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W117 Performance Information in Construction: Research Roadmap Report

Foreword: by Dr. Wim Bakens-Secretary General for CIB

The CIB Working Commission W117, "Performance Measurement in Construction," is one of the more innovative and productive research-based commissions in CIB. It focuses on the utilization of performance metrics in the delivery of construction services. The home for W117 is the Performance Based Studies Research Group (PBSRG) at Arizona State University (ASU) in Tempe, Arizona, where W117 and ASU-PBSRG hold their annual Best Value Conference. From its start in 2009, W117 was led by Prof. Dean Kashiwagi (ASU), and his group of innovators (Dr. Kenneth Sullivan, Sylvia Romero, John Savicky and Dr. Jacob Kashiwagi) and co-coordinator, Professor Charles Egbu, (Glasgow Caledonian University). In 2016, W117 was joined by Co-Coordinator Prof. Sicco Santema, (University of Technology, Delft, Netherlands) the visionary who led to the proliferation of the W117 technology in the Netherlands.
W117 aims to change construction procurement and stakeholder organizations worldwide through the use of the information-based Best Value Approach (BVA). As such, it differs from most CIB Commissions that are more science driven, while W117 is more concept and impact driven. It has been one of the most successful CIB Commission in bridging the gap between the construction industry practice and academic research. It has been prolific in publishing and running research tests with industry partners. W117 and PBSRG have published over 300 papers and generated licensed technology (47 licenses from AZTech, the licensing body of ASU for intellectual property rights). It is the most licensed technology from the most innovative university in the U.S. (as rated by U.S. News and World Report (2016)).

W117 is responsible for the development and continuous testing of the following technologies:

1. Best Value Approach (BVA).
2. Best Value (BV) technology.
3. Performance Information Procurement System (PIPS).
4. Performance Information Risk Management System (PIRMS).
5. Information Measurement Theory (IMT) and Kashiwagi Solution Model (KSM).
6. A new project management model based on IMT.

The activities of WII7 are responsible for the following unique and dominant impacts on the delivery of construction:

1. Rijkswaterstaat, the largest user of construction services in the Netherlands, won the 2012 Dutch Sourcing Award (DSA) for the successful completion of a $1B infrastructure project called "fast-track projects" using BV-PIPS.

2. NEVI, the Dutch procurement professional organization, has licensed the Best Value technology from ASU and has identified the approach as a mainstream approach to the delivery of services, educating and certifying procurement professionals in the delivery of construction and other services.
3. Dutch visionary and author Sicco Santema, and his protégé Jeroen Van de Rijt, published a Best Value Procurement (BVP) Dutch book, using Dutch test cases to show the BVA technology was compliant with European Tender Law (12,000 books sold). Other books (in Dutch) were also published for the contractor community.
4. RISNET, a Dutch risk management association, licensed the Best Value Approach in order to increase the use of the risk-based project management in the construction industry.
5. W117 BVA certification system was developed, which certifies competence of BV professional practitioners.
6. W117 coordinator, Dr. Kenneth Sullivan, introduced the BVA into Canada, resulting in $3M research grants for the delivery of construction services in 25 different universities and government organizations.
7. W117/PBSRG Best Value expert John Savicky, signed a sole source agreement with the National Association of State Procurement Officials (NASPO) and their subsidiary, the Western States Contracting Association (WSCA), to allow all states to utilize the W117/PBSRG technical expertise by "sole source." This has led to tests in 33 different states.
8. Introduction of BV into Malaysia in 2012, into the Project Management Master's Program, led by Dr. Fah Choy Chia at Universiti Tunku Abdul Rahman (UTAR).
9. Introduction of BV into India in 2014 resulting in the noted engineering school, SJCE, adopting the curriculum into their engineering school.
10. Introduction of BVA into Norway in 2014, through the FIR, the construction engineering association. FIR also translated the Dutch book into Norwegian, going public on June 20, 2016, during a three-day event to include the first certification of Best Value professionals in Norway.
11. Introduction of BV into Poland with a three-day conference in Krakow in March 2016, with the publication of the translated Dutch Best Value Procurement (BVP) book into Polish.
12. Introduction activities in Switzerland, Denmark, Finland, Hungary, Germany and Saudi Arabia in 2015 and 2016.

These research efforts have led to the following future research and development opportunities:

1. Development of the language of metrics in the delivery of construction services.
2. The development of a new risk management and project management models.
3. Opportunity to test the sustainability of innovation in traditional environments.
4. Opportunities to test the innovative concepts in different countries.
5. Opportunity to identify and test the sustainability of testing new theoretical concepts in the industry without extensive academic research investigation.

W117 has successfully utilized the CIB Platform to impact the construction industry performance worldwide with the information based academic research. Its drive to make a

difference is to be applauded and this Research Roadmap (for consultation) is one more example of its high quality and high impact deliverables.

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Remark by the W117 co-chairs:

The W117 commission is a very active group. The research is constantly evolving and impacting the direction, scope and speed of evolution of performance metrics, transparency, mitigation of risk and the improvement of the supply chain stakeholders. This Research Roadmap is the latest document, as of April, 2016, but will be continually changed in the coming years. W117 welcomes all other working commissions and industry visionaries to join in the effort towards improving the construction industry.

Towards a CIB W117 Research Roadmap

In 2005, the CIB Program Committee organized TG61, for the purpose of identifying the performance of the construction industry based on performance information or metrics. TG61 produced a report based on a comprehensive literature research on the use of performance metrics in the construction industry. It identified a lack of research based on actual industry research tests (Egbu et. al., 2006). As a recommendation of TG61, the CIB Program Committee established a Working Commission, W117, on the *Use of Performance Information in Construction* in 2009, and appointed Dean Kashiwagi (Arizona State University) and Charles Egbu (Glasgow Caledonian University) as co-chairs. In 2016, Charles Egbu was replaced by Sicco Santema (Delft University of Technology).

W117 Objectives and Scope

The objectives and scope of W117 is to document and explore the potential use of performance information to improve the state of all stakeholders and their organizations in the construction industry supply chain. This includes:

1. To establish W117 as the worldwide center of excellence in both the construction industry and in academic research in the documenting, doing theoretical, prototype testing and implementation research and the testing of performance information to create transparency and the mitigation of risk in the construction and other industries.
2. To identify collaborators who could assist the W117 in the documentation, testing and research of the use and implementation of construction performance information in the industry.
3. To improve supply chain performance and the performance of all stakeholders in the construction industry through research and testing.
4. To advocate the use of performance metrics in the acquisition and delivering of construction work.
5. To advocate for new approaches to performance metrics that improves the construction industry performance.
6. To study different countries and cultures to identify how the use of performance metrics can improve the performance of construction and other services in their respective countries.
7. To document the use, research and testing of performance metrics in the delivery of services in the *Journal for the Advancement of Performance Information & Value.*
8. To quickly and accurately get the W117 research results to the industry and stimulate even more research in area of performance metrics by utilizing the W117 journal.
9. To apply different approaches of research to validate outcomes from different angles. Approaches include literature search, discussion among the industry and academic researchers, and analyzing the opinions of individuals interviewed on the concept of using deductive logic and common sense and hypothesis testing. All of which are validated by immediate testing in practice.

W117 Work Program

The W117 Work Program includes:

1. Conduct research on the use of performance information in the construction industry to develop state of the art practices that increase construction performance and value, minimize risk and resolve longstanding issues in the construction industry.
2. Publishing a CIB preferred journal to document the use and impact of performance information in the construction industry and quickly disseminate to the industry and research community.
3. Hold annual CIB W117 meeting, to discuss the latest results of research in the use of performance information in construction.
4. Do CIB W117 webinars to proliferate the exposure of the use of performance information in the construction industry.
5. Attend and participate in different international conferences to stimulate expert discussion on the use of performance metrics in the construction industry.
6. Partner with different research groups to proliferate research on the use of performance metrics.
7. Expose different countries to the use of performance metrics in the delivery of construction.
8. Hold W117 meetings to assist different countries in implementing performance metrics in the delivering of construction services.
9. Hold meetings with industry stakeholders to help bridge the gap between academic research and industry practices and encourage industry to sponsor academic research testing on their own projects.
10. Generate research funding to do research in the use of performance metrics in the construction industry.
11. Create partnerships with active research groups and the CIB to self-fund CIB W117 activities and research and can be self-sustainable without CIB funding.

Introduction

The CIB Secretariat has created a CIB Roadmap that will assist the working commissions to create their own roadmaps, to become successful, sustainable, focused on a strategic plan and assist the improvement of the worldwide construction industry, see Figure 1. The CIB research roadmaps provide authoritative guidance and support for national and international research bodies and funding agencies.

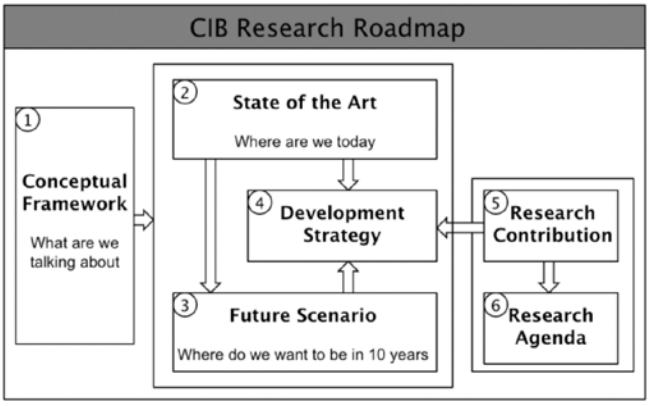

Figure 1: Outline of Research Roadmap

As the illustration indicates, creating a CIB 117 Research Roadmap requires the following questions to be addressed:

1. Conceptual Framework:
   What are we talking about? This question includes the typical: What are the issues, how are these interrelated, what influences all of this, who are the stakeholders, what are the relevant areas of expertise, what are the characteristics of relevant systems, processes, and technologies? This is addressed in the *Conceptual Framework* section.

2. State of the Art:
   Where are we today? This question includes: State of technology, best practices, international variations, perceived problems and the world's leading centers of expertise. The state of the art is elaborated in the section *State of the Art in the Utilization of Performance Information*.

3. Future Scenario:
   Where do we want to be in ten years? The stakeholders' vision is described in section *Future Scenario: Where Do We Want To Be In Ten Years?*

4. Development Strategy:
   This section includes: what is needed in terms of knowledge, information, tools, concepts and applications to enable the respective systems, processes and technologies to be developed over time? These subjects will be described in the section *Development Strategy*.

5. Research Contribution:
   In section *Research Contribution* we describe how W117 research contributes to the development strategy and what the requirements for research are in order to make that contribution.

6. Research Agenda:
   Section *Research Agenda* concludes with the agenda for W117 research worldwide. That will include areas of science and technology development, required sequences of

development, priorities, international cooperation within the research community, cooperation between research and practice.

Conceptual Framework

W117 Research Technology: The Use of Performance Metrics in the Construction Industry

The conceptual framework for TG 61 and W117 was created by co-chair Dean Kashiwagi (Arizona State University) and supported by Charles Egbu (Glasgow Caledonian University). Professor Dean Kashiwagi is a researcher in the area of performance metrics, the language of metrics and the use of metrics to simplify and improve the construction industry. He has had research test responsibilities for more than 23 years. His expertise is defined by over 300 publications, 1,800 research tests and delivery of $6.4B of services. He also has done research testing in six countries and 34 states in the United States. This led him to being named as an original co-chair of W117, and resulted in the conceptual framework for W117 research. Professor Charles Egbu gave W117 tremendous support in exposing the performance information technology in the UK academic conferences.

Co-chair Dean Kashiwagi has gone through multiple cycles of finding new researchers in the area of utilizing performance metrics for the improvement of construction services. The cycles were needed because many of the participating researchers, after a certain time period, did not sustain or receive enough funding in the W117 research area to stay active in this narrow field of research. Dr. Dean has been successful in recruiting new W117 members within the same area of expertise to replace those who moved on to other research areas. The new members are being recruited not only from academia, but from the industry as well, many who are running research tests in different countries. The research tests are continually improving and developing the *technology of performance metrics* (Best Value Approach, language of metrics logic called the Information Measurement Theory, procurement processes, project management processes and risk management processes).

Worldwide construction research was mainly focusing on the documentation of problems. This included the documentation of Key Performance Indexes or KPIs. However, the research community has failed to show how the KPIs increased the performance of construction services. For example, many industries use KPIs but do not know how to apply the metrics to improve construction performance. Each country also has their own perception of the cause of the construction industry non-performance.

In 1993, ASU/PBSRG identified a potential solution. It had the following unique characteristics:

1. Based on deductive logic.
2. Simplification and creation of transparency.
3. Identification of industry experts who could immediately test the hypothesis.
4. PBSRG maintains a high level of control over the industry test.

Issues in the Construction Industry Worldwide

Worldwide, the construction industry has had performance issues for the past 30 years. It appears to be a low performing industry; clients are unhappy and construction projects do not finish on time or on budget and construction companies finish projects at a loss. Over the last 30 years the assertions were validated by numerous landmark studies. The first major study was a breakthrough study conducted in 1994 by Sir Michael Latham (1994), who identified how significant non-performance was attributing to the continued failings within construction in the United Kingdom. He was one of the first researchers to expose that construction non-performance has been existent for the past 30 years. Interestingly, Peter Goff, of the International Project Management Association (IPMA), shares a similar argument by identifying that, despite the hundreds of millions of dollars invested by private enterprises and government to increase education and training of project managers, there has been no performance to back up its validity (Goff, 2014). In all, Latham identified current business practices of management, direction and control as the causes of an inefficient environment, and non-performance on construction projects (1994).

Due to the continuous efforts of resolving construction non-performance, the industry was still not improving. In 1997, the United Kingdom commissioned John Egan to develop a task force to perform another study on the performance of the industry. Similar to the first study, Egan identified a lack of leadership in business practices and integration of standard processes and teams (Egan, 1998). Although both studies have motivated industry and academia to improve the industry performance, the construction industry has seen minimal improvements moving into the 2000's to present day (Chikuni & Hendrik, 2012; Oyedele et al., 2012; Georgy et al., 2005; Bernstein, 2003).

The construction industry has continued to struggle in the 2000s, though some improvement has been documented. The UK, from 2000 to 2011, saw an increase in customer satisfaction from 63% to 80%, but its projects were still only completing on time 45%, and met budgets 63% of the time (KPI REF). In the U.S., productivity has decreased by 0.8% annually (Adrian, 2001). Construction companies have the second highest failure and bankruptcy rate of 95% (Associated General Contractors, 2006). Over 90% of transportation construction jobs are over budget, and almost 50% of time is wasted on job sites (Lepatner, 2007).

According, to a recent Construction Industry Institute (CII) study published in 2015, 2.5% of projects are defined as successful (scope, cost, schedule, and business), 30% of projects completed within 10% of planned cost and schedule, 25 to 50% is wasted due to coordinating labor on a project, and management inefficiency costs owners between $15.6 and $36 billion per year (Lepatner, 2007; PWC, 2009; Yun, 2013).

In 2008, TG61 did a comprehensive literature review of all research efforts worldwide to identify:

1. Research groups who identified the issue of construction nonperformance, and ran research tests to confirm their hypothesis.

2. Research groups who ran repeated research tests to validate their hypothesis to increase construction performance.

The study filtered through more than 15 million articles and reviewed more than 4,500 articles. The study found only 16 articles with documented performance results. The Best Value Approach was one of three construction methods found in those articles, and the Best Value Approach was found in 75% (12 of 16) of the articles (Egbu, et al., 2008; Michael, et. al., 2008).

For the past five years, W117 has been attempting to identify all construction delivery systems with documented performance information. W117 has sifted through hundreds of papers, websites, and personal industry contacts, and found similar results to the first study. Thus far, the only approach with documented performance is the BVA and PIPS. (Thomas, and Napolitan, 1995; Odeh, and Battaineh, 2002; Hsieh et al., 2004; Assaf, and Al-Hejji, 2006; Arain, and Pheng, 2006; Lo et al., 2006; Sambasivan, and Soon, 2007; Al-Kharashi, and Skitmore, 2009; Mahamid, et al., 2011; PBSRG, 2016)

In one promising study, Sanvido and Konchar identified that the design-build approach was significantly better. However, five years later, a follow-up and more comprehensive study identified that there was no significant evidence that one approach was better to any of the other approaches (Leicht, 2015; Konchar, 1998).

A conceptual framework was proposed by Kashiwagi (1991) that has remained as the foundation of the efforts of W117 (Figure 2).

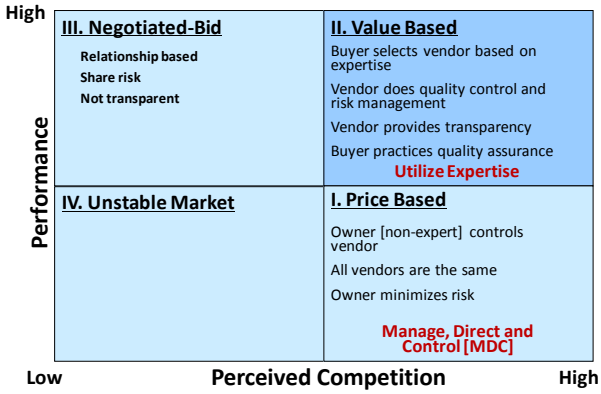

Figure 2: Conceptual framework of the construction industry structure

The Construction Industry Structure has the following proposals:

1. Poor performance is caused by owners using management, direction and control (MDC) to minimize the risk of construction nonperformance.
2. Risk is caused by non-expert stakeholders and not contractors.
3. Risk cannot be transferred by means of contracts.
4. When MDC is utilized to mitigate risk; risk, cost and nonperformance increases.
5. High-performing construction is delivered by utilizing construction expertise instead of MDC.

W117 has proposed the following to the construction management research community and the construction industry based on research test results (Kashiwagi J., 2013; Kashiwagi, D., 2016; PBSRG, 2016):

1. The owner or buyer of construction is one of the biggest sources of risk in the delivery of nonperforming construction.
2. Management, direction and control (MDC) by the owner to minimize the risk of construction nonperformance is a major source of nonperforming construction.
3. The lack of utilization of construction expertise by the owners of construction is a resulting problem.
4. The lack of the quantification of construction problems using performance metrics has resulted in the construction nonperformance being a stubborn and lingering problem.
5. There is confusion in the construction industry on the source of construction nonperformance.

W117 conceptualizes the current problem of construction nonperformance with the following characteristics:

1. The construction industry sees the industry as being too complex and has difficulty simplifying the problem.
2. Because of the lack of understanding of the construction nonperformance, it is very difficult to identify the problem, devise a system/approach to solve the problem, and run tests to validate the proposal.
3. The industry perceives that the problem is a technical problem, and is therefore looking for technical solutions such as BIM to solve their problems.

W117 proposes to solve the problem by using:

1. Deductive logic, natural laws and simple concepts.
2. Utilizing expertise to lower cost and improve quality.
3. Creating transparency by creating simplicity.
4. Creating simplicity by using performance metrics to communicate.

Test results over the past twenty years have validated many of these concepts. For example:

1. When transparency is created, there a very few disagreements between stakeholders.
2. When an expert has a plan that includes the functions of all stakeholders, the stakeholders do much better in minimizing the risk that they would normally maximize.
3. When performance metrics are used, there is minimal discussion on someone's level of expertise.
4. An expert who knows what they are doing should always have a lower price than a non-expert. Therefore, the objective is to hire an expert who can lower project costs.

A study was performed, identifying that the Best Value PIPS was the only delivery system with the concept of no-control or minimizing management, direction, and control (Kashiwag J, 2013). This research also documented the potential impact that implementing the concept of no-control could have on the delivery of construction services (Kashiwagi J., 2013). The study involved 31 construction and non-construction services, among 5 different major buyers in the U.S., comparing the performance of the project when delivered with the Best Value no-control concept and with the traditional management, direction and control techniques (see Table 1). It found the following:

- Cost of services decreased on average by 31%.
- Suppliers were able to offer the buyer 38.5% more value, totaling up to $72.76M.
- The average customer satisfaction of the service being provided increased by 4.59 points on a 1-10 scale (134% greater than the traditional customer satisfaction rating).

Overall Comparison

Criteria	Traditional	Best Value
# of Outsourced Services	31	31
Cost of Services	$274,480,342	$189,001,943.00
Added Value	-	$72,762,248.60
Average Customer Satisfaction	3.43	8.02

State of the Art in the Utilization of Performance Information

PBSRG, W117 and TUDelft, more recently, have been developing the use of performance information in the construction industry for the past 22 years. The state of the art practices include:

1. Using the Best Value Approach (BVA) to deliver construction services which results in a very high level of performance. This includes the use of the Performance Information Procurement System (PIPS) and the use of the Performance Information Risk Management System (PIRMS). PIPS has three major phases: Selection, Clarification and Execution. PIRMS uses the low-bid award system as the selection phase, but the clarification and execution phases are identical.
2. The use of the language of metrics to create transparency. The language of metrics minimizes misunderstandings through unified coding.
3. Risk is caused by non-expert stakeholders. Risk cannot be passed. Risk has to be mitigated. Performance metrics are used to explain to non-experts, thus leading to risk mitigation.
4. The use of Information Measurement Theory (IMT) and the Kashiwagi Solution Model (KSM) to understand human nature, predict future human behavior and utilize these technologies in the selection and alignment of human resources in construction services.
5. The optimization of construction resources using a structure that assists in the optimization of expertise by creating an environment of transparency.

6. Continuous learning from tests and new versions of the methodology. The cycle of learning keeps speeding up as more countries and academics/practitioners are joining the effort.

The W117 sponsored journal captures the latest developments in the use of performance information in the construction and other industries. W117 also keeps a database of published papers in the area of performance information. The W117 committee members are constantly experimenting by using the BVA in new environments (including different industries and countries).

The technology of the Best Value Approach (BVA) is licensed by Arizona State University to 47 organizations and is used by supply chain stakeholders (owners, designers/engineers, facility managers, contractors, subcontractors and material suppliers) and academic researchers. The BVA has led to a new project management model including a new risk management approach (risk can only be mitigated and not transferred) and a new leadership approach which utilizes the entire supply chain.

The CIB W117 Performance Information in Construction working group includes the worldwide experts in both academic research and construction industry practice in the area of using performance metrics in construction projects. W117 is constantly looking for new countries and contributors (both in practice and in academia) who understand the Information Measurement Theory (IMT) and urge them to participate with W117.

The case of the Netherlands adoption of the BVA took five years. These years included the usage of BVA by Rijkswaterstaat on the $1B U.S. fast track road construction projects, the acceptance of BVA by NEVI (Dutch professional procurement group) and the publishing of the first Dutch Best Value Procurement (BVP) book (by Jeroen van de Rijt and Sicco Santema). This book showed that the methodology was compliant with the European Tender Law. Up to 2016, the book is in its third edition and more than 12,000 copies of that book have been sold in the Netherlands. As an example of continuous development, the fourth edition of the book will be published in 2017, adopting all the latest insights.

In the Netherlands, now that the BVA has great exposure, the challenge becomes:

1. How to ensure that the new paradigm is being understood by new practitioners.
2. To ensure proper documentation.
3. To ensure that the contractors/vendors understand the BVA.
4. How to educate the supply chain fast enough to keep up with the demand of Best Value services.

W117 is now faced with the challenge of how to proliferate the BVA in the other European countries. Currently BVA has been moved into Norway and Poland, having the Dutch book translated into Norwegian and Polish. The BVA is currently being exposed to Switzerland, Denmark, Finland and Germany.

The proliferation into other European countries is through the Dutch and European professional engineering groups (in construction) who have observed that their expertise is not being utilized by owners. The Dutch Rijkswaterstaat organization is also exposing the BVA to other infrastructure organizations of other European countries. Also other organizations exposed to the BVA in the Netherlands, are moving it to other European countries where they do business.

Future Scenario: Where Do We Want to Be in Ten Years?

In 10 years, we want the W117 BVA technology to be known in 10 major construction industries worldwide, next to the United States and the Netherlands. The technology has the potential to change national procurement models, project management models and risk management models. The Information Measurement Theory or the language of metrics also has the capability to change the traditional leadership models.

In these countries, the risk management model will change from the traditional model, which is transfers risk by legal contracts, to a risk mitigation model, which identifies risk as what an expert contractor cannot control. The BVA will also mitigate risk by creating transparency, simplicity and utilizing performance metrics.

The successful research model of the future will be a mixed-methods model based on deductive logic and utilizing case studies. The research model will create change by showing dominant improvement in lowering project costs, increase profit margins and projects that are delivered on time and on budget. The approach is not technical in nature, making the W117 technology able to be applied to all industries.

Stakeholder's Vision of the Future

The stakeholders of the W117 technology are the stakeholders in the entire supply chain. Their vision is simple: lower project costs, higher project value, higher performance and higher profits. The success of W117 is that the technology being developed is simple, easy to understand at a very high leadership level, but never the less, counterintuitive. The major requirements of the research effort is to document the technology in a way that fits the culture of the country. The results of the technology are so dominant, that the newer countries are adopting the approach with very few modifications. Education and training are the most critical challenges.

The following points summarize W117's development strategy and research contribution and development:

1. Development Strategy: what is needed in terms of knowledge, information, tools, concepts and applications to enable the respective systems, processes and technologies to be developed over time?

   The basic technology of performance information is already developed. There are two major stages of research development in every country. The first stage is the identification of information workers who understand the change of paradigm. The

second stage of development is the running of research tests. In each stage the following tasks have to be completed. First the communication of the technology, then the education of stakeholders, the acceptance of the change of paradigm and the running of the industry tests. The technology shall be modified slightly to accommodate the culture and understanding of the stakeholders.

Before either stage can be successfully completed, tasks such as the translation of the English text into the local language and education sessions must be completed.

2. Research Contribution: how can research contribute to such development strategy? What are the requirements for research to make that contribution?

   W117 is unique in that it is the organization of the expertise. The research and the research publications are the mechanism in proliferating the information technology. As more and more countries test the new approach, the documentation and database of results will optimize the future implementations, the actual information based technology, and increase the capability of the information based technology. Never before in construction management research has a new paradigm utilized simplicity, performance metrics, transparency and the utilization of expertise to dominantly improve quality, reduce project cost and improve expert contractor profit margins. As discussed earlier, because the majority of academic researchers are involved in traditional research, a major contribution of W117 will be the changing of the research paradigm. The research publications that can impact the construction management research community in the new country will be critical to the changing of the paradigm.

3. Research Agenda: what is the agenda for research worldwide?

   The research agenda of W117 includes simplification of the logic (IMT), translating the IMT into different languages, running tests in different cultures and environments, and implementing the logic to improve construction performance. The W117 journal is being used to get the developments, results and new concepts to the industry stakeholders and researchers as quickly as possible. The journal will minimize the importance of peer review, and maximize the importance of the industry results. W117 research agenda is to proliferate the technology in as many countries and cultures as possible. W117 also is always looking for innovative implementations of the BVA.

Development Strategy

The CIB W117 development strategy is quite ambitious. The development will take place in three dimensions:

1. Knowledge.
2. Tools and applications.
3. Geographically.

These dimensions are set out in Figure 3.

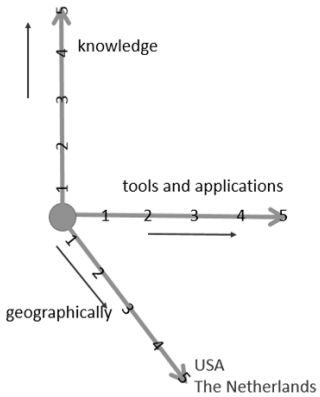

Figure 3: Dimensions of the W117 development strategy.

The knowledge on Value Management in Construction Performance Measurement is constantly being developed. Practitioners are constantly using the technology of the language of metrics and performance metrics. Practitioners are annually getting certified and running best value projects. The key to the BVA to all stakeholders is continuous improvement.

In the tools and application dimension, we use the technology that is a part of the "Information Measurement Theory" (IMT) which is the foundation for the Best Value Approach (BVA). As more and more areas of services are starting to use BVA, additional tools and applications will automatically develop.

The current BVA certification system shows that stakeholder participants have room for growth. Research can track the participant's performance metrics and improve a participant's chance for greater understanding.

The geographical dimension will develop through 'natural growth'. Great progress has been made in the USA, Canada and The Netherlands. W117 can now assist the movement into other countries. In Europe BVA has been introduced in Poland and Norway (Dutch book translated), and presentations have been given in Sweden, Finland, Denmark, Germany, Switzerland, Czech Republic, Hungary and the UK. A major effort is now happening in Saudi Arabia.

The aim of the geographical development is to find a platform that is willing to pick up BVA in the industry from both academia and practice (consulting, purchasing associations, association of engineers) to create a national body that can bring BVA further. This includes the basic materials in the mother language of that countries, licensed from ASU.

All the advancements will be published in the CIB/PBSRG journal.

Research Contribution

In the previous section we illustrated our development strategy. CIB W117 research is clearly contributing to that, mostly on the knowledge and tool and applications dimensions. The developed knowledge will also constantly be tested in practice.

Below we make some short remarks on the research contributions.

1. Opposite to government funded research (l'art pour l'art), resulting in reports and propositions, we propose to actively research practice in order to come up with solutions for the construction industry. Practical, applied research, resulting in applicable tools. One of the cornerstones of that research is construction practice itself, wanting the solutions and improvements to their ineffectiveness and inefficiency.
2. This means that we will use common academic research instruments like literature search, survey of industry perceptions, and case studies. Next to that we use every method that is needed to come up with practical knowledge and tools. Obviously we will report on these in publications, which are a means of communication, not a goal in itself.
3. Through our academic research community in construction we want to make things simple.
4. We will use systems like the deductive logic approach with natural laws of reality such as gravity and combustion that have no exceptions.
5. Successful knowledge and tools will continuously be tested in order to prove over and over their value for the construction industry. It is not the knowledge and tools themselves that have to proof their value, it is the acceptance by the construction industry's practitioners that we are aiming for.
6. We will use a peer review system for our journal based on these practitioners.

The core technology of the W117 is the Best Value Approach (BVA) and Information Measurement Theory (IMT). It is dependent upon metrics and the language of metrics in different processes to improve efficiency and effectiveness of the construction industry. These areas include: project management, risk management, procurement processes, communication between stakeholders and in the research that identifies the success or failure of hypothesis. The Stakeholders include, the entire supply chain of the delivery of construction services: designers, owners and all their representatives, regulatory groups, project managers, procurement personnel, lawyers, general contractors, subcontractors and material suppliers.

PBSRG and TUDelft use their own funds and the available time of construction practitioners to do research. This makes the CIB W117 research independent.

This different approach, new paradigm of industry testing and immediate results was recognized by CIB secretariat Wim Bakens in 2007, and led to the CIB general board approving a TG61 task group. The TG61 final report validated PBSRG and TUDelft hypothesis, and led to the general board approving a new working commission W117.

Research Agenda

This section concludes with the agenda for W117 research in the construction industry worldwide. As previously stated in the Work Program, this includes:

1. Creating a CIB preferred journal to document the use of performance information in the construction industry and to publish research results for the practitioners in the construction industry, in order to improve effectiveness and efficiency.
2. Hold an annual CIB W117 meeting, to present and discuss the latest results of research in the use of performance information in the construction industry.
3. Do CIB W117 webinars to proliferate the exposure of the use of performance information in the construction industry.
4. Attend and participate in different international conferences to stimulate expert discussion on the use of performance metrics in the construction industry.
5. Conduct research on the use of performance information in the construction industry to develop state of the art practices in the construction industry. The agenda is set by practitioners that are willing to participate in the research.
6. Partner with different research groups to proliferate research on the use of performance information.
7. Expose different countries to the use of performance information in the delivery of construction.
8. Hold W117 meetings to assist different countries in implementing performance information in the delivering of construction services.
9. Hold meetings to help bridge the gap between academic research and industry practices.
10. Generate research funding (from practice) to do research in the use of performance metrics in the construction industry.
11. Create partnerships with active research and the CIB to self-fund CIB W117 activities and research, to be self-sustainable without CIB funding.
12. Have PhD's start their work at both PBSRG, TUDelft and other W117 research-based universities. Have MSC students do their graduation projects on the use of BVA in the construction industry.

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A New Learning Paradigm: "Learning More with Less"

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A new learning paradigm has been tested in the delivery of services. It identifies that the act of directing and influencing a vendor or an individual to increase their performance is not effective or efficient. It is based on a deductive logic methodology called "Information Measurement Theory" (IMT) which has been developed over the past 46 years through one of the author's personal and family life, the delivery of services in the construction industry, and in Barrett, the Honors College at Arizona State University (ASU). IMT identifies that the concepts of influence, randomness, chance, or one person attempting to change another person are inaccurate concepts. These facets occur when one party attempts to forcibly change another party, which is a form of abuse. When tested out in the industry, these concepts returned 5 to 50% reduction in cost, simultaneously lowering owner costs, increasing value and resulting in higher profits for the expert vendor. When practiced in the honors education program at ASU, students were able to learn concepts five times as quickly and understand complex concepts with very little detailed data. In 2015, the IMT author brought the education to his alma mater, Saint Louis High School, and the first full year of IMT concepts were tested at the high school level. The results were consistent with the results from industry tests, the honors program at ASU, and the Kashiwagi family.

Keywords: Education, Best Value, Deductive Logic, Stress, Simplicity, Kashiwagi Solution Model.

