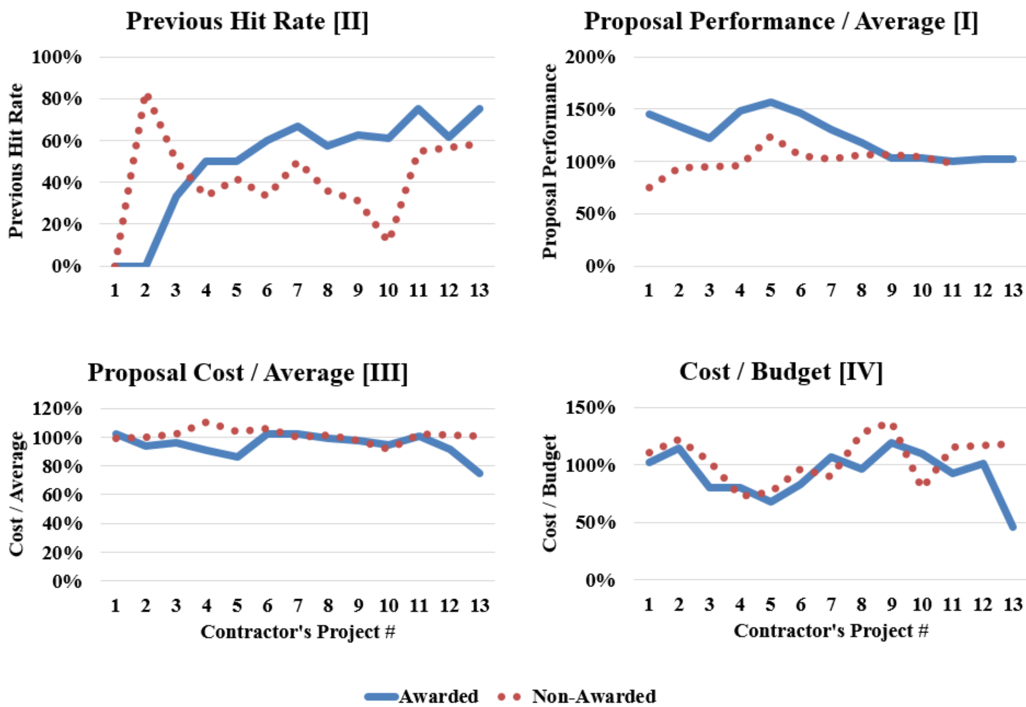

Figure 1. Contractor Response Measurements

Table 3

Pearson Correlations Between Awarded and Non-Awarded Contractors

Factor	Awarded or Not-Awarded	Pearson's r
1 (hit rate)	Awarded	.85**
	Not-awarded	.08
2 (performance)	Awarded	-.80**
	Not-awarded	.40
3 (average cost)	Awarded	-.35
	Not-awarded	-.30
4 (budget cost)	Awarded	-.16
	Not-awarded	.20

**$p < .01$.

Discussion

The most dramatic differences between awarded and not-awarded contractors along the four metrics was seen in the hit rate over time, as evidenced by visual review of Figure 1 and a statistically significant relationship with the awarded contractor's hit rate over time [$r(13) = .85$, $p < .01$]. That is, the awarded contractor's hit rate is very strongly and positively associated with how many projects they've proposed on. This trend suggests a type of contractor "learning curve" in which contractors that understood PSD constraints were more likely to be awarded subsequent projects.

Another interesting result is that the awarded contractor's proposal performance decreased over time (even though they were still being awarded projects). The awarded contractor's proposal performance had a strong negative and statistically significant relationship over time [r(13) = -.80, p < .01]. As contractors had more projects, they approached convergence on proposal performance (see panel III of Figure 1), and therefore the owner relied more on cost as the primary selection criterion (panel IV of Figure 1).

Conclusions and Future Research

A longitudinal study of the performance of projects at a large public school district (PSD) in the State of Minnesota was carried out to chart contractor and project performance. The primary research objectives of this study were to: Identify the impact of project performance (cost and schedule) and understand the dynamics of contractor responses and competitive factors in a "measured environment." The PSD also took on a new initiative to compete vendors based on price and past performance factors, and its impact was measured.

In general, the PSD appeared to experience exceptional results on project performance studied herein. Across the 39 projects in the school district, the overall cost change was 4.7 percent and overall schedule change was 1.5 percent, with the primary driver of all cost and schedule changes being the owner. Overall the PSD achieved high project performance under their PSMI initiative to select contractors based on a combination of price and past performance. This performance data contributes to the construction body of knowledge as one of few research studies uncovered that measures public school construction change order rates and schedule delay rates. Further, this research can be used to assist stakeholders in advancing public school construction projects.

Contractor response metrics revealed interesting trends over time. The notion that high competition results in a more competitive proposal cost was not supported by the results of this research at the PSD. There was no significant relationship between competition and contractor proposal cost over time. However, the contractor response measured by hit rate over time showed a significant relationship. This trend suggests a type of contractor "learning curve" in which contractors that understood PSD constraints were more likely to be awarded subsequent projects (after the second project). However, as contractors delivered more projects, their proposal ratings showed a negative relationship, suggesting more school district reliance on cost proposal factors. For those contractors whose hit rate decreased over time, there was no significant relationship observed over time. For some contractors, their highest hit rate was at their first project and were not awarded a second project.

While this research contributed to the body of knowledge on public school construction project performance as well as contractor competition in public school projects, future research should measure other districts and states, using the performance and contractor response metrics on numerous projects over time. A benchmark is needed to assist public officials with ensuring their projects are both performing and contractor response metrics are optimal. Measurement of individual contractors would also benefit this research and could assist with better understanding the observed "learning curve." Closer examination of contractor proposals, potentially at the individual personnel level may also reveal some interesting trends and indications of how to increase hit rate.

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