Introduction

Education today is facing problems with: student depression, difficulty in meeting federally mandated minimum standards and assisting children from unique environments (single parents, broken homes, inadequate resources or unstable environments) to be successful (Jensen, 2009; McKinsey & Company, 2013;Sandstrom and Huerta, 2013; OECD, 2014; Ray and Kafka, 2014; Accenture Strategy, 2015; American College Health Association, 2015; 3AW693 NewsTalk, 2016). The Wall Street Journal identified that competition for high grades for college admissions and scholarships have resulted in negative student behavior. The superintendent in the Plainsboro Regional School District (New Jersey) identified that 120 middle-high school students were diagnosed with depression, anxiety and suicidal thoughts. In a letter to parents, he stated, "I cannot help but think we may be failing [our students] by reinforcing an educational system that perpetuates grades at the expense of deep and meaningful learning" (Ossola, 2015).

According to the Washington Post, several studies were done in the 1970s-1990s that measured graded and non-graded students. The study showed that students who were graded were not interested in the topic being taught, and when tested, looked for the easiest possible task to be tested on (Oppenheimer, 2016). Alfie Kohn, author of *The Homework Myth*, identifies that when

grades are introduced, the quality of learning diminishes. Employers are starting to understand that grades are not the optimal indicators for assessing talent and competency. For example, a 2012 study by the Chronicle of Higher Education rates GPA (grade point average) number 7 out of 8 (Chronicle of Higher Education, 2012). Higher rated factors included internships, previous employment, and extracurricular activities. It has also been suggested that grades should be removed since they are not uniform from college to college (Kohn, 2011).

An international study comparing different educational approaches identifies that the Finnish approach to K-12 education is one of the most effective in the world because it focuses on eliminating standardized testing and reducing homework (OECD, 2014; Walker, 2015; Biggam, 2016). In turn, the school district in Plainsboro, determined to remove midterms, final exams, and institute a no-homework policy during breaks and weekends. This shift in protocol has caused great concern amongst certain parents because they are worried that their children will be at a disadvantage when applying for some of the elite U.S. colleges. The Plainsboro school district is not alone; one of the largest and highest ranking districts in the U.S., Montgomery County Public Schools in Rockville, Maryland, also implemented similar practices (Goyal, 2016). Numerous other schools are attempting to move further away from rigorous work and grades, and providing students with more opportunities to explore their identities, discover what they enjoy, and allow them to study want interests them most (Goyal, 2016). A report in January of 2016, from the Harvard Graduate School of Education, called for open a discussion on developing a new approach to admitting new students. Over 80 deans, professors, and presidents from various other Ivy League schools endorsed Harvard's goal. The goal is to decrease the importance of academic rigor, and focus more on criteria that encourage the well-roundedness of a student's education. For example, they are discussing the possibility of making the ACT and SAT optional along with encourage students to take fewer honors courses in exchange for meaningful extracurricular activities (Goyal, 2016).

This new move to reform education is an attempt to help high school students but does not seem to have much effect on current college students. Many students who enter college are stressed because they are required to memorize and recite detailed information in order to succeed. This leaves very little time for students to focus on personal development. In a study done to show the effectiveness of the current higher education system, researchers assessed exam scores and survey results of 2,322 students over a four-year period. Test results identified that 45% of the students made no significant improvement in their critical thinking, reasoning or writing skills during the first two years of college. After four years, no improvement was shown in thinking skills (Rimer, 2011). These results show the traditional approach of education, to make students think, does not improve their thinking capabilities.

The average college freshman is stressed, overwhelmed, and underprepared for college. Anxiety and depression are now the most common mental health diagnoses among college students, according to the Center for Collegiate Mental Health at Penn State (Center for Collegiate Mental Health, 2015). The American College Health Association (ACHA) recently published the results of their National College Health Assessment, of which approximately 30.7% of the students polled said that at one point in the past 12 months they "felt so depressed it was difficult to function" (American College Health Association, 2010). An estimated 12% of college students plan on committing suicide each year, and while some are prevented, more than 1,000 suicides

occur on college campuses per year (Wilcox, et. al, 2010). One study surveyed 100 students at a major university to examine 12 major stress-causing factors relating to academic demands and personal development. Out of the 12 factors, the top 3 that cause the most stress is academic work load, time management, and making future plans. Interestingly, finances, social life, and body image were amongst the lowest rated factors (Britz, 2010). Another study conducted by Dr. Ed Ehlinger, Director of Boynton Health Services, surveyed fourteen 2-4 year colleges and identified that students with higher levels of stress had lower GPAs (Ellis, 2015).

The authors propose that students in both high school and higher education are unprepared for life after school because education focuses more on memorizing technical information, instead of helping students understand who they are, and where they should best use their talents and unique attributes. According to the Economic Policy Institute, the recent graduate unemployment rate is 7.2% and underemployment rate is 4.9% (compared to 5.5% and 9.6% in 2007) (Davis, et al., 2015). Fifty to seventy percent (50-70%) of college students change their major at least once during their undergraduate program, most will change majors at least 3 times before they graduate, and more than 50% of college graduates pursue careers that are not related to their degrees (University of La Verne, 2015). Less than 50% of recent graduates possess the 17 most desirable skillsets as identified by the majority of employers (Jaschik, 2015). McKinsey and Company identified that 61% of new graduates are unhappy with their careers, and 57% of employers agree that they cannot find enough skilled entry-level workers (McKinsey & Company, 2013). Additionally, the marketing visionary of one of the largest facility management firms in the world, stated the biggest challenge of the firm is the shortage of quality frontline workers (Peter, 2015).

Another study identifies that technical knowledge is not one of the top 10 most important skillets for recent graduates entering into the workforce. In fact, employers feel that interpersonal skills are more valuable because new hires can be trained in technical skills (Burnsed, 2011). One researcher, Peter Cappelli, author of *Will College Pay Off*, identifies that since the world is changing so rapidly, pursuing a hyper-specialized degree may narrow a student's skillsets and make them a less desirable future employee (Cappelli, 2015). This becomes increasingly more evident as China continues to replace manufacturing floor workers with robots (Knight, 2015).

Problem

The evidence for education reform is clear, but the root of its problem and its solution is not. Students are misaligned because they are not pursuing what they are best at and what they enjoy most. The students who have the most difficult time in life seem to be those who are unsure about their futures and their own strengths that will help them be successful. This misalignment is reflected in numerous types of irrational behavior ranging from stress and depression, to frivolous lifestyles and suicidal tendencies (Ossola, 2015; PBSRG, 2016).

The misalignment of students is prevalent in all forms of higher education and career training. Robert Reich, Chancellor's Professor of Public Policy at University of California at Berkeley, identifies that, despite its benefits, a four-year degree is not the only doorway from lower to middle class living. In fact, he suggests that some students should not attend four years of

college, but rather, develop knowledge in a specific field they are interested in. He identifies that it is detrimental if students fail after being forced to go to college. He further identifies that the traditional education system needs to change its view on university education, and a world-class vocational-technical education must be created as an alternative. He identifies how the emerging economy will need many more people to install, service, and repair high tech machinery for offices, factories, and hospitals. He identifies how it is hard to find a skilled plumber or electrician, because the vocational and technical education available to Americans today is underfunded, inadequate, and viewed as a lower class option to education (Reich, 2015).

According to Georgetown's Anthony Carnevale and Jeff Strohl, less than 10% of lower class children graduate with a four-year degree. Most of these students struggle in school, and are encouraged to attain higher education because it is perceived that it will help them achieve greater success in their life (Petrilli, 2014). According to Micheal Petrilli, executive vice president of the Thomas B. Fordham Institute and research fellow at Hoover Institution, many of these students are being misled by being told to attend college, when according to college-access advocacy group, Complete College America, less than 10% of them will complete a two-year degree within three years, and the rest have an almost certain failure rate (Petrilli, 2014).

The misalignment of individuals may be merely a symptom of a greater problem in life; complexity. Life is complex, and the requirement to become successful in life is increasing as technology advances every year. Logic identifies that a person is more likely to understand who they are and what their purpose in life is at the age of 50 when they have more information and not when they are 15 years old with less information. Yet, the current education system, and society in general, require high school students to figure out their lives at a time when they have the least amount of information. The education system has not done an effective job at creating a structure that can help students develop a sense of identity, discover their purpose in life, and best align themselves with optimal opportunities that can help them be successful (PBSRG, 2016). Instead, students are told that college, more information, and technical details is the key to becoming successful.

This may be the reason why some industries do not have enough employees, while others have too many of the wrong ones (IFMA, 2007; McKinsey & Company, 2013). Many industries cannot fill the need for expert craft and services workers, increasing cost and decreasing quality. In 2020, 25% of the U.S. labor force will be older than age 55 (Hayuten et al, 2013). Over the next 10 years, 40% of employees in the construction industry will retire (PBSRG, 2016). This is a concern for the industry, because a large number of current employers are having difficulty finding skilled employees. Additionally, employers are finding it more difficult to retain laborers. The average pre-millennial worker in the United States remains at their job for 4.4 years. Ninety-one percent (91%) of millennials (born between 1980 and - 2000) have reduced that number by half and are projected to have 15-20 jobs in their lifetime (Meister, 2012). This creates a challenge for employees to maintain stability and develop expertise. This challenges talent acquisition managers because they fear that new employees are more likely to search for new employment opportunities after receiving job training within the company. The industry is faced with the problem of maintaining their competitive edge with an inexperienced and seemingly unstable workforce.

Proposal

The authors propose that implementing methods founded on logic and simplicity might eliminate the misalignment of students caused by the complexity of life. This proposal comes from the testing of the Best Value Approach (BVA) in the delivery of services. The BVA uses simplicity (non-technical, general language) and minimizes the attempts of one party to influence another party through communications and regulations. The BVA proposes that only experts have the capability to identify opportunities to utilize their expertise, and any attempt by non-experts to communicate or influence the experts, result in increased complexity, low performance and higher costs.

The authors propose that any attempt by the education system to direct, control or influence students, will make the students think and stress more, which will lead to poor results. The attempt to direct, control or influence is done by forcing the students to do more work with inefficient and ineffective methods of teaching/learning. Instead, the authors propose to: simplify, allow students to learn more with less effort, and teach students how to use their time more efficiently and effectively. The underlying objective should allow students to find out who they are, what they enjoy, and how to become successful with the talents that they have.

Creating Simplicity

Traditionally, the concept of making someone think or increasing their mental activity was seen as an optimal practice. However, a person, considered to be an expert, can see what will happen before it happens. Their power of observation is greater and, thus, there is less need to think and make decisions. Increased mental activity is not optimal as evident through the following circumstances:

1. Insomnia.
2. Inability to calm the mind.
3. Confusion leading to increased stress.
4. Poor job performance.
5. Athletes who think more do not perform as well as athletes who can make split second decisions.

Research testing at the Performance Based Studies Research Group (PBSRG) led to the following test results (Kashiwagi, 2016, PBSRG, 2016):

1. Experts can see events that they will perform before they do them.
2. When an expert understands their area of expertise, it is simple to them.
3. Experts do not think as much as someone who does not understand. They make fewer decisions. Their stress level is lower.
4. Experts know that most of the stakeholders they interface with are not experts.
5. Experts think less and make fewer decisions, because they know the outcome of an event before it happens. The event is simple to them, and they do not need to think as much.
6. Non-experts, who do not have the expertise to know the outcome of an event before it happens, think more and make more decisions because the event is not simple to them.

7. Experts utilize their expertise to lower costs and improve quality.

The most evident in a case study supporting this idea was shown on a television show, *Stan Lee's Superhumans*, which aired on the History Channel 2 in 2015 (Stan Lee's Superhumans, 2010; Flansburg, 2016). The show studied the mind of Scott "The Human Calculator" Flansburg a multi-award winning Guinness World Record holder for fastest mathematical mental calculations. Scott has run hundreds of tests, showing how his mental computing skills are faster than a calculator for both simple and complex operations. On numerous occasions, his competitions included multiple opponents, all equipped with a calculator. On the television shown, Neurologists scanned Flansburg's brain while he was computing mathematical equations. His brain was compared to the show's host, who was the control sample, and the results showed that Scott's brain was less active and used non-mathematical portions of his brain to compute. His brain was more efficient and effective than the normal brain.

Neuroscience has now just figured out that when people are forced to think it causes them stress (Mitra, et al., 2005; Mitra, 2015). Sugata Mitra, a world-renowned professor of education technology at Newcastle University, who created a non-traditional school that empowers students to work together via cloud technology to solve problems, using adults only for encouragement instead of providing instruction, evidences this. He identifies that the brain shuts down in times of stress or fear. In other words, the use of punishment or examinations, threaten a brain and result in a shutdown of the prefrontal cortex, which is the part of the brain responsible for learning. Mitra identifies that the traditional process of overwhelming students with information makes them think more and requiring them to perform is outdated and not optimal.

Other renowned education systems such as Montessori Education and Lumiar, in Brazil, identify that traditional education systems result in poor performance because they mimic the same educational approach for every student by requiring students to meet the same minimum standards (Lillard, et al., 2005; Carlisle, 2009). Alternative educational systems identify that in order to increase the performance of students, it is better to create a structure that accepts them for who they are, practices no influence or control, and helps them align their strengths. In Montessori Education, instructors are encouraged to minimize teaching technical information and focus more on helping the student figure out who they are and what they most enjoy in life. This allows them to move at their own pace, and achieve higher standards (Lillard and Else-Quest, 2006). Likewise, Lumiar focuses on hiring experts in every field who are typically older, more experienced and have a greater understanding of life to educate the students. The students are also able to choose what path they want to pursue in school, based on what interests them and what they are more proficient at (Semler, 2014).

PBSRG identifies that experts enjoyed their line of work. They are highly motivated to add value. Their expertise simplifies the tasks. The authors propose that if students can identify who they are, their strengths and the areas of life they are interested in, they will minimize their stress levels and improve their observation skills, processing speed, self-confidence and skills.

By observation, simplicity is defined when people have to think less, make fewer decisions, and minimize discussion (Kashiwagi, 2016). When education is simple, concepts become obvious to the least capable and least perceptive person in a group. Simplicity is seen when a group of

people, regardless of technical background and level of experience, can all understand the same concept. For example, if a water bottle was held in the air, everyone would immediately know what direction it would move in if it was dropped. Simplicity results in students having the following attributes:

1. Clearer vision of future.
2. Greater perception and understanding.
3. Minimize decision-making.
4. Identify and increase value to society.
5. Reduced stress.
6. Less use of influence or control of others.
7. Less need of details.

Individuals who have expertise in a certain area and can see an event more clearly create simplicity. They, in turn, use their vision to help others who cannot see as clearly, reduce the complexity of life, and align individuals to their area of best fit.

The authors propose that they will use an educational approach that makes things extremely simple. The approach is called Information Measurement Theory (IMT). IMT is the most licensed technology out of Arizona State University. The IMT technology has been tested in the delivery of services, and is the foundation of the Best Value (BV) Performance Information Procurement System (PIPS) that has been tested for the last 23 years. IMT is a high-level, leadership-based approach that has the following characteristics:

1. Minimizes exceptions by using natural laws.
2. Identifies that natural laws govern all events or happenings.
3. All events have a unique initial condition and a unique final condition.
4. Identifies that there is no such thing as chance or randomness.
5. Uses extremes to explain the difference between entities.
6. Minimizes the need to understand details.

IMT simplifies the complexities of life. IMT allows students to understand complex situations of life with minimal experience and knowledge.

Methodology

The researchers will use the following methodology:

1. Identify the success of the IMT concepts in setting up a Best Value leadership education structure.
2. Test the use of IMT concepts to simplify the education of students at the college level in the Barrett's Honors Program. The metrics used will be the understanding of the concepts, satisfaction with the class and the reduction of stress.
3. Test the use of the IMT concepts with one and two-week high school summer school courses.
4. Run a full-year course implementation test at Saint Louis High School.

5. Analyze the results.
6. Identify conclusion and recommendations.

Other objectives of the research include:

1. Investigate the scalability of the Best Value Leadership Education Approach in K-12.
2. Identify if the simple concepts that work in industry can also work in the education of students in college, high school and intermediate school.

Best Value Leadership Technology

For the past 23 years, the Performance Based Studies Research Group (PBSRG) at Arizona State University has researched and developed an innovative technology that transforms complex situations into simplistic situations. The technology is licensed by Arizona State University through AZTech, the governing group for intellectual property developed at Arizona State University. The technology has the following names and characteristics (Kashiwagi, 2016):

1. Information Measurement Theory (IMT).
2. Performance Information Procurement System (PIPS).
3. Performance Information Risk Management System (PIRMS).
4. Kashiwagi Solution Model (KSM).
5. Industry Structure (IS).
6. Leadership based approach based on alignment with no utilization of direction, control, influence or expectations.
7. Language of metrics.
8. The "Event" diagram that identifies that every event in life moves from one unique condition to another and the change is governed by natural laws.
9. Every person is accountable for his or her own life.
10. "Cycle of Learning" that identifies every individual and organization is constantly changing and the perception, ability to process, application of natural laws and the rate of change are related.

The concepts have been utilized to do the following:

1. Assists clients/vendors to optimize their organization and services they provide by creating simplicity.
2. Assists clients/vendors to use logic and common sense to understand reality and better utilize and align expertise and resources.
3. Created a leadership structure that mentors the client/vendor to increase the utilization of expertise and become even more expert in their own area.
4. Assists clients/vendors to add dominant value by doing more with less.

This technology is the most licensed technology (46 licenses) from the most innovative school in the United States (Crow, 2016). It has been tested in the entire supply chain (construction and non-construction). Its developments have been researched and developed, in support of

professional groups like the International Council for Research and Innovations in Building and Construction (CIB) and the International Facility Management Association (IFMA), and has been identified as a more efficient approach to the delivery of professional services.

The BVA results have been heavily documented. Performance documentation are the following (PBSRG, 2016):

1. PBSRG has received a total of $17M in funding with 300+ grants.
2. 1,800+ projects or $6 billion (1634 projects, $4B construction and 235 projects, $2B non-construction), customer satisfaction of 9.8 (out of 10), 93.5% of projects on time and 96.7% on budget.
3. 98% customer satisfaction / 9.0 (out of 10) client rating of BVA model.
4. Decreased the cost of services on average by 31%.
5. Contractors/vendors were able to offer the client/owner 38% more value.
6. Largest projects: $100M City of Peoria Wastewater Treatment DB project (2007); $53M Olympic Village/University of Utah Housing Project (2001); $1B Infrastructure project in Netherlands (2009).
7. Most audited system with four major audits (State of Hawaii, Corps of Engineers (COE), a Dutch university dissertation, and the National Association of State Procurement Officials (NASPO) (Kashiwagi et al. 2002; State of Hawaii Report 2002 (DISD); Duren & Doree, 2008; Rijt & Santema, 2013).
8. The results of BVA testing has won the 2012 Dutch Sourcing Award, the 2007Construction Owners of America Association (COAA) Gold Award, the 2005 CoreNet H. Bruce Russell Global Innovators of the Year Award, the 2001 Tech Pono Award for Innovation in the State of Hawaii, along with numerous other awards.
9. The changing of the Dutch model to deliver services from the traditional manage, direct and control to the leadership based Best Value Approach. The movement of this change has spread into Norway, Poland, Denmark and Switzerland.

PBSRG is constantly implementing this technology in the supply chain in different countries (7 countries and 33 states in the U.S.), to hasten the movement to a simple and transparent environment that can accurately align resources to reduce cost and time, while increasing value and performance. It is now being taught in higher education at Arizona State University.

Testing of the Best Value Approach in College Education

Arizona State University is identified as one of the most innovative schools in the country ahead of MIT, Harvard and Stanford (Crow, 2016). Barrett, the Honors College at Arizona State University is a program of innovation and impact. The New York Times identified it as the “gold standard” of honors education, and the Best Value in today’s university education systems (Bruni, 2015). Students pay $1,500 per year more in tuition than average students (Barrett, the Honors College, 2015) and complete additional honors program required classes outside of their core concentration. Honors classes aim to broaden students’ worldview and help them innovate and impact society. The majority of the honors students are in the top 1 – 5% of the ASU students and number around 5,400 students annually (6% of the ASU students) (Barrett, the Honors College, 2015). In 2009, honors students were given the opportunity to learn the Best

Value Approach by taking a new course titled "Deductive Logic, Leadership and Management Techniques." This class exposed students to the following:

1. How to learn five times as fast.
2. How to minimize the amount of detailed information required to resolve complex issues.
3. How to provide maximum value to society and happiness in life.
4. Learn a new approach to learning that replaces memorization of details with simple concepts of natural laws, logic and observation.
5. Learn how to know almost everything, without knowing almost anything (understanding of natural laws).
6. Simplification by observation without decision-making, requiring minimal thinking, decision making and work.
7. A new approach to leadership.

The Deductive Logic and Leadership class has identified that each individual is unique and can maximize their value to society by identifying:

1. What they love doing.
2. What seems simple to perform, and therefore identifying their expertise.
3. Ensuring that what they love, and what is simple to them adds value to society.

The course started with one class and has since expanded to five simultaneous classes with 120 students enrolled per semester. It has become one of the most popular honors courses. On Rate My Professor, it is the highest rated class at Arizona State University for a professor who has more than 140 ratings (RateMyProfessors.com, 2016). The class has the following unique characteristics:

1. The professor interviews every student at the beginning of the semester to identify unique characteristics or interests.
2. There are no rules in the class.
3. Students are asked to listen, think about the concepts, and form their own conclusions. No student's conclusion is wrong.
4. Students are requested to minimize the amount of work that they do, minimize the amount of thinking and maximize the impact of their contribution to the class (which they determine).

Concepts of the Deductive Logic and Leadership (DL&L) course include the following:

1. Intelligent individuals are observant and minimize their thinking and decision-making.
2. Less intelligent individuals have a difficult time observing and accepting reality; they are blinded by their own biases.
3. Less intelligent individuals are more likely to get confused, think more, make more decisions and increase risk of failure in their personal life and in society.
4. Making people think and make decisions is a practice of the non-observant.
5. The non-observant increases stress levels and assume that people can be influenced and controlled.

6. Influence and control of others are inaccurate concepts; they have ended in failure when practiced and increases stress levels and depression.

Because of the course, students become much more logical in their thinking. In the span of one semester, students can understand seemingly complex concepts that are outside of their degree concentration. They become leadership oriented. They understand themselves, their families, their peers, their teachers, and their respective industries in a new light. The instructors document significant changes that the students make in their personal life because of the class (Rivera, 2013; PBSRG, 2016). If the leadership approach can have significant results that are easily observed, the authors propose that the logic can be used to create a new paradigm for people and provide them more value than traditional education. The following have been significant documented results of the class (Rivera, 2013; PBSRG, 2016):

1. A student taking antidepressants for 3.5 years, stopped taking medication, stopped receiving counseling, and became proactive, stabilized, and is now planning on graduate school in counseling.
2. An alcoholic engineering student, identified his genetic disposition to being an alcoholic, ceased drinking, and changed his outlook on life.
3. A Navajo student, who hated her life, and her mother, became a happy and successful nursing graduate.
4. A student on the suicide watch list, became confident with himself, happy, productive, and needs no further counseling.
5. An emotionally unstable, depressed single mother of two kids changed her entire life and became a top graduate from the school of construction management. She received multiple offers from construction management firms and graduated from the Arizona State University Law School.
6. An emotionally unstable, depressed male whose wife left him over numerous issues to include alcoholism, was at risk of failing his undergraduate degree, eventually figured his life out, quite drinking, is now back with his wife and doing well, and graduated on time.

Breaching Secondary Education with the Barrett's Summer Honors Program

As a result of the successful ASU Deductive Logic and Leadership class, the curriculum was taken to the high school level, first, as a three-year preliminary case study test in the honors K-12 outreach program, Barrett Summer Scholars, and second as a full curriculum implementation at Saint Louis High School in Hawaii in Fall 2015.

The Barrett Summer Scholars (BSS) education program was conducted over three summers (2013-2015), teaching students exiting 7th, 8th, and 9th grades. The course instructors were undergraduate and graduate research assistants who previously learned the Best Value Approach at ASU. The case study was divided into three functional phases:

1. Phase I: A one-week class for 7th grade students; taught by undergraduate students.
2. Phase II: Three one-week classes for 7th – 8th grade students; taught by graduate students.
3. Phase III: Four one-week classes for 7th – 9th grade students; taught by undergraduate students and one two-week class for 10th grade students; taught by graduate students.

The course curriculum was based off the same curriculum taught to ASU honors students. Throughout the duration of the case study, the instructors tracked the course satisfaction ratings, the impact on student stress, and student comprehension scores. At the end of the case study, the results were compared to other summer engineering, science, and literature courses offered by BSS. The results of the full three-year case study are shown in Table 1. The results of the satisfaction ratings show that students preferred the Deductive Logic and Leadership (DL&L) course and research assistant instructors over the Barrett course and professors respectively.

Table 1

Performance Metrics of the DL&L Course Case Study (PBSRG, 2016)

Case Study Length	3 years
Number of Students sampled	194
Decrease in stress level	-24%
Other BSS Course Rating (1-10)	8.56
Other BSS Instructor Rating (1-10)	8.78
DL&L Course Rating (1-10)	9.06
DL&L Instructor Rating (1-10)	9.60

During Phase II the Barrett Summer Scholars (BSS) staff sent out an additional electronic survey to the students at the conclusion of the program. The courses were rated on three factors: enjoyment, rigor, and instructor quality. The results are shown in Table 2.

Table 2

Student Ratings of all BSS Courses from 1 – 4 (PBSRG, 2016)

BSS Course Category	Enjoyment	Rigor	Instructor Quality
Literature and Philosophy Course	3.27	3.56	3.56
Combined Science Courses	3.71	3.85	3.70
DL&L Course	3.93	3.80	3.83

The DL&L course is shown to be more enjoyable, has a higher instructor quality, and less rigor than the other BSS courses. A fundamental principle of this education is that it is simple and easily understood and implementable, this not only plays a part in the effectiveness and ease of teaching, but it makes the course less rigorous compared to other science and engineering courses as shown above.

In Phase III, students were given an exam on the concepts before and after the class. The results of the exam shown in Figure 1 portray student comprehension. Before taking the course, students of all grade levels had an average comprehension score of 45%, whereas after taking the class, students had an average comprehension score of over 80%.

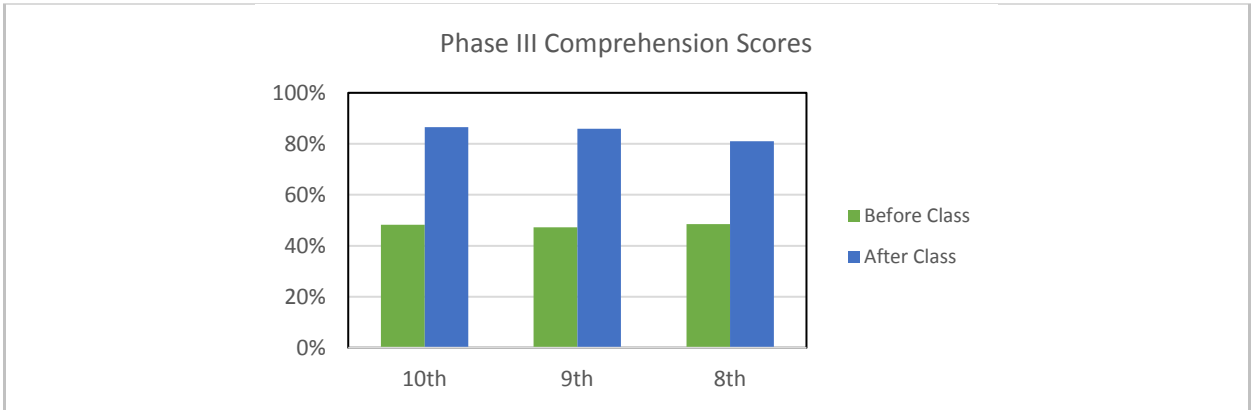

Figure 1: Student Comprehension Scores Before and After the DL&L Course (PBSRG, 2016).

In the comprehension exam, students were asked to provide their feedback of the course. They were asked what they liked, disliked, and any impact the course had on their lives. Students reported to be happier, more confident, and have a better vision of their future after taking the course. Below is a list of some of the most dominant student comments (PBSRG, 2016):

"(The class) completely changed how I view and approach everyday situations. All the information that I learned through this program is completely applicable."

"I like how this class made life easier and actually happier for me; teaching me how I am in control of my life."

"I'm always trying to take challenging classes, but this is the first one that challenged me to think differently. I have learned more this week than in any other course."

Saint Louis High School Case Study

Barrett Summer Scholars program has paved a way for the Performance Based Studies Research Group (PBSRG) to move into K-12 educational research. The curriculum from the college and BSS courses has been compiled into a single class package that can be incorporated into K-12 education programs. In the spring of 2015, Dr. Dean Kashiwagi approached his Alma Mater, Saint Louis High School in Hawaii to identify if they were interested in testing and implementing the Deductive Logic and Leadership (DL&L) course. The goal of the course was to help students eliminate negative behavior, understand who they are, and gain vision for their future to best align their strengths with a career path that they enjoy. The class consisted of young men of whom: 70% had failing grades, 90% had disciplinary referrals, and 80% were diagnosed with ADD and ADHD. Saint Louis High School (SLHS) has made it its mission to help young men become role models in society (Saint Louis High School, 2016). Saint Louis High School, is one of Hawaii's oldest and only prominent all-boy Catholic schools, covering grades 6-12, and has been educating young men since 1846. The school's tradition is to enrich young men's lives by creating a win-win environment that promotes the success of all people, which is in alignment with the Best Value Approach.

When approached with the tenants of the Deductive Logic and Leadership course by Dr. Dean, Director of Faculty and Staff, Mr. Robbie Murakami identified, "Our school became interested in the course because we wished to cultivate leadership in our young men and develop an understanding of self-accountability. We felt that the no rules approach would allow our students to openly discuss topics and learning strategies without fear of reprisal." When considering which teacher at Saint Louis would best fit the course to teach, Social Sciences teacher, Chris Doyle, was immediately identified. With over 14 years of teaching experience, developing and implementing new course curriculum in Hawaii, he seemed to fit the mold. He was in alignment with the Best Value model, identifying "we are facilitators…you will not be able to control students. However, if you show that you are an advocate for them and are willing to work as partners; teachers can be the "guide" to let students realize their potential." Along with Chris Doyle, Saint Louis High School identified 20 students to run a test course in fall 2015 to identify impact.

Course Curriculum Comparison

The course curriculum is based off the same curriculum taught to ASU honors students and BSS. The primary difference is that, in the college courses, professors have more time to cover applications and industry case studies. In the high school course, instructors translated the same industry management and leadership principles to the life of a high school student. The following topics were covered:

1. Managing school workload and projects.
2. Managing personal stress and conflicts.
3. Utilizing the expertise of parents, teachers, and other experts.
4. Discovering personal expertise, interests, and goals.
5. Creating plans to accomplish future tasks and goals.
6. Recognizing when to admit a lack of knowledge and seeking expertise.

Throughout the duration of the course, Chris Doyle tracked the course satisfaction ratings, the impact on student stress, and student comprehension scores. In November, Dr. Dean visited the SLHS class and was impressed with both Mr. Doyle and the students. He discovered that the students were very attentive and participated freely in the discussions. A visitor from the Kamehameha Schools (largest land grant and private school in Hawaii), who had also attended the class, was amazed at the openness and maturity of the students. Director Murakami, also impressed with the results of the class, sought out and received approval from the National Collegiate Athletic Association (NCAA), to assign the class as a core philosophy course for all potential college bound athletes. As the results of the course have exceeded expectation, the program is expected to grow exponentially and has been continued through spring 2016.

Saint Louis High School Test Results

In order to gain a more developed perception of how well the students faired in the class, the authors created a 25 question survey that was given to each student to rate on a scale of 1-10 (1 is low and 10 is high). The survey was the same one that is given to the university class students and industry professionals. The survey was given to the high school students before and after the fall 2015 semester. The survey questions were broken up into the following major sections:

1. Six comprehension questions.
2. Six industry related questions.
3. Thirteen personal opinion questions.

Upon completion of the survey, the authors were able to measure the following:

1. Student satisfaction with the Deductive Logic and Leadership course.
2. The impact on student lives through a reported change in stress, personal confidence, and career preparation because of the course.
3. Difference in student comprehension of core course concepts.

Since the focus of the class was exclusively on logic and leadership application, the analysis for the industry related questions were not documented in this paper. Table 3 shows the overall results of the student satisfaction of the DL&L course and impact on student lives. The results are as hypothesized. Students felt the new class added tremendous value with a rating of 9.6/10, and their comprehension of the material increased by 79%. Student stress was decreased by 46%, their self-confidence increased by 51%, and their confidence for their future increased by 44%. The results match the perceptions of their instructor Chris Doyle, who identified the behavioral issues brought into class by students, were nearly eradicated within the first semester.

Table 3

Performance Metrics of the SLHS Case Study (PBSRG, 2016)

Criteria	Metrics
Total Students	20
Comprehension Score	79%
Change in Stress	-46%
Change in Confidence	51%
Change in Career Preparedness	44%
Class Rating	9.6/10

The benefit of Saint Louis High School was that students had more time in class than compared to Barrett Summer Scholars (BSS). In the BSS case study, the authors were unable to measure the difference in student comprehension of core material, because one week is not long enough for students to fully comprehend the curriculum. The Saint Louis High School survey was the first time the authors were able to measure high school students' comprehension of core concepts. Differentiating between students who understood concepts the most and the students who understood concepts the least, provides a clearer perspective on the effectiveness of the class and its ability to help different students improve their performance.

Table 4 shows a breakout of student comprehension from greatest to least, by analyzing the six comprehension questions. Students who answered 100% of the questions correctly were categorized in Group 1. Students who answered 50% or less correctly were categorized in Group 3. For all others who answered greater than 50% and less than 100% were categorized in Group 2. The authors selected the six comprehension questions because they are simple to understand and closely reflect the core concepts of the course. Prior research has identified that students and professionals who answered them correctly, had a greater understanding of class material.

The six comprehension survey questions analyzed were the following:

1. I believe in influence.
2. I believe that you can control others.
3. I think that the person creates his/her environment.
4. I control my life.
5. Any event has multiple possible outcomes.
6. You can predict the future.

By breaking out each student category, the authors were able to clearly differentiate Table 3 and Table 4. This further illustrates the impact on various student populations, in terms of: stress, confidence, career preparedness, and satisfaction of the course.

Table 4

Analysis of Student Population (PBSRG, 2016)

Criteria	Group 1	Group 2	Group 3
Total Students	7	9	4
Comprehension Score	100%	50-100%	<50%
Change in Stress	-54%	-42%	-38%
Change in Confidence	35%	70%	44%
Change in Career Preparedness	44%	60%	18%
Class Rating	9.71	9.89	8.75

The results indicate that all students, regardless of the category, increased in comprehension, decreased in stress, and increased in self-confidence and career preparation. Further major observations were the following:

- Biggest decrease in stress: Group 1 students.
- Biggest increase in confidence: Group 2 students.
- Biggest increase in career preparedness: Group 2 students.
- Higher satisfaction ratings: Group 2 students.

According to a student's level of understanding, it would be consistent that the students who had a greater understanding of the class applied more course concepts to their lives and decreased their stress, while the least understanding students, began to see how the concepts may help improve their lives and cause them to have a greater increase in confidence. The true value of the Deductive Logic and Leadership (DL&L) course, as evidenced by the results, is how it can help

everyone increase their performance while decreasing their stress. Interestingly, the Group 3 students also perceived that they significantly progressed and were more prepared for life after high school then before taking the class.

Student Impact

Through the Deductive Logic and Leadership course, students were taught the following same fundamental concepts discussed in the college level course:

- All events happen only one way.
- There is no such thing as randomness or chance in reality.
- Everything can be predicted if you have enough information.
- Everything is subject to laws of nature.
- The concepts of influence or control are not accurate. When people attempt to influence or control others, their risk increases, and many times the results are contrary to what was expected.
- People who can see into the future are experts in their area.
- We can create an environment that helps the "blind" or inexperienced people see.
- Everyone is in a silo, and by understanding reality they can remove themselves from the silo and understand reality.

The course environment resulted in students overcoming their shyness, increasing their participation, and becoming more motivated. The students documented their experiences in personal journals, which noted the inclusion and application of the concepts in their lives. On the topic of student utilization of the concepts, Chris Doyle stated, "The biggest take away is that students are realizing that they control their lives. It is very empowering and has given these students a self confidence that was missing in their lives." Additionally, out of the 20 students, Chris Doyle conducted case studies on five 12th graders. He asked them to fill out an additional survey at the end of the first semester (see Table 5). The questions asked were the following:

1. How has this class lowered your stress levels?
2. After taking this class, do you make more or less decisions?
3. After taking this class, are you happier in life?
4. After taking this class, has your thought process changed (do you thinking differently)?
5. How has this class impacted your life?

Table 5

Analysis of Student Population (PBSRG, 2016)

Criteria	Rating
Lowered stress	100%
Minimized decision making	100%
Felt happier	100%
Identified a difference in thinking	100%
Identified positive impact	100%

Additional to the analysis conducted by Chris Doyle, the authors analyzed all the responses by each of the five students and identified three additional patterns in their responses seen in responses 3-5, at the bottom of Table 5. Interestingly, all the students identified a decrease in stress, and that they were happier in their lives. In addition, the students felt their personal relationships had improved, which is a windfall effect of the course that furthers the advancement of Saint Louis High School's tradition of encouraging community and family values. The most impactful student comments are listed below (PBSRG, 2016):

1. Student 1 realized that he had full control over his life and this has helped him to gain more confidence in himself and his ability to lead others. He states, "This class has made me happier and has helped me to be an effective leader in the community. My effectiveness as a leader is not only found in the school, but also on the baseball field. Be happy and enjoy what you do in life because you control yourself."
2. Student 2 learned that those who are better prepared in life tend to be happier, less stressed and more productive individuals. He concluded: "It's your choice how prepared you are."
3. Student 3 realized that the silos of life are in our minds and cause us to become confused and think too much. The concepts we learn in one area of our life can be applied to other areas. He realized the more information he can perceive the less thinking and decision-making is required to choose the most efficient path. He identified as an example, "when I body board, the more I have to think and make decisions, I am more likely to mess up and wipe out. If I just go, then I noticed that usually I make the drop and not wipe out."
4. Student 4 was grateful for the class because, previously, he did not recognize that everyone in his life has value. He concluded that the best way to help others is by recognizing how to add value. He realized that his pride was only causing him more pain. He identified, "My process before taking this class was downhill, meaning I wasn't humble, I wasn't respectful to others, and it was all about me… There was a particular lesson when we were being taught to think about others before yourself. I really considered this and came out with good results. I found that when you help others you feel really good and pleased about what you did, which causes you to do more good acts."
5. Student 5 was struggling with the mentality that he needed to know everything. He quickly realized that it was too difficult and never ending. Instead, he figured out a much faster way to get what he needed: "I've learned to utilize experts, and if you do not know something, ask. The big area this affected was my fitness. I have a good knowledge about lifting and supplementation, but I do not know everything, so I will ask experts when I am unsure about a certain lift or a certain supplement. By asking questions, it's helped me to increase my knowledge on any subject."

Lastly, according to Chris Doyle, he identified that: "This course would be beneficial to our student population and give them more practical thinking skills, to better prepare them for life after graduation. Building more teaching capacity would also serve to integrate more teachers facilitating the course, which would be a positive step in increasing professional development of the teachers."

Sustainability and Impact

Bringing a college-level course to high school students is part of a major research effort at ASU to identify the impact of a simple and transparent educational approach on the existing structure of education institutions. This approach allows students to quickly identify reality, learn who they are, and align themselves with their talents to increase value in society. Instead of the "one size fits all" approach this will help students align themselves into much needed areas such as construction craft areas of mechanical, electrical and plumbing and piping, facility management, project management, procurement and leadership roles in every industry. The industry has a tremendous need to identify the right people, align them in the right jobs, and give them a structure that increases their performance.

Due to the tremendous success of the Barrett Summer Scholars and Saint Louis High School case studies, junior researchers in the PBSRG have created an innovative approach to reach out and integrate this course and its logic within the Phoenix valley. In 4 months, they have reached out to 117 high schools, given 17 presentations to over 1,800 students and 105 professionals, met with 41 professionals, and have identified two high school districts, Phoenix Union and Tempe Unified, who are looking to replicate the success of the BSS and Saint Louis High School education efforts in their own districts.

High schools across the Phoenix metropolitan area have identified a real need to help students decrease their stress and learn better life preparations tool, but Phoenix Union and Tempe Unified have been the only districts to identify two schools, North and Mountain Pointe High Schools, to run a weeklong leadership education test. The junior researchers have developed, and coordinated, one week-long summer sessions (45 students at North High School, 25 students at Mountain Pointe) as tests to identify student impact and scalability of the Best Value leadership education. If successful, the junior researchers will continue to work with Phoenix Union High School and Tempe Unified School Districts, and other able schools to begin expanding this Best Value leadership education research effort into high school curriculums, after school and summer programs.

Conclusion

The traditional K–12 and college educational approach is encountering problems with student stress and poor alignment of student strengths in preparation for their future careers. A new approach, which has been tested in the delivery of services in the construction and other industries for the past 20 years, has been tested at college and high school levels. The new approach uses the following:

1. Simplicity.
2. Minimal thinking and homework.
3. Helping students to understand quickly complex issues.
4. Teaching without using influence or control over students.
5. Minimal rules, direction, and control.
6. The latest scientific developments and current events.

The test results for college and high school levels have shown a decrease of stress, increased understanding of natural laws and reality and enjoyment of the class. It also increases the students' level of confidence and understanding of who they are.

The authors propose this new education approach is the education model of the future. The focus of education is not on meeting the requirements of a system, rather on meeting the needs of each student, by creating an environment that allows students to grow and learn at their own pace and level. The authors propose more research in the testing of this new education approach continue, to help the support and move toward a more efficient education and supply chain management system.

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Best Value Procurement in Construction and its Evolution in the 21st Century: A Systematic Review

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This research attempts to facilitate client needs by describing the priority indicators that could help in decision making for awarding contracts. The indictors are recognized as key variables that impact the subsequent decisions of contracts award. The authors present a hierarchical review of relevant literature and integrate the factors that help in decision making using the Best Value Approach. This framework is comprised of eight dimensions of Best Value contributing factors – *cost*, *risk*, *performance*, *quality control*, *health and safety*, *project control*, *current workload* and *delay claims*. These eight dimensions aid the individual clients and organizations in selecting the most suitable contractor. The authors provide a brief understanding of Best Value contract strategy and the basis for the contract award in terms of business choice, managerial capacity and competency. This paper aims to provide a philosophy as to how Best Value decision making could be influenced by the ranking of contributing factors. This work also help in decision making by providing a hierarchical arrangement of the influential factors and the corresponding criteria for Best Value contract award.

Keywords: Best Value, Performance, Quality control, Health and Safety, Systematic review.

Introduction

In the construction sector, project success is defined in a unique way. Project success is defined by meeting design goals, fulfilling user satisfaction, organizational development and developing technological infrastructure of the country. Projects can be undertaken successfully by achieving the milestones in the designated time, conforming to the quality standards and satisfying the cost impact on the end user (A. M. Liu and Walker, 1998). For many decades, the procurement of most of the construction projects has been carried out under traditional low-bid approach. In the traditional process of contractor selection, most of the projects suffer in terms of time and cost due to the subjective bias in clients' selection mechanisms. According to the user agency, the same level of performance could not be achieved due to subjective bias in contractor`s selection process (D. Kashiwagi and R. Byfield, 2002). The complex and risky decision making in low-bid approach results in misunderstanding, reactive contractor behavior, decreased quality of work, and hostile relationships (J. Kashiwagi et al., 2010). Many owners tend to select based on the lowest price in exchange for quality of work. The actual value of a contractor depends both on cost and project specific criteria (PSC). Supreme value can be measured from contractor's credentials, or 'selection criteria', during prequalification and final tender evaluation stages (Wong et al., 2000). Most research focuses on augmenting the long term performance of projects by evaluating the key factors in selection process (Cheng and Li, 2004). In selection process, the insertion of significant elements that meet the explicit needs of the project, confirms that the selected contractor is the most qualified to build the facility. The Best Value (BV) selection method identifies the most qualified contractor based on verifiable past performance metrics instead of more traditional criteria (Abdelrahman et al., 2008).

Clients and their representatives have to deal with bidding processes which are sometimes very arduous and challenging. The traditional low-bid system of contractor selection is often used because it very easy since it does not involve a lot of effort in evaluation of contractor expertise, personnel and performance, thus making documentation easier (D. Kashiwagi and R. E. Byfield, 2002). There is a level of satisfaction with this process on part of various stakeholders like designers, vendors, suppliers, engineers and project managers (Waara and Bröchner, 2006). This process assumes that the contractors will provide good quality regardless of the price. On the other hand, Best Value ensures that the most qualified contractor is selected regardless of the price. Therefore, understanding the Best Value system can greatly benefit both clients and contractors.

Best Value

Best Value (BV) is an efficient and effective approach that minimizes the detailed wasteful communication and information, and creates a "win-win" scenario for both the client and contractor; the highest possible value at a lowest cost, high vendor profit, and minimal project cost and time deviations (D. Kashiwagi et al., 2012). BV examines various factors that need to be considered in procurement processes to enrich the long term performance and significance of the construction (Chan et al., 2004). BV underlines effectiveness, value for money and performance criteria. It focuses on establishment of best practices for public sector organizations such as formulating verifiable standards and develops sufficient contractual arrangement in delivering services to the public (Akintoye et al., 2003).

Concept of BV

The foundation of BV is based on the concept that by using multiple criteria, vendor competition increases and transparency increases thereby making it more difficult for vendors to mislead clients in their proposals. Undeniably, the quality grounds are not the same for each contractor. Therefore, it is preferable for the procurement party to select a vendor with the optimal quality at an accurate price (Herbsman et al., 1995). All the quality standards could not be implemented on a project at lowest cost. Therefore, it is thoughtful to use a cost-time tradeoff approach (Shen et al., 1999).

Best Value Contract Strategy

The BV contract strategy is implemented in various stages. It consists of a competitive selection phase, a clarification phase and finally the execution phase (J. Kashiwagi et al., 2010). Comprehensive comparison of values and prices is done in competitive selection phase. Since this process caters most of the factors mutually, BV is always the "Best Value proposed for the lowest price" and is relative (D. Kashiwagi et al., 2014). After identification of BV, the contractor should ascertain what they are going to do in clarification phase in which the contractor is encouraged to justify his capability, performance and expertise. The detailed proposal (clarification) is then put into contract along with the contractor's price. The contract is finally signed and the contractor is obligatory to deliver the project in execution phase (Savicky et al., 2014).

Comparison of BV and traditional methods

In the traditional low-bid contract system, the bidders do not have any pricing information of other competitors and the bidder who offers the lowest price wins the contract. Consequently, all the bidders tend to lower their bid-price just to win the contract (Yasamis et al., 2002). This low-bid selection method hinders the quality of the product and services because bidders are not inclined to fully understand the needs of the client (D. T. Luu et al., 2005). As a result of contractor's diminutive performance, the whole project might suffer time and cost overruns which provides a gateway for legal issues like arbitration/ litigation (Assaf and Al-Hejji, 2006).

The BV is different from the traditional method in a sense that it utilizes the expertise of industry professionals by minimizing the management and control of vendors. Experts can think in the best interest of the owner, identify the risks associated to the project and able to prescience the consequences of decision making (D. Kashiwagi and R. Byfield, 2002). Since the owner is not the expert, it is the responsibility of the expert vendor to deliver the project assignments and to compete upon the capabilities to identify and resolve the problems with their accompanying prices. Based upon the expertise, the vendor then clarifies in detail the procedures to be adopted to meet the client's expectations (Chan et al., 2002).

Advantages of BV Procurement

The prime advantage of BV is that it identifies expertise as the only factor that can minimize risk of nonperformance and any attempt to manage and control a vendor is inefficient and costly (D. Kashiwagi and R. E. Byfield, 2002). By using performance information, expert vendors show their high performance on similar projects and address the needs and concerns of client (Abdelrahman et al., 2008). BV encourages the vendor to describe and provide accurate solutions to the problem and methodology that a non-expert vendor can identify expert vendor and utilize expertise to lower cost and risk (Kelly et al., 2009).

Disadvantages of Traditional Procurement

Low-bid practices result in poor wages and working condition and low environmental standards, thus declining the quality and sustainability of products and services (Baloi and Price, 2003). Designers, project managers, politicians, and contractors were comfortable with the existing traditional ‘‘low-bid’’ process. This process ‘‘assumes’’ that all contractors will provide an ‘‘equal’’ quality product but most of the clients find the contractor who offers to undertake the project at the lowest price (Flyvbjerg, 2013). The major reason why the low-bid process continues to be used, despite its subjectivity and bias, is because it is easy to document and explain a low bid (D. Kashiwagi et al., 2014).

BV Contributing Factors

BV is not an isolated concept, it has its origins and contributions within the project performance and team related factors. This study suggests that BV is most effective when it is based on key evaluation criteria for contractors. Based upon the study of previous researches, the criteria contribute the project award are:

1. Cost
   Cost is one of the most significant criteria for measuring project success. It is defined as the basis at which the general conditions that are mentioned in contract stimulate the project completion within the expected budget (Bubshait and Almohawis, 1994). It cannot be suggested as the cost that is only constituted in tender sum, but it covers cost which is being utilized in various stages of project leading form inception, designing, and execution to maintenance. Overheads and profits of contractors are also summed up in cost. It can be measured as unit cost or lump sum. In acquisition, price plays a vital role where the requirements are well defined and risks are negligible. On contrary, where requirements are not well defined, non-price criteria may dominate (Watt et al., 2010). The Best Value Source Selection (BVSS) energizes creativeness and improvement from contractors who intended to fulfill the requirements of public projects and augments the flexibility in selecting best proposal (Zhang, 2006).

2. Risk
   Project risk is an ambiguous event whose occurrence negatively impacts the project outcomes such as cost, quality, schedule and scope (Rose, 2013). In measuring risk, identified risks are further ranked both qualitatively and quantitatively. In this way, the risks are highlighted for further analysis. Project risks and their sources can be classified using various approaches. From the perspective of contractor, project-related risks can be classified that have an impact on project performance in terms of cost (Baloi and Price, 2003). Incentive-based contracts were introduced to overcome the issues that occur in traditional forms of payment. Both client and contractor share the risks and the reward in incentive-based contracts (Floricel and Miller, 2001).

3. Performance
   Past performance of contractor is evaluated prior to its selection. In this process, various attributes such as human resources, machinery and equipment, skill level of project team, optimized resource utilization and number of key personnel are evaluated. In order to improve the overall performance of contractors, they must focus to complete the project in stipulated time, reduce delays and establish good relationships with sub-contractors (Xiao and Proverbs, 2003). Contractor enactment play a dynamic role in success of project since it is the party who has the duty to deliver the project. Augmented contractor performance definitely enhances the user gratification, contractor repute and their effectiveness in the market. Research shows that there is much room for further investigating the contractor performance (Alarcón and Mourgues, 2002) .The contractors who are able to finish by the deadline of project are more viable to bring out future projects (Chan et al., 2002). Therefore, during selection, those contractors who have excellent past performance record should be given preference in contract award (Khosrowshahi, 1999).

4. Quality Control
   The assessment of quality is subjective. In the construction industry, quality is defined as the totality of features required by the products or services to satisfy a given need; fitness for purpose (Arditi and Gunaydin, 1997). Specification is defined as workmanship guidelines provided to contractors by client at commencement of project execution (Boukamp and Akinci, 2007). Corporate-level quality refers to the quality expected from a construction

company in addition to the product and/or service quality. Corporate quality culture promotes quality conscious work environment and corporate-level quality in a construction company. It establishes and promotes quality and continuous improvement through values, traditions and procedures (Arditi and Lee, 2003). Contractors achieve client satisfaction by establishing strong quality culture and delivering higher quality services and facilities. Owners expect that the contractors must deliver the highest quality in each aspect. Therefore, it is of importance to owners to encourage the contractors who follow high quality standards (Cox et al., 2003).

5. Health and Safety
   Health and safety is defined as the extent to which the general conditions are implemented on the project without major injuries and accidents on site (Bubshait and Almohawis, 1994). In a rapidly built environment, general reminders to implement safety are very important to avoid fatalities. Additionally, warning signs must be displayed to develop a safe and healthy environment at workplace. These warning signs keep the workers attentive to follow safety rules, enable them to communicate the hazards, provide them the necessary instructions about using personal protective equipment (Toole, 2002).

6. Project Control
   The project monitoring and controlling process should be initited from planning phase which involes appropriate breakdown into smaller components, using performance metrics and anayltical tools, Earned Value Management (EVM) and performance forecasting (Nepal et al., 2006). The procedure of evaluating project cost and perfomance has been significantly analyzed (Rose, 2013). In order to quantify the progress based on WBS and cost accounts, several models have been developed. The researchers are still an awful long way from achieving the lowest possible level of scope breakdown to evaluate progress without messing with data handling (Chan et al., 2001).

7. Delay Claims
   In the construction process, delay claims are considered to be an area of uncertainty and severance (Wood and Ellis, 2005). The cost of disruptions is production related and often problematic to justify. Several issues may arise such as how to alleviate the risks relating estimation, resource utilization, poor workmanship, plant breakdown, deprived quality or impaired material (Shi et al., 2001). In case of potentially problematic aspects of delay claims in a construction project, study reveals that various aspects like pre-contract negotiation, clarity in project scope, and agreement between contractor, owner and project team are likely to lessen the conflict among parties and increase the certainty in achieving project success (Aibinu and Odeyinka, 2006).

8. Current Workload
   Current workload refers to the number and size of projects that a company is carrying out at the moment. It gives the information that whether the resources will be available for a particular project depending upon the workload during construction (Singh and Tiong, 2006). A company having undertaken few projects at one point in time, then they would have ample capacity of resources to incorporate on multiple projects. In case the company has undertaken many projects then the resources will be distributed, as hence a limited capacity will be available for the projects (Al-Harbi, 2001).

Methodology

A systematic review has been conducted to develop a typology of existing work. Tranfield et al., (2003) stated that systematic review delivers collective discernments through theoretical interfusion of prevailing studies. The traditional approach for qualitative research encompasses the summarized findings which results the accumulation of knowledge as understood through current literature of different fields of knowledge (Ruediger Kaufmann et al., 2012). In contrast to the qualitative approach, management research is wide-ranging and has diverse logic which requires quantitative study of heterogeneous publication from various journals and conferences (Edmondson and McManus, 2007). The methodology for systematic review is rather more flexible and account for different conceptualizations and reasoning of the reviewed studies (Chai et al., 2013).

Based on the previous research regarding contractor selection procedure, a total of 19 factors have been identified. The sources used for searching the literature included "ASCE," "Science Direct," "Taylor & Francis Online," "Cibw117" and "Emerald Insight" etc. Semantic technique and keywords are used in searching process. A total of 62 research publications from different journals of project management, and construction engineering and management published between the years 2000-2015 have been studied. This particular period is selected to focus on the recent trends and examine the attributes that are presently effective in this area of research. The identified factors have been shown in Table 1.

Table 1

Overview of Best Value Contributing Factors Typologies

No.	Factors	References
1	Proposed Tender Price	Greenwood and Wu (2012) Gajjar et al. (2014) Bertolini et al. (2006)
2	Low project life cycle cost	Kagioglou et al. (2001) D. Kashiwagi et al. (2014) Crawford et al. (2006)
3	Financial capability	Xia et al. (2014) Al-Harbi (2001) Brady et al. (2005)
4	Additional financial resources for priority projects	D. Kashiwagi and R. E. Byfield (2002) Zhang (2006) Assaf and Al-Hejji (2006)
5	Transfer of risks related to construction, finance and operation	Hai and Watanabe (2014) Savicky et al. (2014) Eriksson and Westerberg (2011)
6	Ability to mitigate unforeseen risks	Gajjar et al. (2014) Zavadskas et al. (2010) Taroun (2014)
7	Past performance and expertise of the company	Gransberg and Molenaar (2004) Bassioni et al. (2005) Kim and Huynh (2008)
8	Number of key personnel	Yeung et al. (2009) Hai and Watanabe (2014) Assaf and Al-Hejji (2006)

9	Optimized resource utilization	Wong et al. (2000) Wang and Huang (2006) Gajjar et al. (2014)
10	Training and skill level of project team	Wong et al. (2000) Cheng and Li (2004) Dainty et al. (2005)
11	Quality control measures	Edum-Fotwe and McCaffer (2000) Elazouni and Metwally (2000) Lin and Shen (2007) T. V. Luu et al. (2008)
12	Meeting design requirements	Haponava and Al-Jibouri (2011) G. Liu et al. (2004) Crawford et al. (2006)
13	Managing user expectation and satisfaction	Yasamis et al. (2002) Beatham et al. (2004) Flyvbjerg (2013)
14	Health and safety performance	Cheung et al. (2001) Cho et al. (2009) Pan et al. (2012)
15	Environmental impact	D. T. Luu et al. (2005) El Wardani et al. (2006) Abudayyeh et al. (2007)
16	Project control processes	Al-Jibouri (2003) Dainty et al. (2003) Vanhoucke (2012)
17	Actual schedule achieved for similar works	Abdul-Rahman et al. (2006) Odeh and Battaineh (2002) Frimpong et al. (2003)
18	History of claims and disputes.	Olander (2007) Ullah Khan (2014) Zaneldin (2006)
19	Number and size of projects in hand	Fong and Choi (2000) Topcu (2004) Watt et al. (2010)

Grouping & Analysis

A total of 19 factors have been identified that affect the decision making in selecting the most suitable contractor as shown in Table 1. Upon further studies and investigation of related literature, these factors are grouped into eight main criteria. These criteria are developed by extracting the factors from the previously carried out relevant research and available literature. As a result, the above mentioned factors are referred to as sub-criteria and their grouping has resulted into formulation of main criteria as shown in Table 2.

Table 2

Grouping of Factors

No.	Criteria	Identified Factors
1	Cost	Proposed tender price Low project life cycle cost Financial capability Additional financial resources for priority projects

2	Risk	Transfer of risks related to construction, finance and operation Ability to mitigate unforeseen risks
3	Performance	Past performance and expertise of company Number of key personnel Optimized resource utilization Training and skill level of project team
4	Quality control	Quality control measures Meeting design requirements Managing user expectations and satisfaction
5	Health and safety	Health and safety performance Environmental impact
6	Project control	Project control processes Actual schedule achieved for similar works.
7	Delay claims	History of claims and disputes.
8	Current Workload	Number and size of projects in hand

Yearly appearance of Factors

In the next step, yearly appearance of these factors has been studied in order to observe the temporal progress in the published literature. An attempt has been made to classify these factors on the basis of year of appearance. For inclusion in the table, a factor has to appear at least once every two year. The yearly appearance has been shown in Table 3.

Table 3

Yearly appearance of Factors

No.	Criteria	Identified Factors	Yearly Appearance							
			2000-2001	2002-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013	2014-2015
1	Cost	Proposed tender price	✓	✓	✓	✓	✓		✓	✓
		Low project life cycle cost	✓	✓		✓	✓	✓		✓
		Financial capability	✓		✓		✓			✓
		Additional financial resources for priority projects		✓		✓				
2	Risk	Transfer of risks related to construction, finance and operation.	✓	✓			✓	✓	✓	✓
		Ability to mitigate unforeseen risks						✓		✓
3	Performance	Past performance and expertise of company	✓	✓	✓	✓	✓	✓	✓	✓
		Number of key personnel	✓		✓	✓	✓			✓
		Training and skill level of project team	✓		✓					
		Optimized resource utilization	✓			✓				✓
4	Quality Control	Quality control measures	✓	✓	✓	✓	✓			✓
		Meeting design requirements		✓	✓	✓		✓		✓
		Managing user expectation and satisfaction		✓	✓		✓		✓	✓

5	Health & Safety	Health and safety performance	✓		✓		✓		✓	✓
		Environmental impact	✓		✓	✓	✓			✓
6	Project Control	Project control processes		✓					✓	
		Actual schedule achieved for similar works.	✓	✓	✓	✓	✓	✓	✓	✓
7	Delay Claims	History of claims and disputes.			✓	✓				✓
8	Current Workload	Number and size of projects in hand	✓		✓	✓		✓		✓

Appearance and Criticality of Factors

After reviewing 62 papers on this subject, the factors show various differing trends. For the sake of understanding and simplicity, the appearances of factors are calculated in the 62 research papers. This shows the frequency of occurrence of each factor in research papers which have been studied in the selected period of publications. The appearance of each factor has been calculated by taking the ratio of its occurrence in research papers to the total number of studied research papers. This not only provides an insight to the latest trends on procurement strategies for the past 15 years but also in finding the number of appearances and further calculating the relative significance or criticality of the identified factors. Their frequency of appearance and their importance are shown in Table 4.

Table 4

Appearance and criticality of Factors

No.	Criteria	Identified Factors	Appearance	Importance
1	Cost	Proposed tender price	20	32.2 %
		Low project life cycle cost	14	22.5%
		Financial capability	10	16.12%
		Additional financial resources for priority projects	5	8.06%
2	Risk	Transfer of risks related to construction, finance and operation	21	33.87%
		Ability to mitigate unforeseen risks	3	4.83%
3	Performance	Past performance and expertise of company	35	56.45%
		Number of key personnel	12	19.35
		Optimized resource utilization	6	9.67%
		Training and skill level of project team	3	4.83%
4	Quality Control	Quality control measures	30	48.38%
		Meeting design requirements	13	20.96%
		Managing user expectations and satisfaction	12	19.35%
5	Health and Safety	Health and safety performance	28	45.16%
		Environmental impact	10	16.12%
6	Project Control	Project control processes.	7	11.29%
		Actual schedule achieved for similar works.	19	30.64%

7	Delay Claims	History of claims and disputes.	8	12.90%
8	Current Workload	Number and size of projects in hand	6	9.67%

The factor "past performance and expertise of company" possesses highest percentage (56.54%). It indicates that BV procurement strategy has great emphasis on evaluating the contractors on the basis of their past performance. The competency and seriousness of contractor could only be determined by measuring performance of executed projects. The second most important factor is the "quality control measure". It includes the processes adopted by the contractors to determine quality policies and steps that need to be taken to ensure client satisfaction. The factor "health and safety performance" show a significant contribution as it ensures the proper handling and usage of equipment and to facilitate the worker with adequate personal protective equipment (PPE). The other important factor is "proposed tender price". It enables the client to make comparison between the tenders and cost plan to assess the inherent value within different tenders and allowing values for money.

Considering the above data, the criticality of factors enabled us to determine their relative percentages; some factors such as *performance*, *health and safety*, and *quality control* have greater percentages as discussed above. Although factors like *risk*, *cost* and *project control* are showing less deviation comparatively. Figure 1 below illustrates this comparison and shows that both *delay claims* and *current workload* have lowest percentages.

Relative Contribution of Each Criteria

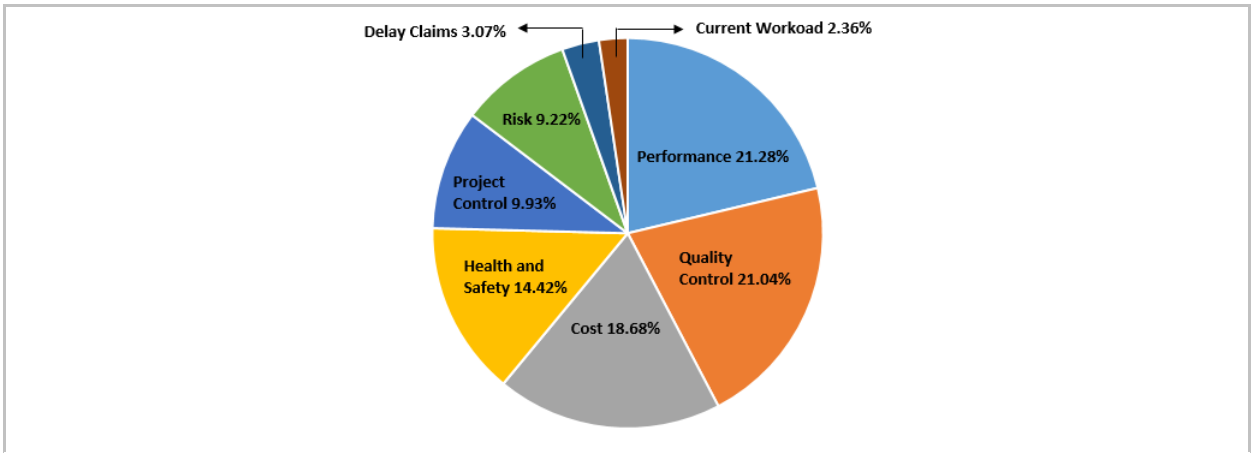

Figure 1: Relative Frequency of Criteria.

Figure 1 presents a clear picture of the components that the researchers have devised through the 21st century in BV literature. Since the execution phase is the most critical of a project and involves many risks, it has been delegated to the contractor who has the responsibility to complete according to the requirements of the owner. Some attributes are pivotal for contractor selection in which the *performance* is the most imperative. This includes attributes such as *"past performance and expertise of company," "number of key personnel," "optimized resource utilization"* and *"training and skill level of project team"*. The first one has higher criticality and the last has lower. As a general rule, individual attributes may have varying importance but if

any of them is reported to have very high frequency, the averaging effect will result in an importance boost into the overall criterion.

Classification of Criteria on the basis of Journal

In the next step, the frequency of factor appearance in major journals was categorized. It is deduced based on detailed observations that some journals have evaluated many factors while some have only examined one. It is evident in Figure 2 that "International Journal of Project Management" has included all the factors. So it may be considered as the most comprehensive journal that researchers can seek guidance from. Some journals like "Construction Management and Economics," "Benchmarking: An International Journal" and "Journal for the Advancement of Performance Information & Value" constituted six criteria. Furthermore, "Automation in Construction" and "Building and Environment" included only one factor. This shows that they do not share the same level of comparative focus on the BV literature. The classification on the basis of journals have been shown in Figure 2:

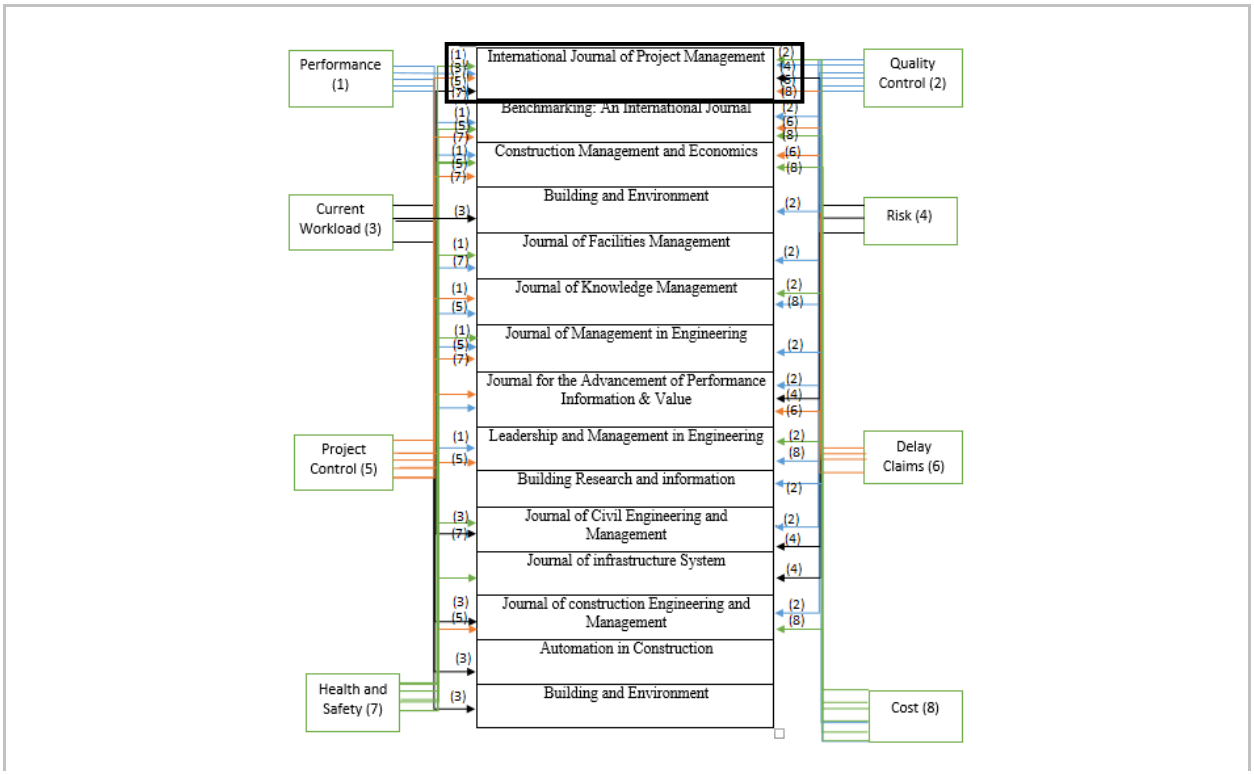

Figure 2: Appearance of Factors in various Journals.

Classification of Identified Factors on the basis of sources

In the final step, the sources of articles covering these factors have been identified. Famous libraries of research publications like "ASCE library" and "Science Direct" constituted all the eight factors and most of the papers regarding this field have been downloaded from these sources. "Taylor and Francis Online" is on the second rank. "Emerald Insight" and "Cibw117" included six factors each. Factors along with their respective sources are given in Table 5:

Table 5

Sources of Factors

Criteria	Sources	Criteria	Sources
Performance	Taylor & Francis Online ASCE Library Emerald Insight Cibw117 Science Direct	Cost	Taylor & Francis Online ASCE Library Emerald Insight Cibw117 Science Direct
Quality control	Taylor & Francis Online ASCE Library Emerald Insight Cibw117 Science Direct	Health and safety	Taylor & Francis Online Emerald Insight ASCE Library Science Direct
Project control	ASCE Library Emerald Insight Cibw117 Science Direct Taylor & Francis Online	Delay claims	Taylor & Francis Online Emerald Insight Cibw117 ASCE Library Science Direct
Risk	ASCE Library Cibw117 Science Direct	Current Workload	ASCE Library Taylor & Francis Online Science Direct

Results and Discussions

Factors Identification Chart

There are several factors that influence the success of project enactment which were identified through an in-depth review of articles as mentioned previously. The contractor and subcontractor perform activities in the construction stage. The elements include contractor performance, site supervision, contractor cash flow, overheads, effective cost control system and onsite communication. An attempt has been made to formulate a new structure that includes the criteria affecting the project success is developed. It can be used as basis for further examination on selection criteria for general construction projects and specific projects like roads, buildings, dams, bridges, etc. Therefore to provide more ease in finding the literature about BV, a more systematic way of project success is established.

The published literature has been limited to 21st century to make it comprehensive and to identify the latest trends regarding the topic. Initially, some work was carried out using BV in which the researchers had identified some factors that would affect the decision making. Since every research is an ongoing flux, it is not viable to only rely upon the factors that have been initially identified. Efforts have been made to find loopholes that affect the long term decision making process. As time progressed, the conditions that were previously reigned in a particular area did not necessarily remain the same in upcoming decision making process, and hence, an inference can be made about the futuristic change in the process. As a result, the maturation of the phenomenon is necessary to be studied.

Considering the literature on BV, the analysis is graphically represented in Figure 3. It shows the crux of this research by indicating the factors which have been identified by the researchers initially. Some factors have been eliminated and new factors have emerged successively, whereas some of them show no change in their appearance over the period of study. Therefore, all of the aforementioned factors should be considered in contractor selection using BV approach. This distribution also shows that some factors like *cost*, *quality control*, *project control* and *performance* have appeared continuously which shows that, despite an evolution of new factors, they demonstrate equal strength over the time. Their continuous emergence in each year shows the significance of these criteria in decision making process of contractor selection.

It is important to note that publications in 2000-2001 have considered all the factors, excluding *delay claims* that arise on construction sites, suggesting that most of the criteria were resolved at the early stages of research in BV procurement process. After that, it can be observed that *current workload* was also not reported in 2002-2003. *Risk* is a key criterion that a contractor should be capable of mitigating but the content analysis shows that it has not been contemplated from 2004-2007. Ample research has been carried out in risk management but risk in decision making has not been considered in the mentioned years. In a similar way, some factors have been ignored in successive years while some have been reported.

The objectives of the BV tendering process guarantee its competitiveness, transparency, equity, fairness and efficiency. Contractors should be clustered on the basis of their capability to meet project requirements. BV provides an efficient way of clearing out the incompetent contractors by assessing them on the basis of identified criteria.

Additionally, the past performance, which has been rendered as the most significant criteria, needs to be substantiated in the selection process. The previous records of contractors should be kept in a register which can be effectively reused for the upcoming projects as it provides evidence for improving the contractor's performance and maintaining their business propagation. The key point is that presently all of the identified factors show some importance. Considering the fact that project execution phase is the most difficult among all phases, it is essential to investigate the contractor ability to meet the execution by examining the aforementioned factors. This shows that the construction industry has evolved in terms of the contractor selection processes. The historical development of Best Value contributing factors is shown in Figure 3.

Figure 3: Historical development of Best Value contributing Factors.

Conclusions & Recommendations

The Best Value Approach for contractor selection focuses primarily on past performance and the level of quality that the contractor has delivered on previous projects. In traditional methodologies, cost is typically the only selection factor. Despite the fact that the selection process in a traditional low bid system is seemingly simpler, it has a lot of issues regarding project delivery, schedule and quality control. Thus it poses serious questions on the project success. Apart from these attributes, research shows that there are some other factors that need to be addressed. This research focuses on the said factors which have been reported in the past few years and through their evolution over time.

The process of contractor selection considering criteria other than low-bid can strengthen the overall success of the project. The current research has presented some paramount practices in this area and also highlighted a well-regulated approach to contractor selection. The aim is to augment the schedule and quality of construction projects while nurturing satisfying and constructive working atmosphere among the parties involved. Such an environment can only be achieved by targeting factors that are mentioned above in contractor selection process. In order to strike a balance in successful project outcomes, criteria like quality control, performance, health and safety must be considered on priority.

The results provide a significant contribution to the body of knowledge regarding contractor selection. Particularly, this research underlines the prominence of typical criteria that is used in

contractor selection. The appearance of each criterion and their criticality guides researchers to develop a weighting system during contractor evaluation. In doing so, a win-win situation can be achieved for both the users and tenderers, particularly with respect to risk, performance and quality control.

In recommendation, currently it is observed that all the identified factors are being considered. Some factors like *performance*, *project control*, *quality control*, *cost*, *health and safety* appear most frequently in recent publications. In this study, the factor, *current workload*, which is placed at bottom position, must be contemplated for future studies. If the contractor has undertaken several projects simultaneously then it is cumbersome to monitor and administer all of them equally. As a result, poor quality and performance hinders the project success. Hence during selection, besides performance and quality control, number and size of projects in hand must also be evaluated.

Based upon the analysis of existing literature, it is authenticated that BV procurement strategy is simple to implement and flexible enough to adjust to the project specific and client preferable requirements. These criteria not only discourse the ultimate performance and overall cost of the work but also subsidize to the efficient execution of the work. It is quite cumbersome for the agencies to completely inspect quality into the work. Therefore, such awarding mechanism is needed that state the Value rated elements for decision making.

The industry needs a more robust and flexible decision making model since every construction project is unique in the sense that each project differs in site conditions, associated risks, human resource etc. In most circumstances, where projects suffer many disputes in terms of cost and schedule, it is difficult to identify what the best solution. This ultimately results in disputes and time deviations focused on solving such issues. If all such factors are catered before awarding the contract, such issue could be eliminated which would definitely save time and money and keep the relationship between parties pacified.

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Construction Health and Safety Self-Regulation in Developing Countries: A Nigeria Case Study

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The study reported in this paper explored the self-regulatory approaches in terms of health and safety (H&S) in the Nigerian construction industry and the attitudes of the industry towards H&S self-regulation. This stems from the premise that the Nigerian construction industry has been viewed as unregulated, but evidence in literature indicates that some parts of the industry are self-regulated in various forms. However, it is unclear how self-regulation occurs in the industry, its approaches and the attitudes of the industry towards it. Based on group and individual interviews, there is evidence of self-regulation that is: enforced, industry-led, voluntary, H&S crusader-led, client-led and community-led. It was revealed that in many cases, when self-regulation is voluntary, the self-regulatory process does not exceed the first stage of self-regulation, adopting or developing standards. The attitudes of the industry towards H&S self-regulation can be described as not limited to "camouflage," "convenience," "context-defined," "secondary," "unstructured," and "tick box." However, there are some in the industry that have a favorable attitude towards H&S where it is "primary" in their organization. The understanding of self-regulation and H&S is advanced in this study, especially in developing countries, which policymakers, socio-legal scholars, practitioners, academics, and various industries may find beneficial.

Keywords: Approaches, attitude, construction, health and safety (H&S), Nigeria, self-regulation

Introduction

Notably, the construction health and safety (H&S) records of developing countries are evidenced as poor (Idoro, 2008; Idoro, 2011; Kheni et al., 2006). Their H&S regulatory environments are characterised with inadequate enforcement and poor implementation of H&S laws (Kheni et al., 2006) and inadequate H&S laws. In particular, in Nigeria, the industry is not covered by any local H&S law (Idoro, 2011; Umeokafor, et al., 2014). Consequently, some construction contractors in Nigeria adopt and administer H&S standards from developed countries (Idoro, 2008; Idoro, 2011), and/or the National Building Code of 2006, which is yet to receive legislative backing (Omeife & Windapo, 2013). Additionally, the oil and gas industry sets standards that its construction contractors, *inter alia*, must adhere to. As a result, Umeokafor and Isaac (2015) argue that based on the premise of self-regulation, the aforesaid activities in the Nigerian construction industry is self-regulation in various forms. This is where H&S self-regulation is the practice where organisations and/or industries develop, adopt and administer programs, standards and policies with little or no external intervention (Anderson & Russell, 2011; Castro, 2011; Gunningham, 2011; OECD, 2015). However, understandably, previous studies such as Idoro (2008, 2011), Umeokafor et al., (2014) view the industry as unregulated because the local H&S law does not cover construction sites and its activities. This suggests that H&S regulatory issues have been addressed only from a state regulatory dimension, overlooking the self-regulatory dimension and creating a gap in knowledge. While self-regulation is noted in studies to improve H&S (Finger & Gamper-Rabindran, 2013), it is, however, reported in Wall and Dyson (2002) to have failed in small firms in New Zealand.

The background established so far informs this study, which seeks to advance the understanding of construction H&S self-regulation in Nigeria. This paper is a part of the empirical evidence in an ongoing research that analyses the attitudes of the Nigerian construction industry towards H&S self-regulation, the various approaches to H&S self-regulation including how they occur. It does not examine the effectiveness of H&S self-regulation in the Nigerian construction industry nor does it investigate its impact on H&S performance. In synthesizing literature, construction H&S in Nigeria and its regulation, and the concept of self-regulation are covered.

Literature review

Construction health and safety in developing countries

It is noteworthy that developing countries face significant H&S challenges (Farooqui et al., 2008; Idoro 2011; Kheni et al., 2006). In particular, there is a lack of systematic procedures for H&S, and owners/stakeholders in construction companies are not committed to H&S (Farooqui et al., 2008). The lack of commitment from owners/stakeholders then result in lack of commitment from contractors (Farooqui et al., 2008). Authors note that the poor regulation of H&S in the Nigerian construction industry results in a lackadaisical attitude towards H&S (Umeokafor et al., 2014). Consequently, accidents are under-reported in developing countries such as Nigeria and Ghana (Idoro, 2008; Kheni, et al., 2006) and little resources are allocated to H&S (Idoro, 2008). The construction environment in developing countries does not help matters as corruption, insecurity, and poor safety culture impact on construction H&S practices (Umeokafor, 2015).

Regulation of construction health and safety in Nigeria

The construction H&S regulatory environment of Nigeria is fragmented in that the activities of various institutions cut across the industry. For instance, the National Environmental Standards and Environmental Regulations Enforcement Agency (NESERA), is charged with overseeing environmental safety such as noise standards, demolition. The Factories Act CAP FI L.F.N 2004 is the local H&S legislation covering factories in Nigeria. It empowers the Inspectorate Division of the Federal Ministry of Labour and Productivity to enforce the law. However, Article 87 of the aforementioned law means that construction sites and their activities are not covered by the law and are thus unregulated (Idoro, 2008). This, among many, has prompted individual efforts in tackling H&S challenges in the sector. In particular, construction contractors adopt or develop and administer H&S policies, standards and programs, from developed countries (Idoro, 2011). This can be on a voluntary basis or due to policies from their foreign parent companies (Umeokafor & Isaac 2015). Additionally, the construction sectors of the 36 states of Nigeria adopt the National Building Code of 2006 that is yet to receive legislative backing (Omeife & Windapo, 2013). The code sets the minimum standards, including safety standards in the building industry. While the oil and gas sector also sets H&S standards for all in the industry, including construction contractors (Umeokafor & Isaac, 2015), the safety issues in Lagos state of Nigeria, including it construction industry is overseen by the Lagos State Safety Commission (Lagos State Safety Commission Law, 2011). However, the extent of state involvement is unclear. Nonetheless, the fact that the state, out of the 36 states in Nigeria is voluntarily regulating safety issues in the state may be considered a kind of self-regulation. Therefore, based on the description of

self-regulation, elsewhere in this paper, the Nigerian construction industry is self-regulated in various forms and not unregulated (Umeokafor & Isaac, 2015).

Self-regulation

Self-regulation takes the form of the general regulatory process (Figure 1). From a self-regulatory perspective, Regulatory Instruments (RI) are conceptualized in this study to be standards, best practices, code of ethics or conducts, policies, and programs (Figure 1). In Figure 1, RI are created by the industry and/or organizations or professional institutions (or in any combination) who go on to monitor its compliance and implementation, enforcing them (Castro, 2011; OCED, 2006). It is also possible to review the entire regulatory process.

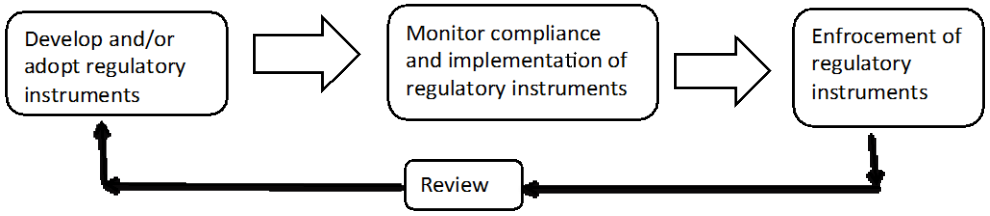

Figure 1: Self-regulatory process. (Modified from Castro, 2011)

The use of self-policing in achieving compliance in self-regulation is noted in Castro (2011). It can be through voluntary self-policing where the industry or professional institutions encourage voluntary detection and reporting of a violation through means such as reduction of fines (Castro, 2011). There is, however, an overlap at the individual and small organization level, when it comes to internal policies.

Self-regulation is flexible, involves the regulated and gives them a sense of belonging. Thus, it is tailored to the industry and consumer issues (Anderson & Russell 2011; OCED, 2006) and various circumstances (Hutter, 2001). In addition to being an effective regulatory means (Anderson & Russell, 2011; OCED 2006), it addresses cost-related issues and reduces the burden on the state (Hutter, 2001). Above all, it can achieve a higher level of compliance (Anderson & Russell, 2011). Consequently, it is viewed as more effective than the command and control regulation. However, there are limitations to self-regulation. Indeed, the extent of government involvement or other external involvement may result in conflict (Gunningham, 2011). Also, one of the parties in the regulatory process may pursue the interest of their members (OCED 2006) over the goal of the regulatory process.

Overview of approaches to self-regulation

Self-regulation varies from industry to industry, country to country. A manifestation of self-regulation is in the combination of private and public regulation (Castro, 2011; Gunningham, 2011; Hutter, 2001; OCED, 2006). This dual party involvement in regulation is conceptualised as co-regulation (Castro, 2011; OCED, 2006; 2015) where it involves governmental involvement in the regulatory process. For example, this can be between the industry and the government (Castro, 2011; OECD, 2015) or between the government entities and other stakeholders, and the industry (OECD, 2015) or between the state and firms. While the state and industry can be involved throughout the regulatory process, the state may set standards for the companies who then devise means of compliance and monitoring- enforced self-regulation (Hutter, 2001). Similarly, Gunningham (2011) notes a case of mandatory self-

regulation, where firms or industries set the standard and enforce them, but the state approves the process and monitors the regulatory process. OCED (2015) reports this as co-regulation. In the current study, the above three are viewed as enforced self-regulation. This is in addition to the situation where construction contractors are forced to self-regulate because they are bound by the H&S policies of their foreign parent companies.

The extent of governmental involvement and legislative backing in enforced self-regulation differentiates it from pure self-regulation (see: OCED, 2006). Pure self-regulation (Gunningham, 2011) or non-state regulation (Castro, 2011) or self-regulation (OCED, 2006) involves the voluntary administration of the regulatory process in Figure 1 with no external involvement. This pure self-regulation can be at industry level - industry self-regulation (Anderson & Russell, 2011; OECD, 2015) or at firm level. Under industry self-regulation, the industry or a group of firms set or agree on rules and standards, monitor and enforce compliance (OECD, 2015).

Methodology

The qualitative approach to research is adequate and efficient in answering "what," "how" and "why" research questions (Erikkson & Kovalainen, 2008), and the study should focus on complex social phenomena (Isaacs, 2014), seeking to understand the phenomena through the eyes of the study population. As the research questions of this study meet the requirements of a qualitative study, semi-structured face-to-face and telephone interviews of thirty-seven participants and a focus group discussion (FGD) of seven participants were conducted.

Noteworthy, qualitative research raises validity, reliability and transparency issues, so investigators should take steps to address the above, ensuring trustworthiness in the research (Umeokafor, 2015). Correspondingly, the following steps were completed. For instance, using two data collection methods (interviews and FGD) to address the same research question (i.e. triangulation) was to ensure validity and trustworthiness in the data (Dainty et al., 1997; Denzin, 1978). Additionally, as will be seen below, interview data was collected from two sources, that is, from members of the construction supply chain and from key informants. This is also another method of triangulation (Denzin, 1978). Other steps to improve the trustworthiness in the research include peer reviewing the data collection instrument on stakeholders in the Nigerian construction industry and academics who are experts in construction and/or H&S. This is in addition to piloting the study on the Nigerian construction industry and revising it before the main data collection process. Furthermore, the transcripts of the interviews were also sent to the participants that signified interest in validating the transcripts. On receipt of their comments, the transcripts were revised. This ensures that the views of the respondents are captured. Lastly, peer debriefing was also adopted where the principal investigator worked together with not only the co-author but also other impartial colleagues, discussing aspects of the study, *inter alia,* the methodologies, the views of the authors.

In the reported study, the participants are members of the construction industry supply chain both in the formal and informal sectors, for example, suppliers, quantity surveyors, engineers. It also involved key informants with direct or indirect association with the industry or who have worked with or for the Nigerian construction industry, for example, a lawyer, an insurance practitioner (see the result section for more details). Both in the interviews and FGD, the atmosphere for data collection was considered, ensuring that it was convenient and

safe for the participants and investigator (Isaacs, 2014). Convenient atmospheres make research participants (e.g. interviewees) relaxed; creating an atmosphere that will make them speak freely (Isaacs, 2014). This resulted in conducting some of the interviews telephonically on the request of the participants. Additionally, as the principal investigator is from a university abroad, the participants may not be eager to provide some information just to avoid tarnishing the image of the country. On the other hand, it is possible that they will tell the investigator what they believe the investigator would like to hear just to please them. Consequently, as the principal investigator is Nigerian and has worked in Nigeria for many years, he created an atmosphere that would make the participants understand that he was or is part of the Nigerian construction industry, demonstrating his understanding of the "Nigerian culture." Language was not a problem, as all the participants had an acceptable understanding and command of English.

Prior to the interviews and FGD, introductory letters were sent the participants' organizations (by email and/or in person) introducing the research project and the investigators to them. In the letter, the participants were also informed of the following:

1. How the information they provide will be used and how it will be stored.
2. That they can withdraw from the interview or FGD at anytime. This includes their rights to request that the information be withdrawn after two months from the day of the interview or FGD.
3. Their rights to anonymity.
4. The expected duration of the interview and/or FGD.
5. That the FGD and/or interviews will only be recorded with their permission.

FGDs can offer insight on views from a group context, showing how the group agrees and disagrees on various matters. The principal investigator facilitated the FGD, and it lasted for about two hours. Before the FGD, the participants were reminded of the ethical steps in the above paragraph. The FGD then started with a self-introduction of the facilitator and the scope and objectives of the FGD. This was then followed by the basic rules of the FGD. The study was also introduced to the FGD participants. The atmosphere was then made lively with icebreakers, local jokes and brief discussions of burning issues in the Nigerian construction industry and Nigeria. The participants then had the opportunity of introducing themselves to each other. The facilitator then explained the concept of self-regulation to the participants. The participants were then introduced to open-ended questions so as to simulate discussion. These questions covered:

1. Their roles, association or relationship with the construction industry.
2. H&S self-regulation in the Nigerian construction industry and/or their organizations where applicable, including how it occurs.
3. How their organizations and/or the industry views H&S self-regulation, including the attitudes of their organizations and/or the industry towards H&S self-regulation.

Typically, questions on the attitudes of the industry towards H&S self-regulation such as the reactive attitude of the industry towards H&S self-regulation, H&S being viewed as responsibility of a certain sector or group in the industry, and open questions on how their organizations and the industry view H&S self-regulation were among the questions. Similarly, the various types of self-regulation as found in the literature review and how they occur were also topics in the FGD, including industry self-regulation and pure self-regulation. These respondents had to sufficiently describe their experiences to support their

claim for any type of self-regulation. At the end of discussing each question, the facilitator noted the excerpts of the discourse. Then at the end of the FGD, the facilitator read the summary of the excerpts to the participants who validated them. The facilitator then concluded by explaining to the FGD participants the importance of keeping the discussion confidential.

For the interviews, the participants' knowledge and understanding of H&S and construction were first assessed and if adequate, the other questions were then asked. These questions cover those asked in the FGD above. Just like in the FGD, the interview participants were reminded of the ethical considerations of the study as earlier stated; for example, anonymity, data protection and the option of discontinuing the interview.

In addition to recording both the FGD and interviews, notes were also taken during the sessions. During the transcription, notes were also taken and these notes were factored in during the analysis. Using NVivo for mac, the data were analyzed in convergence. The analysis first started with reading the transcripts many times to have a good understanding of the data. The analysis involved analyzing the data without the framework first (i.e. the types of self-regulation), seeing how it fits into the framework, (which is outcome-based) before using the framework (which is systematic), thus reducing subjectivity and bias and improving the trustworthiness of the research. This is evident in the results as themes that are outside the framework (i.e. the types of self-regulation) emerged (see Table 2). The themes that emerged from the FGD and interviews are presented below.

Results

Demographic information of the respondents

The interviewees were made up of informants with direct or indirect association with the construction industry. For example, employees of institutions or organizations whose activities cover safety in the industry, an insurance practitioner, members of trade association, and a lawyer. Participants from the construction supply chain include: subcontractors, H&S consultants and employees of public construction agencies. Others included: engineers, project managers, architects, H&S managers and quantity surveyors from consultancy firms and/or contracting firms. From the informal sector are: builders, engineers, and clients. The FGD of seven participants included a civil engineer, a sub-contractor, a supplier, one client, a trade association member, one H&S officer, and a main contractor. All the respondents had a minimum of five years work experience in or with the Nigerian construction industry. The participants from construction firms are from public institutions, multinational and indigenous firms, where many from Small and Medium Enterprises (SMEs) are owners/manager and trained construction professionals.

Attitudes of the industry towards health and safety self-regulation

It is vital to define or describe the themes in Table 1 showing how the evidence supports or warrants the themes. First, "camouflage," this is about pretense, deception or motives to hide the truth. In other words, it is not what you see that really happens, it is about window dressing. For the theme, "secondary," evidence shows that H&S is treated as less important than other things. For the theme "enforced," evidence shows the attitude that the organizations and/or the industry must be forced to self-regulate. For "context-defined," the

attitude here is that the context determines the level of involvement, if self-regulation takes place and quality of H&S self-regulation. "Tick box": the attitude here is to fulfill the requirements. "Responsibility" manifests in two ways: viewing H&S as a responsibility thus will self-regulate; shifting the responsibility to another party. The theme "convenience" shows the attitude of self-regulating when it only involves little trouble or little effort. Those classified under "primary" are those that suggest H&S self-regulation as very important; it is high on the priority list. Lastly, for the theme "unstructured", the attitude here is that H&S self-regulation is perceived and practiced unsystematically; it is not planned and it is unorganized.

Table 1 shows "camouflage" where some SMEs pretend to self-regulate to get contracts or because of clients and/or the industry (e.g. oil and gas), after which, they will "water down" the H&S self-regulatory process or revert to normal practices. However, some continue to self-regulate afterwards. There was no consensus on the latter during the FGD. Further, the FGD and interviews revealed that some multinationals also "water down" standards compared to what obtains in their parent countries. According to an H&S crusader and consultant, construction companies including multinationals do not accept their offer of assistance for H&S support; they rather engage in ostensible H&S so that people will see them as safety conscious. The respondent stated:

"Requests for assistance from construction companies, including large contractors are very little. What they just do in the real sense is that when they are building structures, building roads or building bridges they just have somebody there to look like there is health and safety presence. They put some cones and signs on the road. Health and safety goes beyond those signs… and cones they put on the road."

Although the contractors may not see any need for assistance, thus will not ask, the above quote appears to show pretentious attitude. During the FGD and interviews, there was a consensus that the attitude of many construction contractors towards H&S self-regulation is "window dressing" (Table 1). Some even set up temporary H&S departments just to secure the contracts. One civil engineer stated:

"*Well, I will use my own company as an example. When we are vying for all these government projects, we always create a fake safety department. It does not really exist; it is for us to get the job so that when they come for inspection they will see that we have everything required, that we have taken all the measures. We now present to them a safety department with a* (fake) *safety manager who will now tell them how we are going to ensure that we take safety precautions while doing the job. I believe all or most of these construction companies are like that*."

According to the above respondent, the civil engineer, prior to doing the above, they must have adopted some H&S laws, implementing some to some extent. Another H&S manager from a multinational confirmed the above stating he has been invited on many occasions by some smaller firms to act as an H&S officer, setting up a temporary H&S department and only to leave once the contract is awarded.

Equally important is the understanding that constant H&S self-regulation is mainly for the large construction firms (i.e. responsibility: Table 1) and only to be done by small or medium firms when there is an incident ("secondary": Table 1) or when they are forced to ("enforced": Table 1). The respondents mostly opine that the reactive understanding to self-regulate (i.e after the direct and indirect implications of incidents) mostly occur among SMEs

(Table 1). The quote below supports the above- the themes "responsibility" and "secondary." One of the respondents stated:

"They (SMEs) don't take it (H&S) seriously until the accidents happen… it is only in the large construction companies like Berger, Dantata and Sawoe, Strabag, where it is already part and parcel of the organisation to self-regulate. Apart from those foreign companies operating in Nigeria, you hardly see indigenous companies having H&S. In fact, it is seen as only the responsibility of large firms or what only large contractors can do."

While the above shows that H&S self-regulation is secondary and viewed as the responsibility of a particular category in the industry (Table 1), there was consensus during the FGD and interviews that businesses self-regulate in various forms as will be seen in Table 2. Where companies self-regulate, in some cases, there is "top to bottom" approach where the management is highly interested in H&S and even chairs the H&S departments or program. The aim in some of these organizations is to have a strong H&S culture in the organization. Thus, engaging the workers in H&S, training them where and when need be. Basically, the attitude towards H&S here is that it is "primary," a priority to the organization (Table 1).

Table 1

Summary of the attitudes in the industry towards H&S self-regulation.

Themes	Evidence
Camouflage	Pretentiously adopting some standards that will show the public we are self-regulating, but not really adhering to those that the public will not see. SMEs: Window dressing: putting procedures that make us appear like we self-regulate so that we can get contracts, but only to return to normal practices after we win the contract. Adopting some standards that will make us appear to take H&S seriously just to keep the workforce happy.
Secondary	H&S self-regulation is at convenience. Reactive understanding and attitude because of issues such as incidents. Not an integrate part of company policy. One of those things to be done after doing the main things.
Enforced	Both respondents from multinational and indigenous firms note points relating to/on H&S self-regulation as only enforced.
Context-defined	Multinationals do not maintain the standards from their parent company when in Nigeria – the construction environment determines the thoroughness of H&S. Self-regulation is only done in the oil and gas, banking, telecommunication sectors; in Lagos state; and oil producing states. The type of client or project defines the quality of the H&S procedures or strategies in the projects.
Tick box	There is evidence of the attitude of self-regulating to satisfy requirements or conditions without considering its efficiency or reading meaning to it. For instance, self-regulating to meet the: conditions of prospective contracts; requirements of the industry; norms in a geographic location.
Responsibility	Viewing causal workers as not their responsibility and only covering permanent staff in self-regulatory programs. Some owners/managers view self-regulation as a favor to the society, and not a responsibility. H&S is a responsibility of all in the industry. Self-regulation is the responsibility of the government and/or the industry. Self-regulation is a: top to bottom approach; bottom to top approach. Only large contractors or the oil and gas sector, or banking sectors have a responsibility to self-regulate.
Convenience	Self regulate where and when convenient. Avoiding self-regulation where possible. Adopting, implementing standards based on affordability.
Primary	Adopt, administer and enforce H&S standards, programs or polices from developed countries as a core objective of the firms. Owner/manager leading H&S self-regulation. Employees and management participation in self-regulation as a priority.
Unstructured	Self-regulation is not a thought process. It is informal and unsystematic. It is only considered during the construction stage, neglecting the other stages. It is uncoordinated; you do it as you like. H&S self-regulation is unplanned.

Furthermore, there is a mixture of various philosophies of self-regulation or simultaneous approaches to self-regulation in companies. This can be where an organization engages in industry self-regulation in a project(s) and in another type of self-regulation in other projects (context-defined: Table 1) with different levels of involvement or thoroughness. The project or the location of projects or the clients determines if the organization will self-regulate or not. The main point here is that it is context-defined (Table 1). Typically, a respondent stated:

"We operate with wisdom here because the way you operate in Shell, if you adopt the same method with the federal government, you will lose the contract. The way you operate with the federal government, if you try to adopt the same method with a small private client, you will lose the client so sometimes you have to follow everybody the way they are and the only thing is that as professionals, even though there are no policies for monitoring us on site, on our own we should try to be safety conscious or self-regulate"

To conclude, Table 1 shows that there are both favorable and unfavorable attitudes towards H&S self-regulation in the Nigerian construction industry. For instance, the theme "primary" is favorable, but the themes such as "camouflage," "secondary" are unfavorable.

On a different point, evidence suggests that many construction businesses, excluding large contractors tend to concentrate on less effective strategies in the hierarchy of risk control (i.e. personal protective equipment (PPE). Additionally, so many of the respondents directly or indirectly used PPE as a standard of comparison for H&S.

Types of self-regulation

Table 2 shows the types of H&S self-regulation found in the study. It is vital to remember that some types of self-regulation have been described elsewhere in this paper. However, there are efforts to describe some in Table 2 that were not earlier covered, showing how the evidence warranted the themes.

In addition to Table 2, there are some other significant findings. The size of firms was viewed to highly determine the types of self-regulation that occur in the industry and how they occur. There is evidence that small businesses rarely self-regulate, when they do, it is informal and/or unsystematic and simplistic or enforced, but the medium firms differ as seen below. Most large construction firms are enforced to self-regulate.

H&S crusader-led regulation (Table 2) may be as a result of an organization voluntarily approaching the H&S crusader for support or the H&S crusader naming and shaming the organizations, after covert or overt inspections by the H&S crusader.

The role of clients in H&S self-regulation is also well noted in the interviews (client-led/enforced: Table 2). From the FGD and interviews, the client is at the forefront of H&S, specifying the standards or insisting that H&S standards or programs are adopted, enforced and monitored. The interviews showed that these clients range from international to local clients but the FGD shows that these clients are mainly international clients. In the interviews, there is evidence that local clients can be individuals with high level of H&S awareness. They can also be individuals: who have worked in the oil and gas industry; who are educated; who are very wealthy.

Table 2

Summary of types of H&S self-regulation

Types of self-regulation/themes	Evidence
Voluntary/pure	Voluntary adoption and administration of H&S standards and policies based on affordability. Collective development and implementation of H&S strategies and measures in the absence of H&S department in SMEs. Voluntary structured development, implementation and administration of H&S policies in both SMEs and Large firms.
Client led/enforced	Clients specify that contractors adopt H&S standards, allocate funds and in many cases enforce and monitor the implementation.
Industry	Contractors adopt and administer existing standards in oil and gas or banking or telecom sectors. Oil and gas companies and banks audit the H&S records of contractors prior to the award of contracts; they then go on to monitor and inspect the H&S standards in the projects.
Mandatory/enforced	Chain effect: Multinationals set standards that medium firms meet because they (the multinationals) have to meet standards set by their international parent companies. Standards set by regulatory authorities such as NESREA are met, through strategies developed by organization. Parent company policies from abroad, or adopted H&S laws from abroad compel organizations to self-regulate
H&S crusader-led	H&S crusaders enforce H&S policies through inspections, consultation, partnering, and naming and shaming contractors with poor or pretentious or no H&S policy, making many to improve.
Community-led	The communities stipulate that standards are developed or adopted, enforced and monitored. Communities participate in the self-regulatory process.

Evidence from the FGD and interviews show strong influence and involvement of the local communities in H&S regulations, thus warranting the type of self-regulation, community-led self-regulation (Table 1). Here the communities where the projects take place will require the construction firms to adopt H&S standards or programs and enforce and monitor them. These communities always want to be part of the regulatory process. This can be through appointed representatives from the communities. These companies must adhere to these standards or the communities will disrupt their activities.

However, there are issues of concern in terms of community-led H&S self-regulation. In particular, few respondents in both the FGD and interviews note that in some cases these communities require that they be provided with the funds to employ an independent H&S consultant or to engage in some local H&S programs. However, when the funds are provided, the funds are diverted to private pockets. Many of the respondents in the interviews also decried the high cost of H&S due to community involvement because they already have their own standards or programs and H&S experts but because of the communities, they may have to make some adjustments to them. For instance, one respondent stated:

"When you work in some communities, especially in the oil producing states, they require you to use some of their recommended health, safety and environment consultants. They even require you to employ some people from their communities. They do not care if you already have competent workers. They do not care if you have experts that carry out the environmental test for you. No, they do not care; they just want it their way. This increases cost for us."

As a result, few respondents conclude that, in some cases, there are conflicts between the contractors and the communities.

There is also evidence of enforced/mandatory H&S self-regulation in both the FGD and interviews, but with more emphasis during the interviews. The evidence includes compulsory company policies or international standards and local laws that cut across the construction industry (Table 2). According to these respondents, these local laws include environment laws that regulate pollution and noise.

In terms of pure self-regulation, few respondents demonstrated that they voluntarily self-regulate from the design stage to the post-construction stage, covering the stages in figure 1. However, there is also evidence that plenty of SMEs that engage in pure self-regulation adopt a simplistic approach or a system that is superficial or not thought through. In some cases, they mainly adopt regulations covering PPE, welfare facilities, and first aid. There is also evidence of self-regulation here stopping at only adoption of standards in SMEs, neglecting the second stage- monitoring compliance and implementation of the RI (Figure 1) and so on. The latter is also evident when enforced self-regulation involves governmental agencies whose regulatory activities cut across construction.

Equally important is industry self-regulation where there is no evidence of formal industry regulatory body in the construction industry. However, the FGD and interviews evidence oil and gas regulatory set standards that then have a chain effect on the construction industry in that the standards set in the industry cover all construction contractors that work for them. Oil and gas companies also ensure that their contractors adhere to the standards.

Discussion

There is good evidence of self-regulation, but the quality, in some cases, remains questionable. However, this offers optimism, especially, as the contexts such as the socio-economic context of Nigeria do not encourage involvement in H&S. The strong emphasis on concentration on the first stage of self-regulation –development and/or adoption of RI, leaving out the second stage onwards, tends to be a major challenge in H&S regulation in the Nigerian construction industry (see: Idoro, 2008; Umeokafor et al., 2014). The plenty of significant emphasis on the use of less effective risk control measures such as PPE is consistent with the "traditional stage" of safety culture in Lingard and Rowlinson (2005), which is reactive. The continued dominance of the reactive style of H&S management does not only leave the Nigerian construction industry lagging, but also increases the cost of H&S compared to if the innovative approach to H&S management is dominant. The innovative approach is characterised by proactive measures such as emphasis on elimination of risk where possible, paying greater attention to integrating safety at the decision making stage of projects (Lingard & Rowlinson, 2005). However, elimination of risk where possible can lead to risk aversion, which is not good for business, so care should be taken in such cases. More importantly, there is a thin line between pure self-regulation and internal policies (H&S management) at organizational level, but in the context of this study, that organizations voluntarily design and/or adopt and administer H&S standards is pure self-regulation.

In terms of the attitudes of the industry towards H&S self-regulation, the evidence in Table 1 suggests that the quality of H&S self-regulation may be poor. For example, if contractors self-regulate when it is convenient or if it is context- defined or if it is viewed as secondary, the attention it receives is likely to be low. It is likely to be low on the priority list of the organization. This may explain the concentration on the first stage of self-regulation –

developing and/or adopting RI. Additionally, Table 1 to some extent arguably also contributes to explaining why there are various types of self-regulation as seen in Table 2.

Meanwhile, the influence of large contractors on medium-scale firms (i.e. the chain effect in Table 2) offers optimism in that it can be exploited for improving H&S, as the medium-scale firms would want to retain their contracts. In affirmation, Sunindijo (2015) argues that greater emphasis on improving H&S in developing countries should be on large construction firms. The evidence of H&S crusader-led regulation suggests that it may even be ideal to factor in external actors such as independent pressure groups in the regulatory process. H&S crusader-led regulation differs from social pressure (a driver of H&S self-regulation: Umeokafor & Isaac, 2015) in that in H&S crusader-led regulation, the H&S crusader and the companies work together to improve safety standards while under social pressure the companies are pressured to self-regulate by external actors such as pressure groups, the media without the involvement of the external actors.

More importantly, the involvement of the communities in H&S regulation also offers optimism, but there is a risk of deviation in the interest of the communities from H&S interest to financial gain. If there is a form of third party involvement such as the government who will act as an observer, community-led H&S self-regulation may be quite impactful in Nigeria.

While Table 1 shows the attitude, "enforced," where self-regulation can hardly be voluntary, Table 2 shows it as a type of self-regulation. Therefore, it is logical to say that the attitude that H&S must be enforced in Table 1 underpins the enforced type of H&S self-regulation in Table 2. Above all, this study indicates that H&S laws that integrate and/or foster flexible regulation is likely to flourish in Nigeria's construction industry.

Conclusion

This study advances the understanding of regulation of construction H&S in Nigeria and the concept of self-regulation. This stems from the premise that the Nigerian construction industry is not unregulated as earlier authors note. Based on qualitative approach, there is good evidence in this study that SMEs self-regulate but in some cases, it is not systematic. It is evident that many SMEs adopt laws based on severity of risks; they also self-regulate because multinationals require them to self-regulate. However, there is evidence that they also transfer the knowledge and skills from working with multinationals in some projects, but the quality may need improvement. It is also evident that there are both favorable and unfavorable attitudes towards H&S self-regulation in that in some cases: it is a camouflage; it is secondary; it is primary; it is done only when it is convenient; it is context-based/defined. The aforesaid, among many, may explain the evidence in this study that there is: client-led self-regulation, H&S crusader-led regulation, *inter alia*, community-led self-regulation. These findings have implications on the developing countries, as there may be elements of one type of self-regulation or the other because of inadequate H&S regulatory environment in these countries. Some findings in this study also indicate the determinants of H&S self-regulation. Nonetheless, some limitations of this study suggest the need for further studies. Indeed, examining the Nigerian construction industry holistically may mean that certain characteristics that are solely formal/informal sector-based may need further examination. Thus, further studies can explore the discourse from a formal or informal perspective, helping to deepen the understanding of this discourse.

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Delay Factors and Time-Cost Performance of Construction Projects in Gaborone City Council, Botswana

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The problem of delays in the construction industry is a global phenomenon and the construction industry in Botswana is not an exception. The objectives of this study were to confirm the presence of significant delay in GCC projects; to identify and rank the perceived delay causes; and construct a Bromilow-type time-cost model for the council's projects. The study made use of archival data and questionnaire survey soliciting the perceived causes and effects of delay from the clients, consultants, and contractors that are associated with GCC projects. Chi-square statistical method was employed to prove the presence of statistically significant delay in the council's project. About 150 respondents drawn from three client organizations, five consulting firms and 23 construction contracting companies participated in the survey to rank the perceived causes of delay. The study identified 10 most important causes of delay from a list of twenty eight different causes and six different effects of delay. The ten most important causes are: contractor's improper planning, contractor's poor site management, inadequate contractor experience, inadequate client's finance and payments for completed work, problems with subcontractors, shortage in material, labor supply, equipment availability and failure, lack of communication between parties, and mistakes during the construction stage. The six main effects of delay were: time overrun cost overrun, disputes, arbitration, litigation and total abandonment. In addition, archival data were used to establish the time-cost relationship of the council's projects using Bromilow's model. The derived relationship was given by Time = 1.18Cost0.361861. The adjusted R2 of the model was 0.817812 showing that the model had high predictability. It was concluded that the results of this study can be of immense assistance to the stakeholders of GCC projects in terms of planning future projects and better understanding of the dynamics of project management as lessons for reducing the incidences of project delay and high cost.

Keywords: Delay, time-cost construction projects, Gaborone City Council, Botswana.

Introduction

All over the world the delivery of basic services is invested on the ministry of local government for implementation through its arms. In Botswana therefore, the Ministry of Local Government (MLG) and local authorities under it are responsible for delivering essential services to the populace. Botswana is a landlocked country and is made up of nine districts (provinces) comprising a total of 28 local authorities of which Gaborone City Council (GCC) is one (figure 1). The city council is mandated with the provision, operation and maintenance of all basic services and infrastructure. Hence the council's mandate straddles mainly development projects such as: parks, public toilets, construction of boundary walls, construction of schools and teachers quarters, and sport facilities at community centers and maintenance projects.

Figure 1: Map of Botswana Showing International Boundaries and the Nine Districts (Mapsworld, 2015).

The Construction industry in Botswana is considered to be one of the most significant industries in terms of its contribution to the gross domestic product (GDP) which is currently estimated at 5.3%, gross capital formation, and employment and also in terms of its impact on health and safety of the populace. Like many other developing countries, the main procurement strategy is the traditional procurement system or design-bid-build system at various tiers of government. The contractors and consultants have varying experiences, capabilities and management skills, all of which have major impact on the completion times of construction projects. The growth in the number of these players in the industry over the years has not seen a corresponding

improvement in the timely delivery of projects, although with more contractors and consultants, there has been considerable increase in competition for construction jobs and the clients thus have greater varieties of service providers from which to select. The construction sector in Gaborone is now at a stage where most contractors, both emerging as well as the established, can hardly deliver their projects on schedule, not to mention failing to perform all together. This failure to deliver projects on time and on budget is mind boggling to both public clients and the end users who are expected to benefit from the completed project. This state of affairs becomes more undesirable to the contractors and clients as it is costly and has the potential to trigger disputes whose resolution is usually time-consuming and expensive.

Project success can be defined as meeting the goal and objectives set out during the initiation stage of the project. The main objective of construction project is to complete the construction on time and within budget without sacrificing quality. This cardinal objective is compromised when delays occur and according to Sweis et al. (2008), construction delays are often responsible for turning profitable projects into loss-making ventures. Persistent and painstaking probes are therefore required in all spheres of construction around the world why delays are endemic in the construction industry when it needs not be so. The consequences of these delays, which often manifest as cost overruns, loss of profit, increased overheads, stress, acrimony among stakeholders, project abandonment, corporate contractor failure, litigation, loss of job opportunities and resources tied up in delayed projects, warrant in-depth study. The first step in correcting this anomaly is to identify the root causes of delays so that corrective measures can be taken.

The maintenance and infrastructure development projects of Gaborone City Council are considered as key indicators of its development and economic growth. Many infrastructure and maintenance projects in Gaborone and environ have been facing serious problems of delay for multifarious reasons. Moreover, delivery of projects becomes more complex due to the entrance of new firms, tools, equipment, technology and innovation. When a project exceeds its stipulated time there are always some financial implications that are incurred by both the contractors and clients. A delayed project implies that the contractor is going to be on site longer than planned and hence incur additional overheads while missing out on other contract opportunities as the resources are tied up on the delayed project.

A study was therefore conducted to identify and prioritize the causes and effects of delay in completing construction projects within Gaborone municipality, and to establish the relationship between time and cost of the council's project. The belief here is that when the severity of each factor of delay on project delivery is known, the project stakeholders will be able to prioritize and hedge against them in rank order and hence make the time-cost model more reliable.

Literature Review

Delay could be defined as an act or event that extends beyond the required time to perform the task under a contract. It usually shows up as additional days of work or as a delayed start of an activity (Sweis et al. 2008). According to Assaf et al. (2006) in construction, delay could be defined as the time overrun either beyond completion date specified in a contract, or beyond the

date that the parties agreed upon for delivery of a project. It is a project slipping over its planned schedule and is considered as common problem in construction projects. In some cases, to the contractor, delay means higher overhead costs because of longer work period, high material costs through inflation, and due to labor cost increases. Aibinu et al. (2002), described delay as a situation where the contractor and the project owner jointly or severally contribute to the non-completion of the project within the agreed contract period. Delays in construction projects are frequently expensive, since there is usually a construction loan involved which charges interest, management staff dedicated to the project whose costs are time dependent, and ongoing inflation in wage and material prices.

As indicated by Frimpong and Oluwoye (2003), construction industry all over the world is facing delays in completion of their projects due to different reasons. Various factors are found to be causing delay in completion of construction project. Ahmed et al., (2010), classified into two categories such as internal causes (client, contractor and consultant) and external causes which are beyond the control of the organization. Various scholars stressed the significance of proactive measures to identify the delays in construction projects and came up with key remedies to overcome the delays. Sweis et al. (2008), are of the view that delays occur in all types of construction projects whether small or large, simple and complex and reported that it is very difficult to analyze and classify the delays because there is a large number of activities involved in any construction project. In general many researchers have conducted their studies and identified a large number of causes which are involved in the construction project. Such causes include extreme weather, scarcity of resources, financial problems faced by public organizations and contractors, poor contract management, shortages of materials, and inadequate resources. The issue had also been found as of equal importance in Arab countries. Assaf et al. (2006), conducted a study in construction industry of Saudi Arabia and reported critical causes of delay related to contractor, constructor and client in large building projects. They further classified the causes into nine divergent clusters like financing, materials, contract relationships, government relations, manpower, scheduling and control, equipment, and environment. Later on, El-Razek et al. (2008), used these causes and revised the lists of delay causes with respect to the Egyptian construction industry. They further emphasized the important role of consultants and payment by owner in reducing the delays in large construction projects.

In the Pakistan construction industry, Shaikh et al. (2010), introduced a theoretical framework by analyzing the previous studies highlighting the client, contractor, general and resource related problems are key factors causing delay in construction industry. In the same vein, Haseeb et al., (2011), concluded in their study that the most important and highly ranked causes are related to financial matters causing delays in Pakistan construction industry. They further elaborated and identified the delays like delay in payment to supplier, inadequate fund allocation, inflation and monthly payment problems. However, there is need to identify the client, contractor, consultant, material, equipment, labor related and general factors causing delay in project execution.

Researchers have identified causes of delay on construction projects and classified their sources as being related to the client, consultant, materials supply, availability of equipment and labor supply. Assaf et al. (2006) identified 56 main causes of delay in Saudi large building construction projects and their relative importance. Based on the contractors surveyed the most important delay factors were: preparation and approval of shop drawings, delays in contractor's

progress, payment by owners and design changes. From the view of the architects and engineers the cash problems during construction, the relationship between subcontractors and the slow decision making process of the owner were the main causes of delay. However, the owners agreed that the design errors, labor shortages and inadequate labor skills were important delay factors.

Chan and Kumaraswamy (1997) conducted a survey to determine and evaluate the relative importance of the significant factors causing delays in Hong Kong construction projects. They analyzed and ranked main reasons for delays and classified them into two groups the role of the parties in the local construction industry (clients, consultants or contractors) and the type of projects. Frimpong and Oluwoye (2003), conducted a survey to identify and evaluate the relative importance of significant factors contributing to delay and cost overruns in Ghana groundwater construction projects. The result of the study revealed that the main causes of delay and cost overruns in construction of groundwater projects are monthly payment difficulties from agencies; poor contractor management, material procurement, poor technical performance, and material price escalation.

A number of studies by researchers have identified the contractor related delaying factors. According to Sambasivan and Soon (2007) improper planning by contractor, inefficient site management and inadequate experience of the contractor are the major causes of delay. Financial problems of contractors, sub-contractor issues quality of contractor's work are the main causes of delay, Zaneldin (2006). Similarly, Frimpong and Oluwoye (2003) also proved that contractor related factors play an important role in delaying any construction project. While writing about contractor related delaying factors. Odeh and Battaineh (2002) identified that the major issues related to contractors are the poor site management. Sub-contractors, inadequate planning approaches used for construction and insufficient experience of contractors. In the same vein, Wei (2010) reported that the difficulties in financing, clashes in sub-contractors schedule during the execution of project, rework due to errors, deprived communication and organization, unsuccessful planning and scheduling of project, improper implementation of construction methods, insufficient contractor's work, inadequate sub-contractors work, frequent change of sub-contractors, poor qualification of technical staff and site deployment are the important factors related to contractor.

There are many researchers who identified the client related delay factors. For clients, construction delays are the loss of revenue, lacking in productivity, dependency on existing resources and the lack of rentable resources. Abdul-Rahman et al. (2006) carried out a study in Malaysian construction projects. They extended the concept given by Mezher (1998) and proved through survey that financial problems are the main cause of delay in construction projects. A number of studies conducted in Saudi Arabia found the delay in payments or nonpayment to contractors by clients is the major cause of delay in construction projects of Saudi Arabia. Change orders by clients also play an important role in delaying any construction project. AlKhalil and Al-Gliafly (1999) found that decision making by client is the major problem of delay in construction industry. The reason for slow decision making is low level of technical expertise of the client.

Assaf and Al-Hejji (2006) reported that the main causes of delay from the consultant's point of view are inadequate planning of contractors, contractor's poor site management, payment of completed work and less availability of equipment and materials. According to Haseeb et al. (2011) the drawing changes inefficiency of consultants, preparation and approval of drawings, wrong site investigation, contract management and slow response and inspection are the major problems arose by the consultants in the construction industry of Pakistan.

Material is also a critical factor in the construction industry. There are many researches which have been done to identify the material related delaying factors in the construction industry. According to Sainbasivan and Soon (2007) quality of material and scarcity in material during the execution of projects are the main material related factors which are responsible for delaying a project. Koushki and Kartam (2005), concluded that selection of material is the main contributor of delay in construction industry. According to Sweis et al. (2007) the main causes for delay are the shortage of materials and late delivery of material. Aibinu and Jagboro (2002) identified that the management problems in managing materials are the main contributor of the project delay. Equipment related factors are one of the many delaying factors that cause suspension of construction project**.** Assaf et al. (1995) conducted a study in respect of Saudi construction industry and concluded that equipment failures, scarcity of equipment, unskilled equipment operators, little output and efficiency of equipment and absence of high-technology mechanical equipment. Shree (2007) implied that increase in the cost of renting construction equipment play a substantial role in delaying any construction project. Also it was inferred that short supply of construction equipment can result in serious constraint for successfully completing a project on time. The major factors relate to equipment which may result in schedule delay of any project are the equipment failures, scarcity of material, low skill levels of equipment operators, low productivity and efficiency of equipment and lack of high technology mechanical equipment are material related factors which are responsible for delay in construction projects (Wei, 2010).

A number of studies identified the factors of labor related delays. Frimpong and Oluwoye (2003), identify the labor shortages that contribute to causes of delays. Assaf et al. (2006) identify the shortage of laborers and low productivity level of laborers that contribute to project delays. Sweis *et al* (2007), Sambasivan and Soon (2007), Odeh and Battaineh (2002), Assaf and Hejji (2006) attributed shortage of manpower (skilled, semi-skilled, unskilled labor) and presence of unskilled labor to project delays.

Time and cost are of major concern in construction projects delay studies. In the construction industry, it is customary for contractors to use previous experiences on a project to estimate the new project duration and cost. Bromilow (1969) pioneered the empirical study of the relationship between project time and cost. His model predicts that there is exponential function relating the duration of a project (time) to the cost of the project. The function is given by:

$T=K*C^B$ …….. (1)

Where:

T = construction duration from project start date to handover.
C = project final cost in million dollars.
K = a constant that describes the level of time performance for a one million dollar project.
B = a constant that describes the sensitivity of the time performance affected by project cost.

The model was later updated in a study of time-cost data for a total of 419 building projects in Australia (Bromilow et al., (1980) giving the time cost relationship on these projects as:

$T=313\ C^{0.3}$ ………………………………………………………………………………….. (2)

Many researchers around the world have since taken a cue from this study. For example, Ireland (1986) replicated the study to predict construction time for high-rise buildings in Australia; Kaka & Price (1991) conducted a similar survey both for buildings and road works in the United Kingdom; Kumaraswamy & Chan (1995) investigated the effect of construction cost on time with particular reference to Hong Kong: Chan (2001) did a similar research for Malaysian construction industry: and Choudhury, Khan, & Martin (2002) conducted a study on health sector construction projects in Bangladesh. All these studies found that the mathematical model presented by Bromilow et al. holds good for prediction of construction time if the cost of construction is known.

Literature does not exist on delay factors and time cost performance GCC projects. Therefore, the existing tools of delay analysis were applied to projects executed by the council with the objective of (i) ranking the delay factors and (ii) determining the empirical relationship between project time and cost.

Research Methods

The subjects of this investigation were projects carried out by the Gaborone City Council from the year 2009 to 2014 and the construction stakeholders related to the council projects. The projects were of development and maintenance types. Archival data were used to collect data on project title, initial contract duration, project start date, expected completion date, actual completion date, initial tender price, and revised price for final account. Delay factors were sought in a preliminary study from the three groups of stakeholders (client, consultant and contractor) in addition to those identified in the literature (Masalila and Adeyemi, 2015).

Questionnaires were then distributed to the stakeholders to rate on a five-point Likert-type scale of 1 to 5 the established factors causing delays on Gaborone City Council projects. Before distributing the questionnaire a pilot study was conducted using GCC (client) professional staff. The basic purpose of the pilot study was to verify the completeness of the questionnaire in capturing the factors relevant to the council projects. The Likert-type scale is often used to measure respondents' attitudes by asking the extent to which they agree or disagree with a particular question or statement. The responses were coded as: strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5. The sampling method used in this study is convenience/snowball sampling. The relative importance index (RII) for each factor of delay is given by:

$$\text{RII} = \frac{\sum W}{A * N} \quad \text{……………………………………………………………………… (3)}$$

Where *W* is the weighting given to each factor by the respondents (ranging from 1 to *5)*, *A* is the highest weight (i.e. *5* in this case), and *N* is the total number of respondents. The higher the value of RII, the more severe the cause or effect of the delay factor.

Archival data relating to project time and cost were obtained for 26 major projects executed by the council between 2009 and 2014. These were subjected to statistical modeling to (i) determine if the difference between the expected project duration (E) and the observed actual project duration (O) is significant using chi square test, and (ii) to arrive at a Bromilow type model for the council.

Results and Discussion

Table 1 shows the comparative expected project duration as contained in the contract documents versus the observed actual project duration for each of the projects with the associated chi square calculations. Chi square was employed to test if there is significant difference between the two categories of project duration.

Null Hypothesis: There is no significant difference between the observed actual project duration (O) and the expected project duration (E).

The critical value when DF is 25 (n-1) for 95% confidence of accepting or rejecting the null hypothesis is 37.652

Decision Criteria:

- If the calculated chi square value is greater than 37.652 reject the null hypothesis.
- If the calculated chi square value is less than 37.652 accept our null hypothesis.

Chi square is given by:

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i} \quad \text{……} \quad (4)$$

Table 1

Comparative expected and actual project duration with chi square calculation

S/No.	Project Description	Expected Project Duration (E) (Weeks)	Observed Actual Project Duration (O) (Weeks)	$(O-E)^2/E$
1	Construction of public toilet	16	30	12.25
2	Refurbishment and Maintenance of a clinic	25	39	7.84
3	Erection of a pharmacy block	20	31	6.05
4	Primary school boundary wall	22	29	2.23
5	Primary school boundary wall	36	32	0.44
6	Primary school boundary wall	24	23	0.04
7	Primary school boundary wall	14	17	0.64
8	Community sports facility	14	19	1.79
9	Water reticulation of teachers' quarters	12	17	2.08
10	Nurses houses	20	60	80.00
11	Construction of special education classrooms	36	54	9.00
12	Teachers quarters	34	107	156.74
13	Teachers quarters	40	60	10.00
14	Maintenance work	8	13	3.13
15	Maintenance work	10	11	0.10
16	Maintenance work	8	13	3.13
17	Maintenance work	11	69	305.82
18	Maintenance work	16	16	0.00
19	Maintenance work	14	29	16.07
20	Maintenance work	13	14	0.08
21	Roofing	16	16	0.00
22	Maintenance work	15	22	3.27
23	Maintenance work	16	48	64.00
24	Maintenance work	7	11	2.29
25	Maintenance work	4	4	0.00
26	Supply and Installation of abattoir equipment	12	20	5.33
			Chi-square value (x_c^2)	**692.30**

Since our Chi-square value (i.e. 692.30) is greater than the critical value at 95% confidence level (i.e. 37.652), the null hypothesis is rejected. This means that there is a significant difference between the expected project duration and the actual project duration. It is therefore inferred that the time overrun incurred in the councils' projects are statistically significant.

The primary data collected from the questionnaire was analyzed from the perspective of clients, consultants and contractors. The relative importance index, RII, was computed for each cause to identify the most significant causes. The causes were ranked based on RII values. From the ranking assigned to each cause of delays, it was possible to identify the most important factors or causes of delays for Gaborone City Council projects. Based on the ranking, the five most important causes of construction delays as perceived by clients were: (1) Contractor's improper planning (RII = 0.811); (2) contractor's site management (RII = 0.789): (3) inadequate contractor experience (RII = 0.778): (4) labor supply problems (RII = 0.778) and (5) subcontractor problems (RII = 0.756). The five most important causes of construction delays as perceived by consultants were: (1) contractor's improper planning (RII = 0.842): (2) contractor's site management (RII = 0.821); (3) shortage in material (RII= 0.804): (4) inadequate contractor

experience (RII = 0.770), and (5) inadequate client's finance and payments of completed work (RII = 0.792). The five most important causes of construction delays as perceived by contractor were: (1) contractor's poor site management (RII = 0.869): (2) inadequate client's finance and payments of completed work **(**RII = 0.823): (3) subcontractors (RII = 0.789); (4) inadequate contractor experience (RII = 0.783), and (5) equipment availability and failures (RII = 0.777). From the above list, it is interesting to compare the causes as perceived by clients and contractors. Most of the disputes that arise in the construction industry in Gaborone, Botswana are between clients and contractors, most often one party blaming the other. Three of the factors perceived common between clients and contractors are: contractor's site management, inadequate contractor experience, and subcontractors. The clients blame contractor's improper planning and labor supply as other important causes of delay. The contractor's inability to plan can be attributed to contractor's inexperience. A significant portion of the labor force in the construction industry is from neighboring countries like Zimbabwe. It is quite difficult to prevent the movement of these laborers from one construction company to another, causing disruption of work. The contractors blame client's inability to pay for the completed work and equipment availability and failures as other important causes of delay. These causes can be attributed to the client's financial position and contractor's improper planning. In government related projects, payments to the contractors take relatively longer time. It is the responsibility of the contractors to factor in this time during the planning process. Table 2 gives the ranking of the delay factors based on the response of all respondents (clients, contractors and consultants). It can be drawn from the table above that the ten most important causes of delay on GCC projects in ranked order are: contractor's improper planning, contractor's poor site management, inadequate contractor experience, inadequate client's finance and payments for completed work, problems with subcontractors, shortage in material, labor supply, equipment availability and failure, lack of communication between parties, and mistakes during the construction stage.

Table 2

Overall Ranking of the Causes of Delay

Causes of Delays	RII	Rank
Client related causes		
Finance of and payments for completed work	0.820	4
Owner Interference	0.360	20
Slow decision making	0.520	13
Unrealistic contract duration and requirements imposed	0.300	24
Contractor related causes		
Subcontractors	0.760	5
Site management	0.860	2
Construction methods	0.460	15
Improper planning	0.880	1
Mistakes during construction stage	0.600	10
Inadequate contractor experience	0.840	3
Consultant related causes		
Contract management	0.378	19
Preparation and approval of drawings	0.440	16
Quality assurance/control	0.333	22
waiting time for approval of tests and inspection	0.320	23
Material related causes		
Quality of material	0.560	12
Shortage in material	0.750	6
Labor and equipment category causes		
Labor supply	0.740	7
Labor productivity	0.580	11
Equipment availability and failure	0.680	8
Contract related causes		
Change orders	0.350	21
Mistakes and discrepancies in contract document	0.420	17
Contractor relationships related causes		
Major disputes and negotiations	0.500	14
Inappropriate overall organizational structure linking to the project	0.267	25
Lack of communication between the parties	0.660	9
External causes		
Weather condition	0.200	26
Regulatory changes	0.200	26
Problem with neighbors	0.200	26
Unforeseen site condition	0.380	18

The main effects of delay were identified as: time overrun, cost overrun, disputes, arbitration, litigation and total abandonment. Their rankings are as produced in Table 3.

Table 3

Rank order of the effects of delay on Gaborone City Council projects

Effects of delays	RII	Rank
Time overrun	0.855	1
Cost overrun	0.825	2
Dispute	0.650	3
Arbitration	0.600	4
Litigation	0.580	5
Total abandonment	0.450	6

Time-Cost Performance

Data related to the construction time and cost were collected for 26 major construction projects completed by the council between 2009 and 2014. SPSS statistical program was used for the analysis of the data. A scatter plot of the data was prepared preparatory to analysis to preview the pattern of the relationship between the actual construction time and total project cost (Figure 2). The plot exhibited positive curvilinear relationship between the two variables as first predicted by Bromilow (1969). The data collected for the study was then used to validate the time-cost relationship model in accordance with Bromilow et al. (1980) procedures using the following equation:

$Time = K * Cost^{B}$ …. (5)

Where:

Time = duration of construction time in days;

Cost = completed cost of the project in thousand BWP or project value (in national currency)

K = a constant indicating the general level of time performance for a project worth one thousand BWP

B = a constant indicating how the time performance is affected by the size of the construction project measured by its cost.

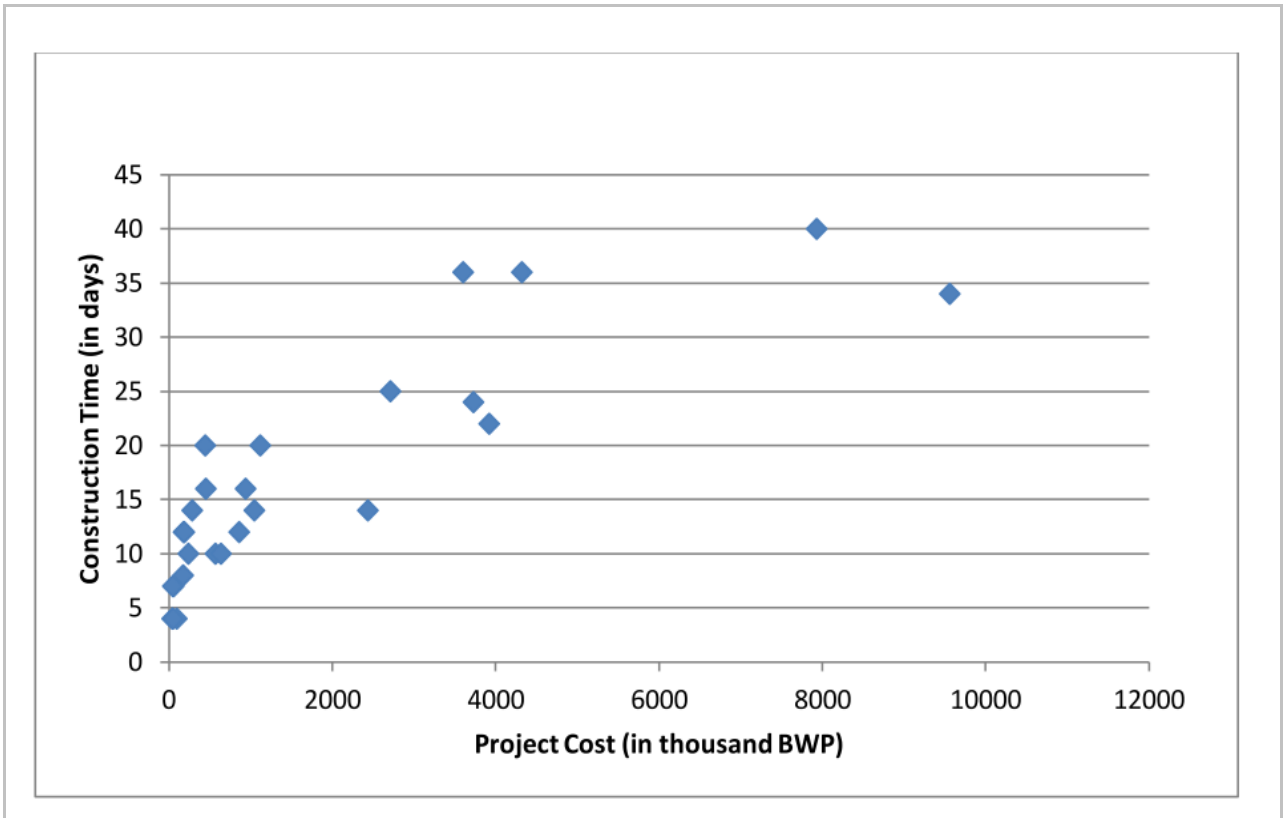

Figure 2: Scattered diagram of the relationship between construction time and project cost.

For statistical analysis, Equation (5) was rewritten in the natural logarithmic form as follows:

LnTime = Log K + BLnCost ……..(6)
Where:
LnTime = Natural logarithm of time**.**
Log K = Natural logarithm of K.
B = coefficient of LnCost.
LnCost = natural logarithm of cost.

The computer output for the input time and cost data collected and based on Equation 6 is shown in Table 6. The results of the analysis indicated a positive relationship between construction time and project cost for GCC construction works. The value of LnK is required to be transformed to K, using an exponential function (exp (LnK), for expressing the model in its original form (Equation 1). Hence, Exp (LnK) = Exp (0.110998) = 1.18.

An important aspect of a statistical procedure that derives a model from empirical data is how well the model predicts the results. A widely used measure of the predictive efficacy of a model is its coefficient of determination, or R-Squared value. If there is a perfect relationship between the dependent and independent variables, R-Squared is 1. In case of no relationship between the dependent and independent variables, R^2 is 0. Predictive efficacy of this particular model was found to be quite high with an R^2 of 0.825099, and an adjusted R^2 of 0.817812. It can therefore

be concluded that the time-cost relationship for the GCC construction project can be expressed using the model developed by Bromilow et al. (1980). This can be expressed as:

$$Time = 1.18Cost^{0.361861} \quad \text{(7)}$$

Table 4

Computer Output for Time-Cost Relationship

Dependent Variable: LNTIME
Method: Least Squares
Date: 03/13/15 Time: 14:26
Sample: 1 26
Included observations: 26
Convergence achieved after 3 iterations
LNTIME=LOG(C(1))+C(2)*LNCOST

	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
C(1)	0.110998	0.050523	2.196976	0.0379
C(2)	0.361861	0.034008	10.64052	0.0000
R-squared	0.825099	Mean dependent var		2.608334
Adjusted R-squared	0.817812	S.D. dependent var		0.668229
S.E. of regression	0.285224	Akaike info criterion		0.402717
Sum squared resid	1.952460	Schwarz criterion		0.499493
Log likelihood	-3.235317	Hannan-Quinn criter.		0.430585
Durbin-Watson stat	1.822223			

Conclusions

The objectives of this study were to confirm the presence of significant delay in GCC projects; to identify and rank the perceived delay causes, and construct a Bromilow-type time-cost model for the council's projects. The study used both archival materials and questionnaires distributed to the three major groups of stakeholders (clients, consultants and contractors). Chi-square statistical method was employed to prove the presence of statistically significant delay in the council's project. Relative importance index was used to rank the perceived causes of delay and the ten most important causes in ranked order were: contractor's improper planning, contractor's poor site management, inadequate contractor experience, inadequate client's finance and payments for completed work, problems with subcontractors, shortage of material, labor supply, equipment availability and failure, lack of communication between parties, and mistakes during the construction stage. The main effects of delay in ranked order were identified as: time overrun, cost overrun, disputes, arbitration, litigation and total abandonment. The derived GCC project time-cost model (Eq. 7) hah adjusted R^2 of 0.818 and could be used reliably to predict the project time if the cost is known.

It is believed that the results of this study can be of immense assistance to the council's project stakeholders in planning future projects and better understanding of the dynamics of project management as lessons for reducing the incidences of delay.

Recommendation

The overwhelming adoption of traditional procurement system (TPS) in the country as a whole and at GCC in particular has the tendency to negatively affect project outcomes. TPS has been widely criticized in literature as lacking in vision and value and as a major source of corruption in public project delivery (Kong & Gray, 2006; Davis et al. 2008; Chan and Kumaraswamy, 1997; Love et al., 1998; Kashiwagi and Byfield, 2002**;** Adeyemi and Kashiwagi, 2014; Adeyemi et al. 2014; Adeyemi et al. 2015).

There has been a decline in the popularity and use of traditional procurement system (Mo and Ng,1997; Rwelamila and Myer, 1999;Kashiwagi & Savicky, 2002; Kashiwagi et al. 2004; Love et al. 2008; Tan, 2011). Adeyemi et al. (2011) have recommended adoption of performance-based model, the Performance Information Procurement System (PIPS) for implementation in the Botswana built environment due to its demonstrable efficacy in delivering projects at 98% on time, budget and quality as experienced in the USA and the Netherlands where it found wider applicability. Experiment with two projects in Botswana even confirms these feet. The superior strength of PIPS to any other procurement system lies in the contractor sieving stages during bid adjudication to arrive at one contractor that can best identify and manage the risks (all possible delay factors) associated with the project. All the ten most critical factors of delay identified in this research are hallmarks of TPS which have no place in best value procurement system.

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Hail Study on a 15 Year Old Sprayed Polyurethane Foam Roofing System

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The Dallas Independent School District (DISD) has utilized Alpha sprayed polyurethane (SPF) roof systems since the 1980s. Alpha SPF roof systems are high performing roof systems if installed properly and are very resistant to hail damage (hail damage is significant in the Dallas area). However, DISD, due to their low bid award procurement system, have had some poor performing roof systems installed by contractors who did not utilize performing materials and processes. The Alpha SPF roof system is now being questioned by designers who are not aware of their high performance and wanted to tear-off one of the oldest SPF roofing systems after a hail storm. This case study is on one of DISD roofs which were studied to determine the actual and potential service period based on actual performance. It was concluded that the roof is capable of lasting another 15 more years with a simple recoat (resulting in 38 years of performance at a fraction of the cost of a traditional modified roof).

Keywords: Roofing, high performance, SPF, performance measurement, Neogard.

Introduction

Sprayed Polyurethane Foam (SPF) roofing systems have been installed since the 1960s, and have several advantages over other systems. These advantages include:

- The SPF system is considerably lighter (PCI) than any other roofing systems. The SPF is a 3 – 4 PCF material, with a coating weight that is negligible.
- The SPF system can be applied over existing roofing systems, eliminating the tear-off of the existing system.
- The SPF roofing system can also be sprayed to non-uniform surfaces (corrugated metal decks, roof penetrations, and parapet walls).
- The SPF insulates the roof.
- The entire system creates a monolithic (seamless) roof that eliminates seams.
- The system can be easily renewed by recoating the existing system.

On April 26, 2015 heavy rain and power outages were observed in the various parts of Dallas and Ft. Worth region. Along with major power outages, a hail report estimated the hail size of about 1” damaging the skylights and car windshield. Again on May 10, 2015 the Dallas region experienced a severe thunderstorm where the hail size was estimated to be about 1.75”. Over the past five years, there have been approximately 51 hailstorms in the Dallas Fort Worth area with hail ranging up to 3” in diameter (www.stomersite.com). One of the major components of a building that is exposed directly to the environment is the roofing system of a building. A severe hail storm (1.75 inch diameter hail) can cause major damages to the roofing system.

The Dallas Independent School District (DISD) has been installing the Alpha Sprayed Polyurethane Foam (SPF) Roofing System for the last 15 years. SPF roofing has an R-value of R6 per inch and is used by the owners of the building as a recovery system over existing roofs including built-up roof, modified bitumen, concrete, wood, asphalt shingles, clay tile, and metal (Knowles, 2005). The Alpha Sprayed Polyurethane Foam (SPF) roofing system has documented performance of 20 years with the ability to last 32 years with a simple recoat (Wattle & Daub Performance Line, 2015). The advantage of the Alpha SPF roof system is that it does not require the removal of the existing modified or BUR system saving owners as much as $6/SF (50% less than the traditional BUR system) in removal costs and costs of a new modified or BUR system. However, installation workmanship is one of the major reasons for SPF roofing defects which can severely minimize the service period (Alumbaugh et. Al., 1984; Kashiwagi & Tisthammer, 2002)

For this reason, DISD has used a high performance "Alpha" urethane coated SPF roof system installed by expert Alpha contractors in a quality control roofing program known as the Alpha Program (Gajjar, 2012). A properly installed Alpha roof system has been documented to resist up to 4 inch diameter simulated hail stones (four inch diameter steel ball dropped from more than 17-3/4 feet height). The Dallas Independent School District is self-insured against hail damage and is interested in using roofing systems that have the capability to withstand hail damage to minimize their cost. The Alpha Program is a group of high-performing contractors that have to meet strict performance requirements as follows:

- Roof inspections of risky roofs (leaks or have defects) once every two years
- Annually perform customer satisfaction checks on newly installed SPF roofs over 5,000 SF
- 98% of the roofs checked not currently leaking
- 98% customer satisfaction of all roofs
- Respond to leaks within 7 days of notification and fix within a couple of weeks

An Alpha roof system is installed by an Alpha contractor (meets the above quality control requirements) with 45mils of Alpha urethane roof coating and SPF that has 50 PSI compressive strength. If it is installed correctly (meeting the requirements of the Alpha specification), the Alpha roof system has a potential of 30 year service period at half the cost of installing another new BUR or modified bitumen system. There are several problems that have occurred at the DISD with limitation of funding being one of the major ones. This has led to the following practices:

1. A 10 year traditional SPF roof system instead of the 15 year Alpha SPF roof.
2. The Alpha contractors hired in "low bid" environment by general contractors, making it a low bid roof with low bid materials.
3. The SPF roof system is installed in less than ideal conditions (over moisture laden BUR/insulation systems).
4. SPF roofs being installed over existing SPF or BUR systems with moisture.
5. The SPF roof system is stepped on before it adequately cures causing blistering.

These issues have confused DISD project managers into thinking that the Alpha System may not perform as expected. Doubts such as the Alpha system being a performing roof system and the Alpha system being resistant to hail damage have emerged amongst the DISD project managers.

Problem

Some of the low bid installed SPF roof systems are having problems. One of those roofs (Foster Elementary) at DISD, which was installed in 2002 (one of the first Alpha SPF roofs installed before the other low bid SPF roofs), experienced a severe hail storm in 2014 and was inspected by the insurance company representative (DISD are self-insured). The inspector proposed that the entire roof (both the existing BUR underneath and the over layed Alpha SPF roof system) to be replaced after 13 years of installation in the summer of 2015. This paper will study the economic and waterproofing performance of the Alpha roof system installed at Fosters Elementary by testing it against hail damage and inspecting the SPF and coating characteristics.

Methodology

The Foster Elementary Alpha SPF system will be studied in the following ways:

1. The inspection report of the past four years of the roof will be reviewed.
2. The roof will be tested according to the ASTM Hail Test using a 2 inch steel ball being dropped from 17 feet, 9 inches height (the standard test is using a 1-3/4 inch diameter steel ball). This test used a larger ball as a more conservative approach. The Alpha roof system warrants against hail damage if a 1-3/4 inch steel ball rips through the Alpha urethane coating.
3. The roof will be tested using a 4 inch diameter steel ball dropped from 17 feet 9 inch height. This is an oversized hail test (Kashiwagi, 2004).
4. Test the SPF under the Alpha coating to ensure that it is a 50 PSI SPF.
5. Make a conservative estimate of the performance of the SPF roof system if it had been recoated instead of tear-off.
6. Conclude whether an Alpha SPF roof system is a performing system for DISD.
7. Conclude on the ramifications of this case study on the expectations of the Alpha roof system at DISD.

Inspection of the Fosters ES Roof

The Fosters ES roof has the following history:

1. Original roof was BUR that was installed in the 1970s (conservative estimate).
2. A SPF roof system was installed over the existing BUR system previous to 1988.
3. A second SPF roof system, that is an Alpha roof system, is installed over the existing BUR and SPF roof in 2002.

4. Hail storm occurred in 2015, and a hail inspector recommends that the roof is damaged and should be replaced.
5. The hail test and analysis of the SPF was then conducted in the summer of 2015.
6. The Foster Alpha SPF roof was removed due to "perceived hail damage" in the summer of 2015, and replaced with a $16/SF roof system.

The roof was physically inspected every year from 2011 to 2014 to measure the percentage of blisters on Fosters ES as shown in Table 4. The contractor fixed the blisters in 2012 with no cost to the client and the manufacturer. Only 3 SF (0.006%) of blisters currently exist on the roof. This roof was in no danger of failing. The roof defects and repairs for the last four years are shown in Table 1.

Table 1

Inspection Results (2011 – 2014)

2011		2012		2013		2014	
SF Blisters	% Blisters	SF Blisters	% Blisters	SF Blisters	% Blisters	SF Blisters	% Blisters
74	0.150%	260	0.510%	3	0.006%	3	0.006%

However, an independent insurance adjuster identified that the Foster elementary school Alpha roof was damaged by hail. An inspection by the PBSRG research staff identified minimal hail damage on the roof. PBSRG then decided to run the FM hail test and the severe hail test (FM-SH Hail Test #4470 (SH)) on the roof. Evaluating roof coverings using physical inspection have been used for asphalt composition shingles, wood shingles and shakes, and slate and clay tile roofs (Sharara et. al., 2009). Hail test studies have been performed on numerous building materials to test their ability to withstand hail (Nelson, 2012; Askari et. al., 2011). ASTM D-1621 test was also performed by the Naval Laboratory at Port Hueneme, CA by Robert Alumbaugh. In 1996, PBSRG at Arizona State University did a similar comprehensive hail study, and in 1998 followed it up with a hail test using a 4 inch diameter steel ball. It was called a severe hail (SH) test. PBSRG reached the following conclusions in those two studies:

1. The Factory Mutual (FM) publication on their hail test results was inconsistent with the PBSRG test results. FM identified the silicone coating as the most resistant, and the urethane coating as the least resistant. PBSRG could not duplicate the FM results. Conversations with FM resulted in no action. Since that time FM has proposed new hail standards. However, there has been no new information since their publication in the 1990s.
2. The FM weathering test using the Weatherometer (Xeno 1200 Xenon light source) was not valid. The test results from the Weatherometer did not match the results of aged samples from the field.)
3. The silicone coating could not pass the hail test. The acrylic coating could also not pass the hail test.
4. A high strength acrylic coating put on at a 40 mil thickness was tested, and the 1-3/4 inch steel ball smashed right through the coating and the SPF. This result was not published at that time due to an agreement with the contractor who provided the sample. It is being published now due to the time that has elapsed.
5. Aged Neogard urethane coated SPF roofs passed the hail test with 20 mil coating after 20 years of age.

6. Aged Neogard coating systems passed the FM SH (4 inch diameter steel ball dropped from 17-3/4 feet height) at 15 years of service period at 50 mils of urethane coating.

Due to the poor performance of the majority of the SPF roofing systems to hail damage, roof traffic, and improper application, SPF systems are traditionally thought of as a cheaper roofing system, with marginal performance. This has contributed to its lack of popularity (less than 3% of the roofing market). PBSRG has published the following publications that relate to the performance of Sprayed Polyurethane Foam Roofing Systems:

1. Hail Resistance of SPF Roof Systems – 1996
2. Oversize Hail Resistance Test of SPF Roof Systems – 1997
3. Hail Resistance of the Alpha SPF Roof System – 2003
4. Hail Resistance of SPF Roof Systems – 2008

The previous hail tests revealed that the customers were extremely satisfied (9.8 out of 10) with the SPF roofing system. SPF roofing systems are high performing roofs when installed by an expert and capable contractor and can resist severe hail damage (drop of 4 inch diameter steel ball from 17-3/4 feet height). In 2015, PBSRG performed several tests on the aged Foster Elementary SPF roofing systems to confirm the opinion of the independent insurance adjuster. The roof information is as follows:

Roof Name: Stephen Fosters ES
Location: 3700 Clover Ln, Dallas, TX 75220
Job Area: 50,754 SF
Year Installed: October 2002

The test performed in Dallas was done in early July, with an average roof temperate of 78 degrees.

On-Field Testing of the Coating Using the FM-SH Test

The Factory Mutual Severe Hail (FM-SH) test #4470 was utilized. This test simulates the damage caused by freefalling severe hail (up to 1.75” in diameter). This test requires dropping a 1.75”steel ball from a height of approximately 18 ft onto an SPF sample (figure 1). PBSRG researchers used a more conservative larger 2 inch and 4 inch diameter steel balls. The result of the impact cannot show any signs of failure (cracking or tearing) in the coating system. The FM-SH test has been used on previous publications that the PBSRG has published, and was used once again for this research test.

Figure 1: Hail Testing Apparatus.

After setting up and dropping each steel ball, the impact was examined to determine if there were any failures (cracks or tears) in the system. A total of 20 hail drops were performed (10 drops with 2" steel ball and 10 drops with 4" steel ball). Nineteen (19 out of the 20 hail drops passed the test.

Foam Testing using the ASTM Test

The American Society for Testing and Materials (ASTM) Test D-1621 is used to measure the compressive strength and the density of the SPF. A sample from the roof was collected and analyzed. Five tests were performed for each SPF sample for a total of 15 tests for three layers of SPF. The three layers of SPF are as follows with 4" total thickness (figure 2).

- Bottom layer: Old, yellow foam materials (2" thick).
- Middle Layer: New SPF material (1" thick).
- Top Layer: New SPF material (1" thick).

Figure 2: Three Layers of SPF (4" thickness).

Research Results

Measurements were taken after the tests were performed to determine the impact depth and impact diameter of the 2" steel ball and 4" steel ball (figure 3).

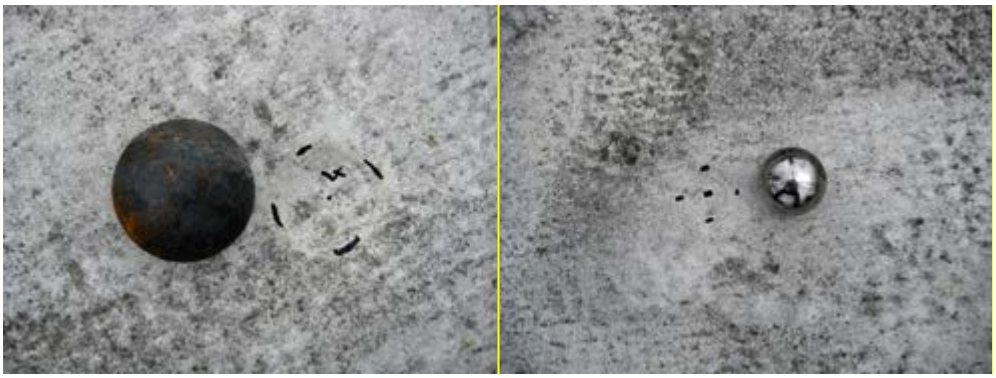

Figure 3: Indentations - 4" and 2" steel ball.

Table 2 provides a detailed analysis of the impact depth and impact diameter of the hail drops. The average impact width for 2" steel ball and 4" steel ball were 1.5" and 3.5" respectively whereas the average impact depth for 2" steel ball and 4" steel ball was 0.193" and 0.388" respectively.

Table 2

Impact depth and impact diameter

2" Steel Ball				4" Steel Ball			
Drop No.	Pass / Fail	Average Impact Width (in.)	Average Impact Depth (in.)	Drop No.	Pass / Fail	Average Impact Width (in.)	Average Impact Depth (in.)
1	Pass	1.5	0.125	1	Pass	3.5	0.5
2	Pass	1.5	0.25	2	Pass	3.5	0.25
3	Pass	1.5	0.125	3	Pass	3.5	0.875
4	Pass	1.5	0.125	4	Pass	3.5	0.25
5	Pass	1.5	0.375	5	Pass	3.5	0.375
6	Pass	1.5	0.1875	6	Pass	3.5	0.25
7	Pass	1.5	0.125	7	Pass	3.5	0.375
8	Pass	1.5	0.375	8	Fail	3.5	0.375
9	Pass	1.5	0.125	9	Pass	3.5	0.25
10	Pass	1.5	0.125	10	Pass	3.5	0.375
Average		**1.5**	**0.193**	**Average**		**3.5**	**0.388**

Slit samples were taken on the roofs to determine the average coating thickness of the in-place systems (figure 4). Sixteen (16) total slit samples were taken from the dropped locations. Four (4) measurements per sample were taken to determine the average thickness of the sample (64 total measurements).

Figure 4: Slit Sample Mil Thickness.

The average coating thickness and the minimum coating thickness were measured on each slit sample. The results of the measurements are shown in Table 2a and Table 2b, and indicate that the average mil thickness was 46.25 mils and 44.11 mils for 2" and 4" steel ball drops respectively.

Table 2a

Analysis of Coating Thicknesses (2" Steel Ball)

Drop No	Pass / Fail	1st Coating Thickness (mils)	2nd Coating Thickness (mils)	3rd Coating Thickness (mils)	4th Coating Thickness (mils)	Average Coating Thickness (mils)
1	Pass	50	50	50	50	50
2	Pass	50	45	45	50	47.5
3	Pass	40	45	45	50	45
4	Pass	50	50	50	50	50
5	Pass	N/A	N/A	N/A	N/A	N/A
6	Pass	N/A	N/A	N/A	N/A	N/A
7	Pass	40	45	45	40	42.5
8	Pass	45	50	35	50	45
9	Pass	35	45	40	40	40
10	Pass	50	50	50	50	50
					Average	**46.25**

Table 2b

Analysis of Coating Thicknesses (4" Steel Ball)

Drop No	Pass / Fail	1st Coating Thickness (mils)	2nd Coating Thickness (mils)	3rd Coating Thickness (mils)	4th Coating Thickness (mils)	Average Coating Thickness (mils)
1	Pass	40	40	40	40	40
2	N/A	N/A	N/A	N/A	N/A	N/A
3	Pass	40	50	70	50	52.5
4	Pass	45	50	45	50	47.5
5	Pass	35	45	40	50	42.5
6	Pass	40	40	40	40	40
7	Pass	35	40	35	35	36.25
8	Fail	60	70	50	50	57.4
9	Pass	40	40	50	45	43.75
10	Pass	45	35	35	35	37.5
					Average	**44.11**

The compressive strength and the density of the SPF material were tested individually for three different layers as shown in Table 3. Similar tests have previously been performed on foam materials to verify the physical properties (Priddy & Newman, 2010).

Table 3

Compressive Strength and Density of SPF

Bottom Layer SPF (2")			Middle Layer SPF (1")			Top Layer SPF (1")		
No	Comp. Strength (psi)	Density (pcf)	No	Comp. Strength (psi)	Density (pcf)	No	Comp. Strength (psi)	Density (pcf)
1	56.5	3.12	1	49.9	3.17	1	34.8	2.73
2	57.9	3.14	2	53.2	2.91	2	42.9	2.85
3	58.3	3.11	3	52.3	2.80	3	43.9	2.89
4	61.7	3.10	4	51.6	2.77	4	40.5	2.69
5	53.6	3.15	5	53.2	3.22	5	50.8	2.72
Avg.	**57.6**	**3.12**	**Avg.**	**52.0**	**2.97**	**Avg.**	**42.58**	**2.78**

The Fosters roof is a high performance roofing system that has performed for 28 years with the potential of performing for another 15 years with a recoating. The Alpha SPF system ($5/SF - $8/SF cost) becomes an economic and value based alternative to the $16/SF traditional modified roofing system.

Conclusion

The Fosters SPF roof system that was analyzed in this case study was 15 years old. In 2002, additional SPF and the Alpha hail resistant coating were added to increase the performance to 28 years, and were in perfect condition to extend the service life to 38 years old. Instead of recoating the system, the roof was removed and a new modified bitumen roofing system was installed. The modified system is estimated at $16/SF, which is twice the cost of the Alpha recoating system.

The reason why the roof was removed was the concern that a recent hail storm had damaged the existing modified bitumen system and the existing Alpha roof system (split system roof). To ensure that the Alpha SPF roof system could perform in a 1-3/4 inch hail, the Factory Mutual (FM) hail test was performed with a 2" diameter steel ball resulting in no damage to the Alpha SPF roof system. To identify if the roof could withstand a 4" diameter steel ball dropped from 17 – ¾ feet height (very severe hail damage, only one of the ten drops resulted in a break of the Alpha roof coating).

A summary of the test results of the Alpha SPF roof system as an alternate value for the traditional $16/SF modified bitumen system include:

- The hail test on the Alpha coating showed no signs of damage.
- Only 1 out of 10 drops of the 4" steel ball (severe hail simulation) resulted in a ½" slit.
- The SPF sample had a total thickness of 4", average compressive strength of 50.7 psi and average density of 2.96 PCF (matching new Alpha roof SPF requirements).
- The roof only has 3 SF of blisters (.006% of roof area) and is free of leaks and deterioration.
- Roof is capable of lasting another 15 more years with a simple recoat (resulting in 38 years of performance at a fraction of the cost of a traditional modified roof).
- Roof is being replaced after the hail storms, but there is no visual damage on the roof (figure 5).

Figure 5: Actual Roof.

The authors conclude that the Alpha SPF roof system should not have been tear-off, but should have been recoated at a cost of $5.00SF. The roof would have lasted an additional 15 years, taking the full service period of the roof at 38 years. The roof would have cost DISD less than 50% of the procured BUR system, and would have been a financial windfall. The Fosters Elementary School also shows that the Alpha SPF roof system is a renewable, green roofing system that is an economic alternative to the modified BUR system.

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Improving the Management of Environmental Engineering Projects through the Best Value Project Management Model for a State Agency

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The State Agency is the regulatory agency responsible for ensuring quality of air, land, and water resources. Historically the State Agency has experienced difficulty in managing environmental professional services. To potentially address the issues, the State Agency tested a new approach to managing their projects, the Best Value Project Management Model (BV PMM), which focuses on using logic and natural laws instead of technical information and experience to improve project performance. This paper presents a case study on the State Agency's implementation of the BV PMM on their indefinite delivery indefinite quantity (IDIQ) Water Quality contract that ran 60 individual projects. The main functions of the water quality unit program is to identify, assess and remediate sites that are contaminated with hazardous substances. This paper presents the BV PMM, its development, and documents the case study results after one year of implementation. Results include an improved PM utilization rate (22% increase), increase in vendor work performed (102%) in 33% less time, and increase in customer satisfaction (22%).
Keywords: Best Value Project Management Model, State Agency, Best Value PIPS, traditional.

Introduction

The State Agency covered in this paper is the environmental regulatory agency for one of the United States' top 18 largest states, covering a population of close to 10 million people. Its mission is to protect and enhance public health, welfare and the environment in its state. The State Agency today administers a variety of programs, to improve the health and welfare of its citizens and ensures the quality of its air, land and water resources meet regulatory standards. With an average of 400 employees managing various contaminants and pollutions, the State Agency strives to lead its state and the nation in protecting the environment and improving the quality of life for the people in its State (PBSRG, 2016).

Over the last decade, the State Agency has tried to make the changes necessary to accomplish its mission, but has been having difficulties with the performance of their environmental professional services. The upper management at the State Agency identified the following problems:

1. Unable to identify performance and value of vendors / environmental experts.
2. Vendors were not meeting the quality expectations of the State Agency.
3. Management requirement of the vendors was too high.
4. Inability to spend all available resources.

Most of the issues the State Agency was experiencing were common among environmental quality projects. Environmental projects are expensive, complex in nature and often times require multiple testing and invasive investigations over a period of many years before the final end goal of the project can be clearly defined. This makes it difficult to clearly set expectations and plan resource requirements, causing inaccurate expectations of the time, cost, and quality of projects. The lack of important pieces of information at the beginning of a project also increases the risk of the project. This is an issue that has been plaguing the environmental engineering industry and many others worldwide for decades (Vaughn and Ardila, 1993; Filipovich, 2001; Esty & Porter, 2005; International Rivers, 2005; Macek, 2006; Reuters 2009; Bo-Jie, et al., 2010; Fu et al., 2010; Buntaine, et al., 2013; Fisher, 2013; IEG, 2013; Padgett, 2014; AFP 2014).

As a result, over the past few years the State Agency has become increasingly dissatisfied over the past few years, with the delivery and project management requirement of environmental professional services. The State Agency identified that the lack of information forced them to make more decisions on projects, making it difficult to hold the vendors accountable for their work due to the direction the State Agency was giving them.

With the budget continually shrinking and increasing requirements, the State Agency was in search of a solution to help them improve their management, efficiency, and performance in delivering environmental services, and minimize the issues they have been facing.

Problem

The State Agency began deploying Lean principles in 2013, which geared staff toward eliminating waste and increasing value for its customers by improving internal systems and processes. Its water quality program has implemented process improvements to accelerate clean-ups, engage responsible parties and ultimately reduce the overall costs of remediating contaminated sites. The State Agency lacked a consistent contracting and project management mechanism that paralleled the process improvements that the agency was implementing. As the water quality contract was coming up for re-bid, the State Agency desired a process that would accurately identify the quality and performance of the environmental work being completed, and promote their vendors and internal personnel to be more proactive and accountable for their work to achieve their accelerated cleanup model. Some of the difficulties the State Agency faced in doing this are as follows:

- Lacked the number of in-house project managers to perform environmental work.
- No project performance information was collected.
- Current processes did not differentiate the value and performance of vendors for new contracts.
- Increased pressure on the State Agency to utilize all resources provided.

Best Value Performance Information Procurement System (BV PIPS)

The State Agency identified the Best Value Performance Information Procurement System (BV PIPS) as a potential solution to their problem, due to the similarity of the complexity that construction and IT projects have with environmental quality projects.

The BV PIPS has been tested in the entire supply chain (construction and non-construction services). Its developments have been researched and developed, in support of professional groups like the International Council for Research and Innovations in Building and Construction (CIB) and the International Facility Management Association (IFMA) for the last 23 years, and has been identified as a more efficient approach to the delivery of professional services.

Some of the impacts of the BV PIPS are as follows (Kashiwagi, 2013; Rivera, 2014; PBSRG, 2015):

- 1800+ projects and services delivered / $6.4B of projects and services delivered.
- 123+ unique clients (government and private sectors).
- 98% customer satisfaction / 9.0 (out of 10) client rating of BV PIPS model.
- Decreased the cost of services on average by 31%.
- Vendors were able to offer the client/owner 38% more value.
- Decreased client efforts by up to 79%.
- 57% of the time, the BV PIPS selects the highest performing experts for the lowest costing services.
- International recognition: Canada, Netherlands, Botswana, Malaysia, Australia, Democratic Republic of Congo, and France.
- Largest projects: $100M City of Peoria Wastewater Treatment DB project; $53M Olympic Village/University of Utah Housing Project; $1B Infrastructure project in Netherlands.

The BV PIPS process consists of three major phases (selection, clarification, and execution). During selection, vendors compete based on their level of expertise. This is determined by their past performance metrics, ability to identify risk, and capability of their key personnel. The vendor that is highest ranked move into clarification. In clarification, the vendor is required to explain how they will accomplish work efficiently and with high customer satisfaction. They are required to identify performance metrics that they will track throughout the contract. Vendors do this by creating a plan that includes their scope, detailed and milestone schedules, budget, risk management plan, and performance metrics. Vendors then set up a meeting to clarify the project to the owner for approval. Upon approval of the project, the last phase vendors move through is execution. In this phase, vendors will receive projects, as work is required. Vendors project progress is tracked in a Weekly Risk Report (WRR), which is an excel spreadsheet that measures cost and schedule deviations, and turned in each week to the client. The WRR is submitted to the client throughout the execution of the project, and becomes performance documentation of the project after completion.

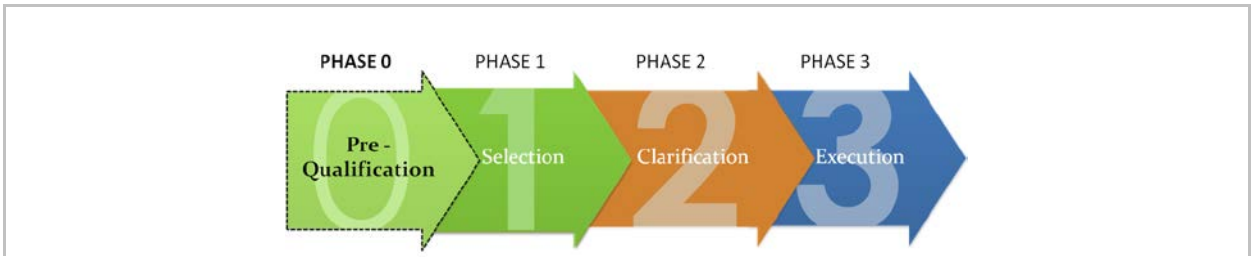

Figure 1: BV PIPS Model.

Currently the BV PIPS is a proven high performance process of no decision-making, no management, direction, and control, and no thinking. It is used mainly as a procurement and risk management system. The process has project management applications; however, it has not previously been used as a project management system.

Hypothesis

Due to the success of the BV PIPS in improving project performance, using its principles as a new project management model, could increase the efficiency and productivity of the State Agency's project managers and assist in delivering high performing project results.

Methodology

To confirm the hypothesis, the following research steps will be taken:

- Identify the project management principles used in the BV PIPS process to develop the Best Value Project Management Model (BV PMM).
- Perform a research case study implementing the new PM model on the State Agency projects for one year.
- Document implementation of the new project management model.
- Document the results of the new project management model.
- Compare the results of the State Agency's traditional PM model with the new BV PMM.

Best Value Project Management Model

A literature research was performed identifying the project management (PM) principles found in the BV PIPS process. The following publications and sources were used (Kashiwagi, et al., 2009; Kenny, 2008; Kashiwagi & Mayo, 2001, Kashiwagi & Byfield, 2002a-d; Kashiwagi, et al., 2003a-c; Kashiwagi & Morrison, 2012; Rivera, 2014; CIB W117, 2015; Kashiwagi, 2015; PBSRG.com, 2015):

1. 200+ academic conference and journal papers.
2. The Information Measurement Theory and Best Value Approach manuals.

The BV PIPS was derived from the principles of the Industry Structure (IS) model and Information Measurement Theory (IMT). The IS was developed in 1991, and proposed that the buyer or end user, may be the major source of project cost and time deviation. The Industry Structure model shown in Figure 2 identified that in the environment of high competition, the biggest difference in low performance and high performance, was the use of management, direction, and control (MDC) by the buyer over the vendor.

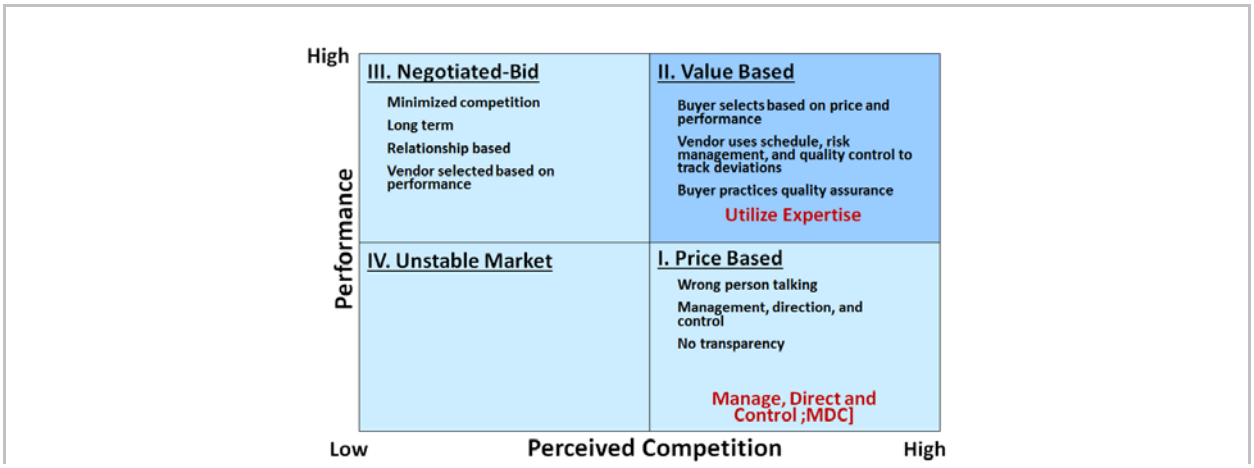

Figure 2: Industry Structure chart.

The IS proposes that a project manager should not manage, direct, and control others. They should utilize the expertise of others on a project. Utilizing expertise instead of MDC involves the following changes to a project manager's role (see Figure 3):

1. Identify an expert to perform the project.
2. The PM is responsible for Quality Assurance and not Quality Control. The PM is responsible for ensuring the expert has a plan, the plan is understandable to everyone, and they have a way to measure the quality of their work throughout the project.
3. Minimize the decision making of the PM. The PM requires the expert to take control of the project and make any decisions required. This will also increase the accountability of the expert.
4. Coordinate and ensure any tasks outside of the expert's scope of work are complete for the project.

The Information Measurement Theory (IMT), which uses natural laws and logic to explain reality and identify expertise and value, was also used to develop the BV PIPS system. The main idea IMT proposes is that one individual has no impact, influence, or control on other individuals, it supports the IS in minimizing management, direction, and control. It also identifies characteristics of an expert. The logic it uses to come to this conclusion is as follows:

1. Natural laws are not created. They are discovered.
2. Every set of conditions based on a location and time is unique. Each set of conditions has a different set of characteristics that makes it unique. Unique characteristics include time, location, resources, people's perceptions, and physical conditions.

3. Unique conditions change over time based upon natural law. Thus, unique conditions of the past are related to the unique conditions of the present and the future.
4. The more information (understanding of natural laws and knows the unique conditions) an individual has the more they can predict the future conditions.
5. If future conditions are predictable then any event can happen only one way.
6. The initial conditions of an event will determine the final conditions of an event.
7. Any attempt to change unique conditions that is not based on natural law is impossible.
8. The more information an individual has in an area the more expertise and value they can provide.
9. The more expertise an individual has the more they do not believe in the ability to control or influence other people.

An expert is identified as an individual with more information in a certain area. Hence, the more expertise someone has the less they believe in the ability to control or influence other people. The more they believe that they control their own life and have 100% accountability for it. Figure 3 shows the difference between the belief in influence and control and no-influence and no-control. On the left side, the arrows are facing out showing that the individual is accountable for his life and his environment. On the right side, the arrows are facing in showing that the individual believes their environment and life is responsible for what happens to them. The corresponding characteristics of each belief are also found in Figure 3.

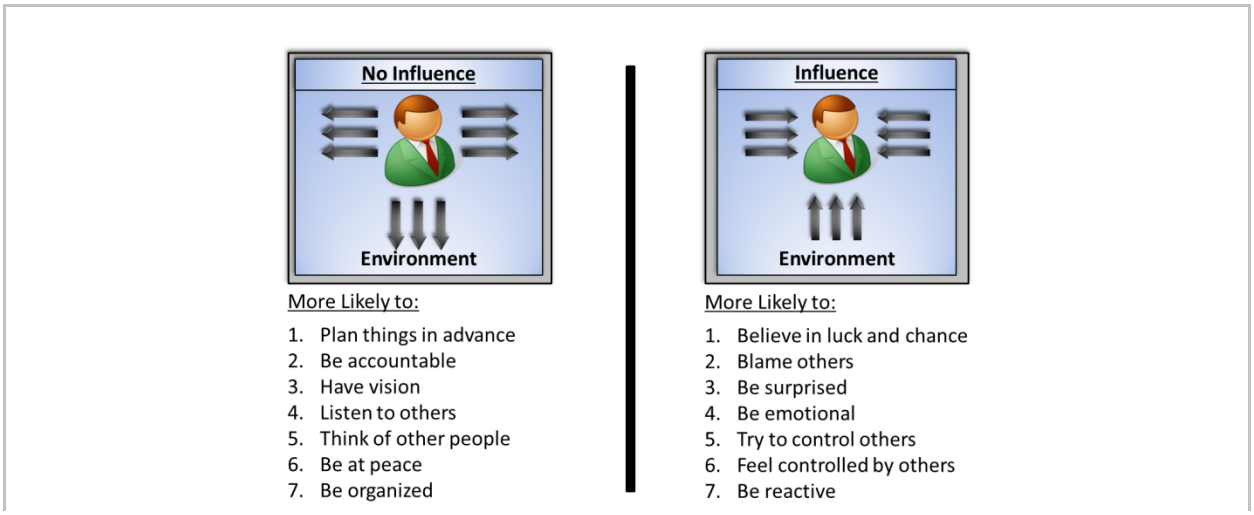

Figure 3: No-Influence vs Influence model.

The IS and IMT identify that the more a PM has to MDC the less efficient they are. Characteristics of MDC are the following:

1. Communications.
2. Meetings.
3. Reports.
4. Inspections.
5. Making decisions.
6. Requirements.

The new BV PMM identifies that the role of the PM changes from being a manager to now being more of a leader. A manager being an expert that directs others and makes decisions on project (PMI, 2000), and a leader being one that aligns expertise. The manager requires technical knowledge and understanding. The leader requires an ability to use the expertise of others. To make this transition the IS and IMT identify the following requirements for the new model:

1. Due to the PM no longer being the expert all communication must be non-technical.
2. The PM must ensure and require the vendor to simplify the project and create transparency.
3. All efforts must be measured. Measurements must be simple, understandable, and non-technical. Measurement enables the PM to know the level of performance of the expert.

From literature research of the BV PIPS, the following characteristics of the BV PMM were identified (Rivera, 2014; PBSRG, 2015):

1. Utilize expertise – Align vendors and personnel with projects that fit their expertise.
2. Minimized MDC (meetings, decisions, reports, inspections, and communications).
3. Non-technical communication – simple and non-technical performance metrics.
4. Quality assurance – ensure that the expert has a plan before they begin a project and they can explain the progress and changes to the plan throughout the execution of the project.
5. Out of scope coordination – PM takes responsibility for anything outside of the expert's scope of work.
6. Transparency – all stakeholders have access to all project information and can understand the information without an explanation.

State Agency's Implementation of the BV PMM

In January 2014, the State Agency partnered with a world renowned research group at Arizona State University, called the Performance Based Studies Research Group (PBSRG), for training, mentorship and assistance, in the implementation of the BV PMM, for the delivery of their professional services on their environmental assessment and remediation projects. The new model proposed the replacement of management, direction, and control (MDC) with the utilization of expertise. The effort would develop a project management structure that would use performance metrics and non-technical communication to create transparency and increase the accountability, value of expertise, and efficiency of the entire supply chain of professional environmental services.

The State Agency chose to test the BV PMM in their water quality unit, on its indefinite delivery indefinite quantity (IDIQ) contract. The contract had 10 vendors that could perform work for the department. This department was responsible for identifying, assessing, and cleaning up soil, groundwater, and surface water sites contaminated with hazardous substances. The unit conducts these efforts throughout its state with support from state funds. The program also oversees privately funded cleanup efforts. Before the BV PMM was implemented, the State Agency project managers were given training to help them understand the change in their roles. Figure 4 shows the main difference between the PMs and vendors previous responsibilities and roles on a project, and their new roles under the BV PMM.

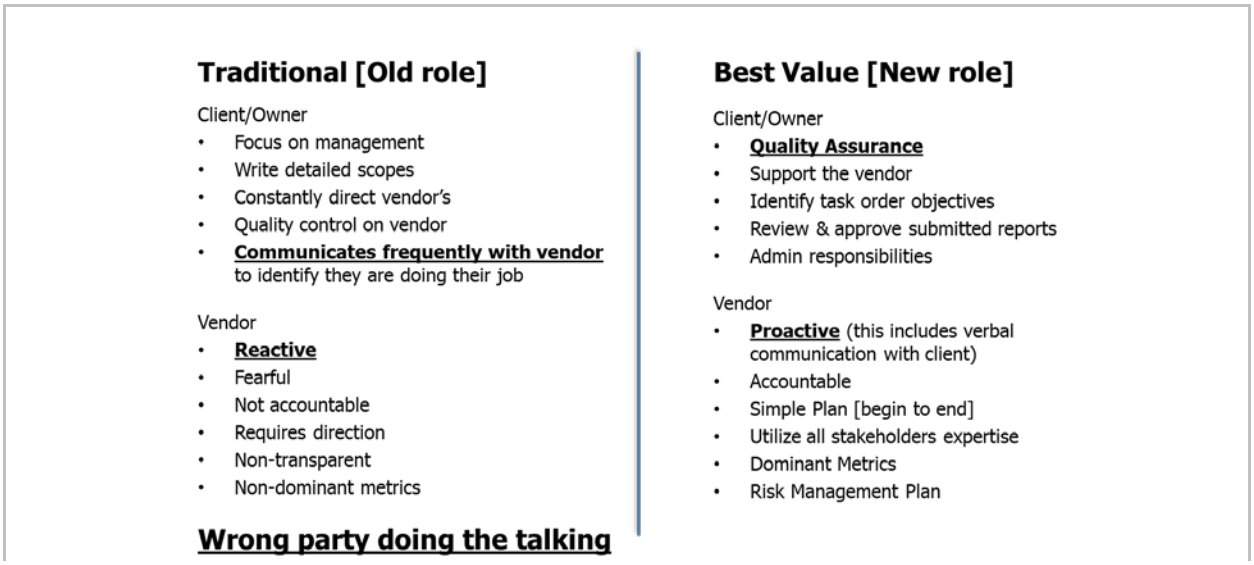

Figure 4: New Project Management Roles model.

This next section will discuss the implementation of the six BV PMM characteristics in the water quality unit, and how each characteristic changed the responsibilities of the State Agency's PM. The six characteristics are the following:

1. Utilize expertise.
2. Minimized MDC.
3. Non-technical communication.
4. Quality assurance.
5. Out of scope coordination.
6. Transparency.

Utilize expertise

Utilizing expertise is one of the most difficult leadership characteristics for traditional PMs to adhere to (Kashiwagi, 2013, PBSRG, 2016). It requires the PM to understand that they must minimize MDC. It requires the PM to turn over the decision-making and accountability for the project to the vendor (expert). The PMs were only able to provide the experts an objective and estimated budget. They were no longer required to MDC the project set up through completion. Instead, they were only required to ask questions of the expert when they did not understand. The traditional decision-making performed by the State Agency's project management was as follows:

1. Identify which vendor should perform each project.
2. Identify what is included in the scope of each project.
3. Identify what a reasonable cost for the project should be.
4. Identify what the timeframe for the project should be.

The State Agency was asked to explain how they performed the above decisions. These are the main actions performed to make the above decisions:

1. The vendors where chosen based upon the relationship they had with the State Agency and their price.
2. The State Agency determined the scope, cost, and timeframe of each project based upon their technical experience and understanding of the site.
3. When the vendor was selected for a project, a negotiation would occur to ensure the vendor was offering a reasonable cost.

The success of this process was based off the State Agency PM's expertise and experience. The BV PMM identified that the vendors (experts) must perform all of these responsibilities now. This changed the above four traditional PM responsibilities to the following:

1. Identify overall State Agency expectations on work that should be performed.
2. Identify overall State Agency budget to be spent on the projects.
3. Require the vendors to differentiate themselves based upon performance and price to identify which vendors should receive each project.
4. Once it was identified which vendors should receive each project, then let the vendor identify the scope, cost, and time required to complete each project.

At the start of the implementation of the BV PMM the vendors were unable to differentiate themselves by their performance. None of the vendors had documented sufficient performance information to differentiate themselves. Due to the inability of the vendors to differentiate themselves for the first year, the State Agency assumed all vendors had the same level of expertise and used a round robin (rotational) system to divide the projects. The round robin system is depicted in Figure 5 and Table 1. The only reasons a vendor would not receive a project was due to:

1. The vendor declined the project.
2. The State Agency had information that caused doubt in a vendor's ability to perform.

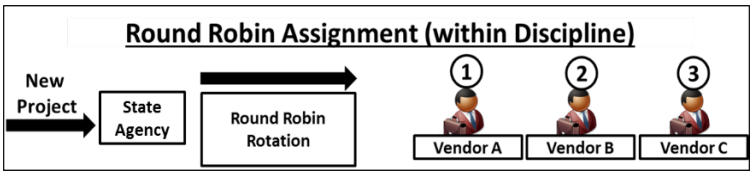

Figure 5: Round Robin Selection Tool.

Table 1

Round robin selection tool (PI Phase)

No.	Firm	Project	Vendor
1	A	1st Street	A
2	B	2nd Street	B
3	C	3rd Street	C
4	D	4th Street	D
5	E	5th Street	E
6	F	6th Street	F
Next Vendor in Line:		7th Street	A
C		8th Street	B

After each vendor was assigned a project, the vendors were then given the following information:

1. Overall expectation of the State Agency for their projects.
2. Overall the State Agency budget limitations for their projects.
3. A requirement to create a plan for the project, within a timeframe of 14 days. The amount of days that deviated from 14 was dependent upon how simple or complex a project was.

The above information was incorporated into the State Agency's regular project administration form. In order for the vendor to complete their plan and begin the project, the State Agency PM was required to approve the plan. The State Agency PM would not approve the plan if they had any of the following:

1. Questions.
2. Concerns.
3. Confusion.

It was the vendor's responsibility to create a plan that was clear, understandable, and made the State Agency PM feel comfortable. If there were any questions on price or the scope of work, the vendor would have to provide a sufficient explanation to the State Agency PM.

One of the requirements of the plan was identifying performance metrics that would track the vendor's performance on the project. This was performed for every project. Due to this requirement after one year, there was sufficient performance information to differentiate the level of performance of each vendor. Thus, moving into the second year of implementation of the BV PMM was now using performance information from the vendors to select vendors for each new project. Figure 6 shows the shift from a round robin to a selection of vendors based on past performance information.

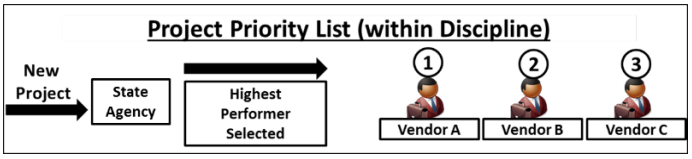

Figure 6: Highest to Lowest Performers Selection Model.

Table 2 and 3 identifies one type of project performed for the State Agency and the information that the State Agency PMs looked at to differentiate the vendors based upon performance and price. Looking at Table 2 it identifies that Vendors A, E, and F had lower levels of expertise than vendors B, C, and D. It also shows that vendor C was able to deliver projects the quickest, with the lowest price, and the highest customer satisfaction. Future distribution of work will enable C to receive the most work, followed by B. If cost is an issue, the State Agency could also give vendor D work depending on the complexity of the project. Table 3 shows a cost breakout of the projects. This table shows the efficiency of vendor C compared to the other vendors.

Table 2

Preliminary investigation vendors

PI Phase						
Criteria	**A**	**B**	**C**	**D**	**E**	**F**
Total Cost	$ 87,026	$ 226,321	$ 78,414	$ 84,393	$ 105,302	$ 36,750
Average Project Cost	$ 29,009	$56,580.25	$15,682.72	$21,098.20	$ 21,060.40	$ 6,125.00
Budget deviation justification	yes	yes	yes	no	yes/no	yes
# of projects	3	4	5	4	5	6
Average Duration of Projects	177	274	132.2	210.5	131.6	103.5
Complexity	5.0	6.3	5.0	5.3	6.9	5.0
% of SOW completed	100%	100%	100%	100%	100%	100%
Customer satisfaction	6.7	10.0	9.9	7.1	4.8	6.7

Table 3

Preliminary investigation vendors

Criteria	A	B	C	D	E	F
Data Collection	$ 13,000.00	$ 10,000.00	$ 4,000.00	$ 8,500.00	$ 15,000.00	$ 3,000.00
Work plan/Tech Memo	N/A	N/A	N/A	$ 9,600.00	$ 10,000.00	$ 6,400.00
Draft PI	$ 5,000.00	$ 10,000.00	N/A	$ 9,600.00	$ 10,000.00	N/A
Final PI	$ 6,000.00	$ 2,500.00	$ 3,420.00	$ 6,400.00	$ 4,902.00	$ 13,200.00
NFIA	$ 1,200.00	$ 6,500.00	$ 2,500.00	N/A	N/A	$ 6,400.00

The main purpose and benefits from this characteristic of the BV PMM are:

1. Increases efficiency of projects by letting people who are experienced and already know what to do, perform the projects.
2. Increase project performance by allowing the people who perform the work, to also identify what the project is and what the outcome of the project will be.

The PM's role now changes from the expert on a project to now ensuring that an expert is chosen to perform the work, and that the expert knows what to do to complete the project.

Minimized MDC

In the traditional project management model, management, direction, and control are a critical responsibility of the PM (PMI, 2000). This is due to the PM assuming the position of the expert (the PM taking accountability for the performance of the project). Now that the PM is utilizing expertise, the vendor now becomes the expert that will take accountability for the success of the project. Thus, the PM no longer needs to make decisions, manage, direct, and control, or think.

The main activities the State Agency PMs performed in MDC on a project were as follows:

1. Directing the vendor on what to do if something unforeseen occurred on the project.
2. Directing the vendor on how to carry out a deliverable for the project.
3. Reviewing the vendor's work and directing them on how to adjust it.
4. Explaining to the vendor why a part of their work is not acceptable.

Under the BV PMM the State Agency PMs were no longer responsible for any of the above activities. The responsibility for knowing what to do, how to do it, and ensuring that it was correct and acceptable was moved from the PM to the vendor. The vendor was still required to obtain client approval before any changes to the project were performed, but the vendor became responsible to bring the issue and the solution to the client and present the changes in a way the client could understand.

The BV PMM model recognizes that to an extent the State Agency PM and the client had information important to the project that the vendors did not have. Minimizing MDC did not mean the PM and client could not share information with the vendor. It only meant that the PM did not tell the vendor what to do and how to use the information. The State Agency PM only relayed information to the vendor when:

1. The vendor requests the information.
2. The vendor had identified their plan of action and the PM had questions or concerns with the plan or direction of the project.

The PMs were still allowed to review the vendor's work, but their role became an information source for the vendors instead of being responsible to identify what should be done or to correct the vendor's work.

The State Agency PM's responsibility became:

1. The client authority to approve changes to the project.
2. Provide client information to the vendor.
3. Identify any concerns with the vendor's plan.
4. Verify the vendor's plan is understandable.

The main purpose and benefits of this characteristic is as follows:

1. Moves accountability for the success of the project to those that perform the work (expert).
2. Requires the PM to be informed of all changes to the project.
3. Enables the PM to voice any concerns with the vendor's actions before any work is performed.

Non-technical communication

Previously, the State Agency PMs were responsible to understand the technical work of the vendor's due to their responsibility to make decisions and MDC. The BV PMM now required the PMs to ensure that whenever the vendor relayed information it was simple and non-technical. Instead of caring about the technical details of the vendor's work, they now cared that the vendor was able to explain what they were doing to people who had no knowledge of the project and the technical work being performed. The PM now became more concerned with how the vendor's work interacted and affected anything outside of the vendor's responsibility.

Technical information is identified as (Kashiwagi, 2015):

1. Requires technical training/education to understand.
2. Requires knowledge in a certain area to understand.
3. Detailed and complex.
4. Focused on the technical work instead of the impact and interaction the work will have on anything outside of the vendor's responsibility.

The BV PMM made certain the State Agency PMs were also responsible to ensure that any information exchanged between parties in a project was simple and understood by everyone. Thus, the PM became the mediator of information, ensuring that the client, vendor, and all stakeholders' relayed information that was non-technical.

During the first year of implementation, the State Agency PM's focus was on ensuring the following information was communicated in non-technical terms:

1. Client expectations and constraints.
2. Vendor progress and performance on projects; change orders required on projects.
3. Client administrative requirements.

The first step to developing an environment of non-technical communication was creating a simple way for performance expectations to be relayed. Two things occurred here, first expectations were developed, and second the expectations were not on the technical quality of work of the vendors, but on the overall expectations the State Agency had on all projects. This was performed by developing a short list of performance metrics that identified the State Agency's concerns. The State Agency's major concerns being:

1. The vendors do not complete all of the work on a project.
2. The vendors work is not satisfactory to the State Agency.
3. The vendors require excessive support from the State Agency.

Table 4 shows the list of metrics that were developed to relay to the vendors the State Agency's expectations.

Table 4

State Agency Baseline Metrics

No.	Baseline Metrics	Unit	Metric
1	Milestone Deliverables	#	
2	Revisions required on milestone deliverables	#	
3	Hours requiring State Agency Support	#	
4	Client Satisfaction	(out of 10)	

After the vendors understood the expectations of the State Agency, a reporting system was created that would ensure project progress and updates were communicated in non-technical information. The report that ensured this was called the Weekly Risk Report (WRR), which is an excel spreadsheet that the vendor filled out to document the project. The following is how it was used:

- Submitted weekly by vendor to the State Agency PM.
- Includes a weekly progress report pertaining to major deliverables, milestone schedule, risks that occur on project, risk management plan, invoice and price schedules, and a final report showing overall project progress and performance.

The WRR does the following for the State Agency PM:

- Alleviates the State Agency PM from remembering all the technical details of each project and what responsibilities the PM must do (see Table 5).
- Weekly informs the State Agency PM on progress and performance of project (see Table 6).
- Helps the State Agency PM perform quality assurance to make sure the vendor is doing what they said they would (see next section).
- Increases accountability of the vendor, requiring the vendor to be proactive and notify the State Agency PM, instead of the State Agency PM having to MDC the vendor due to not knowing what is going on.

The WRR contains the following sections:

- Project Setup Tab: basic information of project and contact information.
- Progress Report: a weekly report on the major activities the vendor conducted the week prior, and any major issues they believe the State Agency PM should be aware of.
- Schedule and Budget Tab: identifies the milestone schedule and any change orders on the project.
- Risks Tab: identifies all risk (what the vendor does not control) that is occurring on the project. It provides a description of the risk and how the vendor will manage it, date expected to resolve the risk, and impact to cost and schedule.
- RMP Tab: identifies the plan of the vendor's foreseen potential risks on the project and how they will mitigate and manage it, and an estimated impact to cost and schedule.

- Performance Metrics Tab: identifies the performance metrics the client wants the vendor to track, as well as any additional metrics the vendor tracks to differentiate themselves and show high performance.
- Invoice and Price Schedule Tab: identifies the cost break out of each major deliverable, and when and how much the vendor will invoice the client.
- Final Report Tab: identifies the initial cost and schedule, and reflects any deviation to it, as well as what party was responsible (vendor, client, unforeseen, other).

Table 5 shows an example of a milestone schedule that includes the major tasks on a project from beginning to end including stakeholder responsibilities. This helps the State Agency PM quickly see what the vendor expects from them, what major tasks are being completed, the progress of each task, and when they can expect final deliverables. Additionally, if a deviation occurs, the actual schedule quickly assists the State Agency PM to see if the critical path has been affected.

Table 5

State Agency Milestone Schedule

#	Activity	% Complete	Initial Schedule	Actual Schedule	Risk Sr.#
1	Start Ground Water (GW) Sampling	100%	03/02/16	03/02/16	
2	End GW Sampling	100%	03/30/16	03/22/16	1
3	Draft Monitoring Memo	100%	05/16/16	05/16/16	1
4	Monitoring Memo Comments	80%	05/23/16	05/23/16	1
5	Finalize Annual Memo	25%	06/10/16	06/10/16	1
6	TO Completion Date	81%	06/30/16	03/22/16	1

Table 6 is an example that shows a weekly progress report on all vendor activities relating to project completion and any upcoming State Agency responsibilities.

Table 6

Weekly Progress Report

Task Order Weekly Update History Log		
Week #	**Date**	**Notes**
1	2/5/2016	~ project administration ~ preparation for field sampling ~ laboratory coordination
2	3/11/2016	~ project administration ~ received TO#88 on 3/3/2016 ~ Conducted groundwater sampling ~ laboratory coordination
3	3/18/2016	~ project administration ~ received TO#88 on 3/3/2016 ~ Conducted groundwater sampling

4	3/25/2015	PDBs began being pulled and GW sampled on 3/21/2016. Some samples submitted to the laboratory for analysis. Vendor received an email on 3/22/2016 at 4:34 PM from State Agency that stated "Effective 3/22/16 please stop all work on the groundwater sampling for the following sites: Site 1: $42,600 Site 2: $39,700 Site 3: $46,800
5	4/8/2016	Final invoice sent 4/6/16, final WRR

The final area the BV PMM minimized technical communication was with the client relaying the bureaucracy of their administration processes and business procedures with the vendors. This encompassed the following business processes:

1. Submitting invoices to the State Agency.
2. Submitting change orders to the State Agency.
3. Documentation and updates of accurate budget projections.

One of the constraints many vendors have is their conflicting internal processes that are different from the client's internal processes. One of the methods the State Agency PMs used in order to overcome this issue was the following:

- Identified the internal processes the vendors need to become familiar with (invoice, change order, and budget projections).
- Mapped out their internal processes and simplified.
- Educated vendors on the three processes, and showed examples of how to use each one.
- Posted all internal processes online for vendors to easily access.
- Used the WRR as a mechanism to forecast budgets, invoicing, and change orders.

The invoicing process originally was lacking uniformity. Vendors submitted invoices to whomever the State Agency PM identified, which deviated from one department to the next. Figure 7 shows the adjusted system the State Agency put in place to create uniformity amongst vendors. All vendors were now required to submit their invoices to the accounting department for processing, and may copy their State Agency PM and business specialist for internal documentation. Once processed, the accounting office would notify the State Agency PM and/or business specialist of payment receipt.

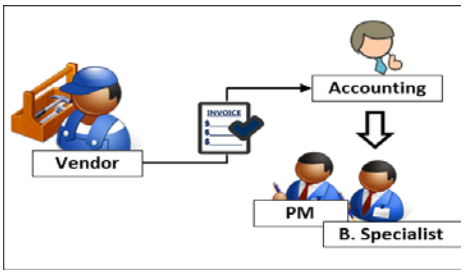

Figure 7: Invoicing Process.

Second, the State Agency did not have a simple way to track each change order and whether it was justified. Each change order was handled slightly different depending on the State Agency PM. In the new process (see Figure 8), there were four major steps:

1. Each vendor was required to fill out a pre-made one-page change order template that included impact to cost and schedule, and attach their WRR with proper justification documented.
2. Submit to the State Agency PM for approval.
3. The State Agency PM submits to procurement for processing.
4. Vendor receives payment.

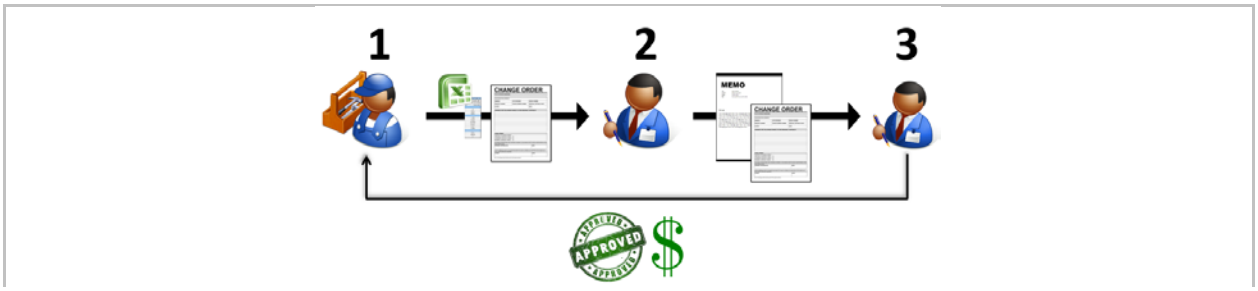

Figure 8: Change order process.

Lastly, in the traditional system, vendors were required to submit detailed time and materials cost breakouts that were confusing and difficult for the State Agency to compile for accurate budget projections. In the new system, vendors were required to simplify their time and materials to a price schedule which identified the major tasks on a project, cost of each task, and what month they would charge the State Agency. Table 7 shows an example of a simple price schedule.

Table 7

Price schedule

Task	Description	September 2015	October 2015	November 2015
	Project Management and Sub Markup	$950	$950	$913
Reporting Activities				
	Finalize PI Report; FY2015 data submittal	$4,895	$0	$0
PI Activities				
	Kengla bottled water	$300	$200	$140
	Groundwater sampling and analysis of 15 private registered exempt wells and up to 8 unregistered exempt wells; Preparation of technical memo; Hand deliver fact sheets; Identify additional drinking water wells	$9,000	$10,000	$5,481
	Database submittal FY2016 data	$0	$0	$2,850
	SUBTOTAL	***$15,145.00***	***$11,150.00***	***$9,384.00***
	BUDGET TOTAL			***$35,679.00***

Quality assurance

Due to the role change of the PM from a manager to a leader. The PM no longer needed to perform Quality Control (QC) activities. QC activities included:

1. Inspection of the vendor's work (Deming, 1982).
2. Explain to the vendor when work did not meet the technical standard and ensure that they fixed the work in a timely manner.

The elimination of the above activities made the State Agency PMs the most nervous. The main concern they had was: How do you ensure the vendor's work meets the minimal quality standards?

The BV PMM does this through quality assurance (QA). Quality assurance is ensuring that the vendor has a plan, is following the plan, reports deviations to the plan, and is documenting the performance of the project, throughout the entire project, not just at the end. If a client performs QA correctly, the vendor will always produce high quality work.

Quality Assurance includes the PM ensuring the vendor does the following:

1. Creates a plan for the project.
2. Has a quality control (QC) plan to ensure the quality of their work.
3. Has a way to ensure they meet their schedule and budget forecasts.
4. Can explain any deviations that occur to their work, quality, cost, or schedule.

The difficult part of this for the PMs is that they were used to being informed on the technical details of a project and how things were being performed every week. When their roll switched to QA and they received no technical information on a project the PMs became confused on what their function was.

Due to this confusion, training was developed for the PMs to help them understand how to perform QA. The following are the main QA activities and responsibilities that the PMs were required to perform:

1. Require the vendor to turn in a plan before they start working on a project. The plan included a scope of work, milestone and detailed schedules, price schedule and cost breakout, risk they do not control, risk mitigation and management plan, and performance measurements.
2. Understand and review the weekly risk report each week to ensure the plan is being followed.
3. Check any dependencies with related projects/activities and see whether deviations affect the critical path of the general plan.
4. Ensure vendor main deliverables are completed before payment is sent to the State Agency.
5. Compare the invoices of the vendors with their price schedules (budget projections).
6. Document and track all support and correspondence with vendors.
7. Ask questions whenever the PM is uncomfortable with any aspect on the project.

The following detailed steps and processes were developed for the PMs to help them understand how the above activities would help them know if the vendors were following their plan and were on schedule and budget:

1. Review of milestone schedule on WRR to identify progress of project.
2. Comparison of invoices to actual progress of projects.

3. Review of risk documentation on WRR to ensure change orders and adjustments to the project are justified.
4. Requesting of information from vendor before any approvals or changes are made.
5. Use of performance information to identify if a vendor is meeting expectations.

When the State Agency PM receives the vendor's WRR each week, one of the first QA activities is to look at the milestone schedule (see Table 8). The milestone schedule shows the State Agency PM's five major sections: major activities, percent complete, initial (baseline) and actual schedules, and any identified risks. There are only two major items of concern to the State Agency PM: what is the percent complete of the upcoming tasks, and is there any deviation in the actual schedule from the initial schedule marked by a risk serial number? If that is the case, they can immediately follow the risk serial number tracked in the risks tab, and now review a detailed plan on how the vendor will manage the risk, when they expect to complete it and what the potential impact to cost and schedule is. This minimizes the State Agency PM's communication with the vendor, by only focusing on any concerns they have regarding the vendor risk plan.

Table 8

Milestone schedule

#	Activity	% Complete	Initial Schedule	Actual Schedule	Risk #
1	Milestone 1	100%	11/25/14	11/25/14	
2	Milestone 2	100%	12/05/14	12/05/14	
3	Milestone 3	50%	1/25/15	2/25/15	1
4	Milestone 4	35%	2/10/15	3/10/15	
5	End Milestone 5	20%	2/26/15	3/26/15	

The second major QA activity the State Agency PM conducted was to compare the vendor price schedule with both the milestone schedule and submitted invoices (see Table 7, page 17). In the price schedule, the State Agency PM was able to quickly see which major tasks were going to be completed, for how much, and when the vendor would bill the State Agency. It was also the responsibility of the vendor to update and notify the State Agency PM if there was any deviation. This allowed the State Agency PM to quickly ensure the vendor was being efficient.

The third major QA activity (see Table 9) the State Agency PM conducted was to look at the risk tab in the WRR and verify the vendor had a simple plan that identifies a planned resolution date and impact to cost and schedule. This quickly allowed the State Agency PM to understand if the vendor was taking the most efficient steps to resolve the issue. The value of the risks tab was its ability to document all deviation and identify the responsible party. It was a tool to increase accountability and proactivity.

Table 9

Risks tab

Sr. #	Date Entered	Foreseen Risk	Risk Items	Plan to Minimize Risk	Planned Resolution Date	Actual Date Resolved	Impact to days	Impact to Cost	Entity Responsible	Client Satisfaction
1	3/22/2016	1	State Agency stops all work	1) PDBs began being pulled and GW sampled on 3/21/2016. Some samples submitted to the laboratory for analysis. 2) Vendor received an email on 3/22/2016 at 4:34 PM from State Agency that stated "Effective 3/22/16 please stop all work on the groundwater sampling for the following sites: 48th St & IS $42,600	3/22/2016	3/22/2016	0	$0.00	Client	1

The fourth major QA activity done by the State Agency PM after checking the vendor's WRR, was to identify any upcoming deadlines the vendor is close to and requesting milestone information from the vendor. It is the responsibility of the vendor to know when they should turn in information periodically to the State Agency PM before approvals or changes are needed, however sometimes the vendors do not. The WRR is a mechanism that aids in the protection of the State Agency PM to foresee any issues and minimize them before they become one.

Director's Report (DR)

To help the PMs and the management at the State Agency perform QA a Director's Report was setup to quickly compile the information in a format that enabled the State Agency to know the status of any project quickly. This report was created once a week, to ensure accurate information.

When all the WRRs were collected each week by the State Agency PMs, they were compiled into the Director's Report for upper management. The Director's Report is a flexible and simple excel spreadsheet that includes:

- Overview Tab: identifies the overall project performance (compiled budget, deviations, risks, change orders, and responsible parties).
- Discipline Tab: breaks each of the projects by major discipline and allows the State Agency to compare one against the other.
- Vendors Tab: identifies all vendor performance in terms of on time/on budget and compares them with each other.
- Budget Tab: identifies the entire water quality unit budget in terms of vendor budget, change order amount, budget spend rate and projected spend rate. High-level compilation of the water quality unit budget.
- Riskiest Tab: identifies the riskiest water quality unit sites and vendors in terms of number of unresolved risks that have occurred on the projects.
- Risks Tab: compilation of all the project risks in one tab that is easily sortable. Upper management can quickly review detailed explanations from identified sites in the riskiest tab.

- Progress Reports Tab: compilation of the projects last week of progress report entries. This allows management to see at a high level, what all the projects have been doing in the prior week.

The Director's Report was created to ensure all the projects are performing and can be easily seen together in one spreadsheet. Figure 9 shows the flow of the Director's Report. Every Friday, each expert vendor was responsible to submit an updated version of their WRR to PBSRG for compilation and copy their State Agency PM. After PBSRG compiled the DR, PBSRG would present it each Monday during a State Agency PM meeting to verify accuracy and identify any issues to be resolved. Following the PM meeting, the DR would be published on the State Agency PBSRG website.

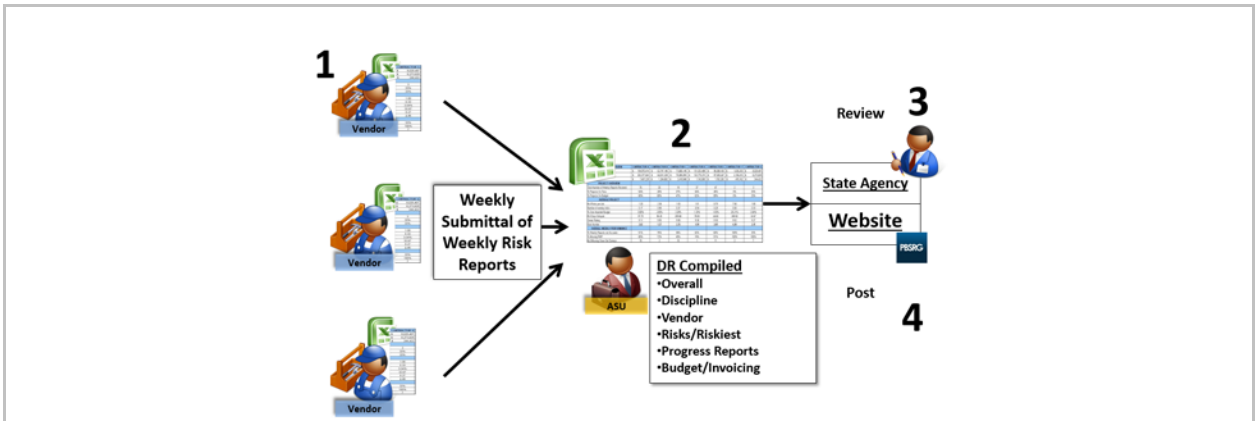

Figure 9: Director's Report Flow Chart.

Table 10 shows how upper management was able to use the DR to now identify the major criteria of on time/on budget and major cause of deviation very quickly and compare each vendor.

Table 10
Vendor's tab

Vendor	A	B	C	D	E	F	G
Original projects budget	$1,257,291	$150,329	$113,800	$1,212,500	$2,151,800	$287,529	$199,905
Original project duration	1568	624	597	1121	3589	1160	1023
Project Performance							
Total Number of Projects	6	4	5	5	15	7	5
Customer Satisfaction	8.0	6.3	4.8	9.9	9.2	9.6	8.0
% projects on time	83%	100%	80%	100%	100%	100%	40%
% projects on budget	100%	100%	100%	80%	100%	86%	100%
Average Project Performance							
% Over Awarded Budget	-0.29%	0.00%	0.00%	1.10%	-0.20%	1.37%	0.00%
% over budget due to Client	0.00%	0.00%	0.00%	1.85%	0.00%	0.00%	0.00%
% over budget due to Vendor	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% Delayed	4.96%	0.00%	4.80%	-3.25%	0.00%	-3.42%	7.53%
% Delayed due to Client	0.00%	0.00%	4.80%	-1.95%	0.00%	0.00%	6.65%
% Delayed due to Vendor	-0.36%	0.00%	0.00%	-1.30%	0.00%	-3.42%	0.00%

Additionally, Table 11 shows how upper management can quickly compare each of the vendor's costs, change orders, projected and actual spend rates, and vendor projection error rates with one another. This quickly allowed the upper management to spot any issues in their budget projections.

Table 11

Budget tab

Task Order	Discipline	Estimated Budget	Vendor FFP	Risk $$	CO	Actual Spent	Projected	Actual	Projection Error Rate
A	D3	$ 40,000.00	$ 39,838.90		$ (2,723.00)	$ 9,460.00	26%	24%	0
AA	D3	$ 50,000.00	$ 49,548.00	$ 16,546.00		$ -	52%	0%	1
AAA	D3	$ 250,000.00	$ 209,266.55	$ 13,375.00	$ 1,200.00	$ 72,915.58	30%	35%	1
AAAA	D3	$ 255,000.00	$ 432,975.20	$ 11,856.60		$ -	0%	0%	0
AAAAA	D3	$ 190,000.00	$ 287,176.50	$ 375.97		$ 22,221.00	7%	8%	1
AAAAAA	D3	$ 495,000.00	$ 238,487.84	$ 362,238.70		$ 6,343.00	3%	3%	0
		$ 785,000.00	**$ 1,257,292.99**	**$ 404,392.27**	**$ (1,523.00)**	**$ 110,939.58**	**117%**	**69%**	**3**
B	D1	$ 40,000.00	$ 39,750.00			$ -	0%	0%	0
BB	D1	$ 20,000.00	$ 12,346.00			$ 9,671.25	15%	0%	1
BBB	D1	$ 20,000.00	$ 12,346.00			$ 7,607.16	33%	0%	1
BBBB	D1	$ 20,000.00	$ 12,346.00			$ -	33%	0%	1
		$ 100,000.00	**$ 76,788.00**	**$ -**	**$ -**	**$ 17,278.41**	**81%**	**0%**	**3**
C	D3	$ 200,000.00	$ 452,000.00	$ 68,000.00		$ 37,340.00	100%	8%	
CC	D3	$ 243,000.00	$ 256,000.00	$ 30,000.00	$ 3,210.00	$ 46,840.00	100%	18%	
CCC	D3	$ 183,000.00	$ 209,000.00	$ 10,000.00		$ 6,585.00	100%	3%	
CCCC	D3	$ 50,000.00	$ 40,000.00	$ 5,000.00		$ 14,000.00	#DIV/0!	35%	
CCCCC	D3	$ 250,000.00	$ 255,500.00	$ 33,000.00	$ 22,700.00	$ -	#DIV/0!	0%	
		$ 926,000.00	**$ 1,212,500.00**	**$ 146,000.00**	**$ 25,910.00**	**$ 104,765.00**	**#DIV/0!**	**65%**	**0**

One of the final QA activities performed by the State Agency PM is to use the WRR and DR to differentiate between high and low performers (see Table 2 and 3). Table 2 and 3 are explained in the Utilize Expertise section on page 8.

Out of Scope Coordination

One of the major issues with the traditional project management approach was the lack of preplanning required from each expert vendor. Often a vendor and client PM would not know what to do on the project until they started the work in the field, and still would not know exactly what was required to fully complete the project (Fearnside, 1988; Filipovich, 2001; Esty & Porter, 2005; International Rivers, 2005; Macek, 2006; Rueters 2009; Bo-Jie, et al., 2010; Fu et al., 2010; Sood, 2011; Buntaine, et al., 2013; Fisher, 2013; IEG, 2013; Miller, et al., 2013; Padgett, 2014; AFP 2014; PBSRG, 2015). This caused a reactive state between the vendor and the client PM. This caused the State Agency PMs to do the following:

- Only work on vendor expectations when told by the vendor.
- Due to inability to know when vendor expectations were needed to be completed, many were delayed and increased costs.

Part of the BV PMM is for the expert vendor to identify "what is in" and "what is out" of their scope of work to the State Agency PM in the clarification meeting upfront before the contract is signed (see Figure 10). This will ensure the State Agency PM knows exactly what the vendor is expecting from all stakeholders, to include any coordination the PM must do in order to stay on schedule. The requirement for the State Agency PM to minimize MDC is to make sure the vendor tells them exactly what coordination and responsibilities they expect from the PM.

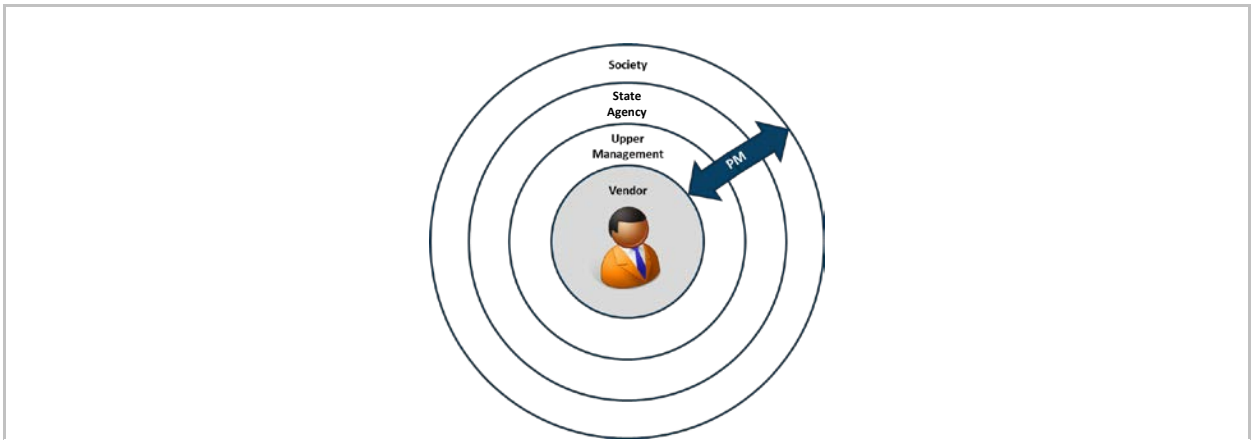

Figure 10: Vendor scope of work.

Major responsibilities for outside the scope of the expert's plan is the following:

1. Site access.
2. Community involvement.
3. Dealing with upper management.
4. Resolving any legal issues.

Site access is gained from a landowner, and can often take time and energy. It is typically out of the scope of the expert vendor to request site access from the landowner, therefore, it is important for the PM to ensure site access so work is not inhibited or delayed.

Another major responsibility for PMs is the coordination between multiple stakeholders regarding the community involvement meeting. The community involvement effort includes communication between the State Agency, the expert vendor, and local citizens and city officials, regarding the progress of each site. Delay in community involvement may impede on the progress of the site.

Each PM is also responsible for understanding the requirements upper management expects from each expert vendor, and must coordinate with the vendor on critical dates for deliverable submissions that will be reviewed by upper management to identify any concerns.

Lastly, any legal issues regarding any site will be the responsibility of the PM to coordinate meetings, discussions, and court hearings. The new role of the PM now becomes non-technical and supportive toward the vendor accomplishing their project on time, and on budget.

Transparency

Before the implementation of the BV PMM, the State Agency was having difficulty with the following:

- Identifying internal processes and project performance.
- Identifying and utilizing expertise.

- Identifying projected spend rates of program budget.
- Upper management knowing the performance of their PMs.

Using the traditional project management approach, the State Agency was having difficulty with creating transparency and making things simple. This increased the amount of communication and MDC of internal management and external management of expert vendors.

The BV PMM, was able to help the State Agency create an environment of transparency and increase the accountability by producing the following:

1. Developed a custom website to post all project information and performance.
2. Developed a custom project report, called the Weekly Risk Report (WRR), which measures deviation of each project in terms of cost and schedule.
3. Developed a custom management report, called the Director's Report (DR) (see Figure 9), which is a compilation of all water quality unit project performance, prioritizes the projects by risk, budget [spend rate and change orders], and internal reports interpreted from collected data.

Benefits of the new transparent structure:

1. All stakeholders can easily access each other's documentation and performance.
2. Provides the State Agency management team with accurate vendor performance and water quality unit budget.
3. Provides full access to all BV education and project documentation.
4. Updated the task order selection process with documented performance information.
5. Worked with water quality Business Specialist to simplify water quality unit budget that assisted upper management in financial decision making.
6. Created a dispute system that uses ASU as a non-bias third party to help facilitate and resolve any issues or confusion raised by vendors.
7. Adjusted and simplified change order process. Created new documentation for change order approval and documentation.
8. Simplified invoice process, and educated water quality project managers on system. It also began to identify vendors who were not invoicing the State Agency quickly, and how their project managers could minimize it in the future.

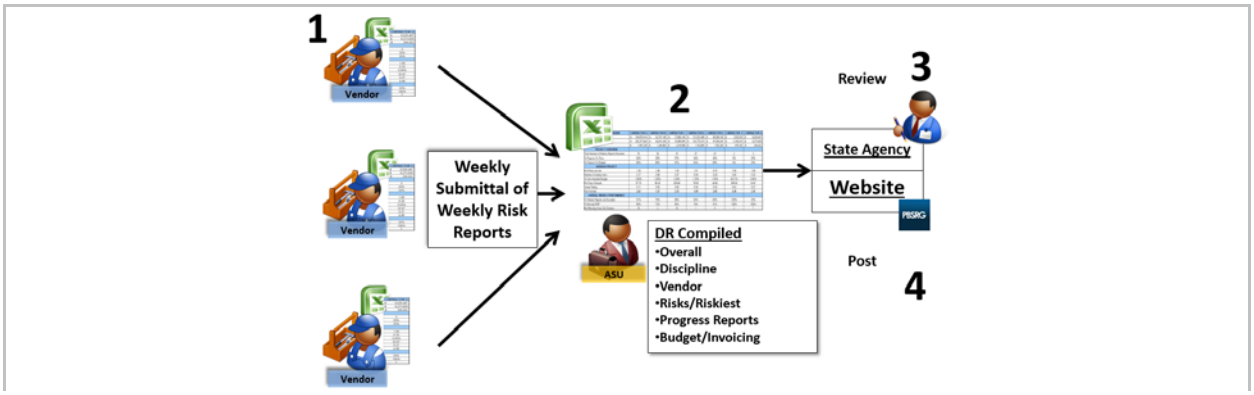

Figure 9: Director's report flow chart.

As stated in the Quality Assurance section on page 18, Figure 9 shows the flow of the Director's Report, which is a compilation of all project WRRs. It is a unique and simple management tool to quickly determine the progress and performance of all projects in one location.

Creating efficient internal processes

One of the major issues the BV PMM identified was that all the major stakeholders within the State Agency were in silos. Neither silo coordinated with another, which caused the following issues:

1. Programmatic functions were complex.
2. Management and PMs needed a method to streamline the invoice and change order processes.
3. Most of the silos had their own interpretations of internal protocols, and each acted in their own best interest.
4. Management needed a third party non-bias representative to help answer and resolve vendor issues and complaints.
    a. Ensure the State Agency is in alignment and vendors are best serving the taxpayers.
    b. Ensure both parties are not being cheated.

Once the projects began work during late November 2014, management became aware that their internal invoice and change order processes were not well understood or practiced by all the silos. In order to resolve this issue, PBSRG did the following:

- Worked with the business specialist in the water quality unit, the State Agency PMs, and procurement officers, to identify the current understanding of each party's interpretation of the processes.
- Identified the major components needed by each party.
- Streamlined the processes and mapped out the new processes.
- Presented the new process to each party and received final approval from management to adjust the old process to the new streamlined process.
- The State Agency has not had any new issues regarding the flow of either process since it was corrected.

During the course of the FY14-15, management needed a way to communicate with the vendors to help answer and resolve any issues that arose. PBSRG acted as the third party, and helped the State Agency by the following:

- Used the BV PMM as a logical framework to identify issues and complaints.
- Assisted the State Agency in using performance information to resolve issues and complaints.
- Documented all proceedings and posted online.

As long as both the vendor and the State Agency used PBSRG as a third party channel to resolve issues, each party was fairly treated and came to positive resolutions. The opposite also remains true.

Windfall Effect of Transparency

With the change of Governor in 2015, the State Agency's budget was heavily scrutinized. The water quality unit being the largest unit at the State Agency, was under the most pressure by the Governor's office to spend the entire budget, with a threat of receiving budget cuts. Up until FY14-15, the water quality unit has only spent up to 50% of their budget, and have had a constant uncertainty to the amount it would receive each fiscal year. The water quality unit needed a way to show their entire budget could be entirely spent for future funding opportunities. In order to help the State Agency, achieve this goal, PBSRG did the following:

- Required all vendors to submit price schedules in their clarification documents for accurate budget projections. Placed the price schedule in the WRR for weekly updates.
- Helped the water quality unit business specialist [person in charge of water quality unit finance tracking] develop a simplified budget overview.
- Customized the Director's Report to include a high-level budget overview of the entire water quality unit budget. It also included an updated monthly spend rate and projections to end of fiscal year.
- The DR previously only tracked the majority portion of the water quality unit budget.
- When the entire water quality unit budget was incorporated into the DR within the first three months, the State Agency noticed they were able to accomplish a budget projection spend rate of 100%.
- This was also the first time the State Agency was able to see the entire water quality unit budget on one screen in an understandable form.
- It was also the first time all the PMs were able to see the progress and budget of all the projects in one spreadsheet.

Within one month following the new transparent water quality unit budget, the State Agency identified the following:

- The State Agency overspent. There was not enough money left to cover basic expenses if they continued with their plans.
- Needed to begin de-scoping projects immediately, in order to recover enough money to cover expenses.

In order to assist the State Agency with this new impending issue, PBSRG did the following:

- Held a meeting with water quality unit management to discuss a logical progression of steps.
- PBSRG identified the water quality unit must first identify a priority list of projects.
- PBSRG identified the water quality unit will need to speak with vendors on the lower priority list in order to identify what could be de-scoped without affecting the progress of their work.
- Educated vendors on accuracy of price schedules, in order to accurately identify the amount needed to de-scope lower prioritized projects.
- Created comparison reports of all project costs on one sheet.
- PBSRG compiled reports and presented to the State Agency's water quality unit, and identified the vendors were not cheating the State Agency.

- The State Agency was satisfied with the reports and costs of all projects.

Following the initial comparison reports, the State Agency decided to empower its PMs to select work they felt was not needed to be completed in the upcoming FY15-16, and began telling vendors to de-scope it. This led to the following issues:

- The State Agency did not have a priority list of projects for targeted de-scoping.
- The State Agency implemented MDC to de-scope what work on the project they felt was not important.
- Vendors became highly upset with the State Agency for not utilizing their expertise to identify what should and should not be de-scoped on their projects.
- Vendors claimed the State Agency caused them to do more work from de-scoping work that was needed in order to complete baseline milestones.
- Vendors identified how they lost faith in the best value process, due to the State Agency overriding it and replacing the utilization of expertise with MDC.

Despite the State Agency overriding the best value process and implementing MDC to cause the vendors more work, the overall program fared well with high performance to compensate for the latter.

BV PMM Case Study Results

Table 12 identifies the transformation of government, after 8 months (November 2014 – June 2015) of implementing the BV PMM on the water quality unit IDIQ contract. One of the major accomplishments was the State Agency's ability to spend the entire budget, which has never been done in its history (PBSRG, 2016).

Table 12

Paradigm shift

Traditional PMM	**Best Value PMM**
MDC	Utilize Expertise
Technical	Non-Technical
Communication	No Communication
No Pre-planning (reactive)	Pre-planning (proactive)
Complex	Simple
Quality Control	Quality Assurance
No use of metrics (trust)	Use of metrics (no trust)
Relationships	No Relationships
Non-transparent	Transparent
Spent up to 50% of budget	Spent 100% of budget
Lack of vendor accountability	Increased vendor accountability
Inability to filter out non-experts	Process to filter out non-experts
Inability to track and measure project performance	Measures internal and external performance (DR/WRR)

The water quality unit Manager, identified the BV PMM as a success. Due to the State Agency's Lean initiative to introduce new models like the BV PMM, it helped support the improvement of internal processes and create transparency. Table 13 compares the overall performance of the State Agency's traditional and best value implementations. Although the State Agency attempted to implement the BV PMM on their projects, management, direction, and control was still a factor. The BV PMM approach assisted the State Agency with the following:

- Reduced the amount of preparation needed to select and monitor vendors.
- Reduced the risk of the State Agency's management, by implementing a decision-less structure to identify the level of the expertise of competing vendors.
- Forced the expert vendor to become accountable and identify their level of expertise.
- Required the expert to make things simple enough that even non-experts can understand.
- Required the expert vendor to take control over their project, which was to their benefit in the end by reducing client MDC.

Table 13

Overall State Agency Performance

No.	Criteria	Traditional	Best Value
1	Total # of projects	69	60
2	Total cost of projects	$5.5M	$5.6M
3	% of projects SOW completed in fiscal year	50%	99%
4	# of State Agency PMs to manage projects	7	5
5	Customer satisfaction of vendor performance	6.9/10	8.4/10

*Data was adjusted due to project de-scoping (24 projects, $1.2M (17.32%, 355 days (10.14%). State Agency PMs were reduced by 2, due to leaving State Agency.

Tables 14 shows the overall water quality unit program performance. After 8 months of implementing the BV PMM, the author identified the following dominant observations:

- State Agency PMs increased work capacity by 22%.
- Vendors performed 102% more work in 33% less time.
- State Agency customer satisfaction increased by 22%.

Table 14

Detailed Project Breakout

Detailed Project Performance	Metric
% Over Awarded Budget	0.17%
% over budget due to Client	0.30%
% over budget due to Vendor	-0.13%
% Delayed	-0.95%
% Delayed due to Client	-0.09%
% Delayed due to Vendor	-0.86%

Consistent with the documented results of numerous BV PMM implementations in the past, Table 14 identifies the cause of budget deviations where primarily due to the client (though

minimal), despite MDC minimization. Even though the vendors still experienced client MDC, they overall performed better than in previous years and had a budget and schedule deviation rate of less than 0%.

Analysis

This research effort is using the deductive approach (confirmatory) instead of the inductive approach (exploratory). The success of the State Agency Unit implementation was determined by measurements of observation, which minimized subjectivity as much as possible.

The following lessons were learned when implementing the BV PMM:

1. BV PMM system is difficult to implement in an organization.
2. Need to have visionaries in the organization to become successful.
3. You cannot expect people to change.
4. The structure (rules and metrics) are critical.
5. Transparency creates vision and people doing the “right” thing.
6. Project manager of the future is a leader who aligns resources and utilizes expertise.
7. WRR was a significant tool used to help create transparency on all task orders.
8. Education is an important element in assisting environmental professionals to use the BV system.
9. Requiring vendors to pre-plan and explain their plan from beginning to end in the clarification period is the most important time in the BV system.
10. The BV documentation and website helps to minimize blame and quickly resolve issues.
11. The risk from the BV system is political and not environmental service related. The political risk is from individuals who are not ready for change to become more efficient.

The BV PMM has identified the following observations:

1. Best value application has been a total success by providing transparency.
2. Third party expertise (PBSRG | ASU) should be utilized.
3. Expertise lowers costs and increases performance.
4. An expert vendor can accurately identify a projects scope and cost.
5. Measurement brings transparency and minimizes decision-making.
6. BV PMM has been identified by the State Agency as a proven method to transform its agency’s environment from a management, direction, and control to a best value, alignment, win-win, and leadership based environment.
7. A visionary core team has been organized that is optimal in terms of a high-ranking visionary leader, and visionary project management and procurement components.
8. For the first time, strategic plans have been developed by the State Agency to increase government funding for future fiscal years based on the successful BV PMM implementation results.

Conclusion

The State Agency is implementing an advanced and theoretically sound best value project management model (BV PMM) to transform the traditional approach of project management from a price based to a best value environment. The major objectives included minimization of management, direction, and control, the transfer of risk and control to vendors who can minimize the risk, measurement of performance of the vendors and the State Agency, and to measure an increase in performance and value of the services being delivered. A core group of visionaries are attempting to transform the organizational approach from one of management of personnel to a systems management, where performance measurements drive alignment of resources. This BV PMM has aligned well with the State Agency's ongoing internal process improvement initiatives.

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Important Causes of Delayed Projects in Saudi Arabia vs. PIPS: A University Campus Case Study

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Saudi Arabia has been facing issues with completing construction projects on time and on budget. It has been documented that 70% of public construction projects are delayed. A case study was performed, at a University campus in northern Saudi Arabia, identifying the major causes of project delays. The University was experiencing delays from 50% to 150%. The delay factors were gathered from the University Projects Director. The University delay factors were then compared to delay factors experienced on Saudi construction projects, identified by performing a literature research. The comparison identified nine causes of delays that both studies documented. The study also proposes a solution to minimize the nine major delay factors. A literature research identified one construction management method, the Performance Information Procurement System (PIPS), has documented multiple times its ability to improve project performance and minimize delays.

Keywords: Project delay, public construction, Saudi Arabia, Best Value, PIPS.

Introduction

"What matter are not budget figures, but what they represent in reality as quality projects and services that people can feel and enjoy." That is what King Abdullah, the Custodian of the Two Holy Mosques, said after Saudi Arabia's financial plan was released on Dec. 23, 2014 (*Arab News*, 2014). Saudi Arabia has been experiencing a construction boom for the past three decades. The construction industry is considered to be a big business, estimated to be worth more than $3.9 trillion yearly worldwide (Jackson, 2010). The estimated nearly investment budget for the Saudi construction industry from 1990 to 2000 was $234 billion (Albogamy, Scott, & Dawood, 2013). In 2011, nearly $147 billion was at stake because of nonperforming public projects (*Arab News*, 2011). On the other hand, the Saudi Ministry of Finance allocated about $48 billion for 2,330 projects in 2013 alone. In 2014, the government expected to launch projects worth a total value of more than $66 billion (*Arab News*, 2014). However, the majority of public projects are not completed, and the chronic delays that beset most public projects make Saudi citizens uncertain about the likelihood they will gain any utility from these projects (*Arab News*, 2014). According to Assaf and Al-Hejji (2006), 70% of public projects were delayed in Saudi Arabia. Are delayed projects a new phenomenon in Saudi Arabia? In 1983, Zain Al-Abedien reported that 70% of projects were delayed when the Ministry of Housing and Public Works was responsible for them. Since that time, Saudi Arabia has suffered from project postponement problems. The university campus being used as a case study is considered to be one of these projects. This campus is located in Northern Saudi Arabia and was established in 2005. It has been under construction since 2006.

Problem

The university campus should have been completed in 2012. However, only two buildings of the university campus are operational, despite the fact that, as of 2015, there are 22 buildings in the execution phase. As a result, the percentages of delayed construction were from 50–150%. The stakeholders of university made decisions to solve the problems that were causing delayed projects and slowed construction performance at the university campus.

Methodology

This study depended on a literature review to explore essential factors that caused delays in public construction projects in Saudi Arabia. A stakeholder at the university was interviewed to learn about the delay factors from an owner's perspective. After that, the delay factors at the university were compared with important delay factors around the country, which were collected from extant literature. The comparison showed the important factors that causes of delay projects at case study campus. The study then explained how the Best Value Performance Information Procurement System (BV PIPS) worked. Finally, the results of the study showed that the important delay factors could be solved by using PIPS.

Research Hypothesis and Questions

BV PIPS help solve important delay factors in Saudi Arabia.

1. What are the important delay factors in public projects in Saudi Arabia?
2. What causes delayed projects at the university?
3. What is the relationship of the delay factors in Saudi public projects to the university's projects?
4. How can PIPS mitigate the causes of delayed projects in Saudi Arabia?

Objectives of the Study

1. Show important delay factors in public projects in Saudi Arabia.
2. Find the causes for delays in projects on the university campus.
3. Show how delay factors at the case study university are classified within what was found in the literature review.
4. Show how PIPS can deal with important delay factors to improve project performance in Saudi Arabia.

Literature Review

Because of the high number of previous studies, there is a large amount of data related to delayed projects. According to Al-sultan (1987), 70% of Saudi public projects faced time overages. Al-Barak (1993) reported that poor estimation practices and a shortage of skilled contractors cause project delays. Also, he believed that the national economy's stagnation was a factor that caused

delays (Al-Barak, 1993). In 1999, Al-khalil and Al-Ghafly performed research to find the causes of delays in Saudi public utility projects. They investigated among owners, consultants, and contractors to determine who was responsible for project delays. They found that about 60% of projects begun between 1985 and 1994 were delayed. The owner and the consultant often blame the contractor for the project delays. Conversely, a contractor often accuses the owner and consultant of delaying the project (Al-khalil & Al-Ghafly, 1999). Likewise, delayed projects impact both the owner and contractor. The owner loses revenue because of the uncompleted project, which forces him or her to rent temporary premises. Contractors also incur overhead costs because delayed projects keep them from getting another project (Assaf & Al-Hejji, 2006). Other studies mentioned that government departments, as owners of public projects in Saudi Arabia, are affected by the disruption of public development plans, the financial execution plan, and community annoyance caused by the delay of particular projects. Whereas, a contractor is influenced through; increasing period of project, increasing overhead cost, and hindering contractor of finding another business opportunity (Al-Kharashi & Skitmore, 2009). All parties aim to complete construction projects on time. However, many previous studies found major factors that affected the performance of organizations working on construction projects. Al-Karashi and Skitmore found about 112 factors responsible for project delays. They also obtained about 39 more factors from respondents in their study. The authors found 131 total factors, which are listed in the appendix (Al-Karashi & Skitmore, 2009). So, here in this study classified the related causes in four levels: owner-related causes, contractor-related causes, consultant-related causes, and other-related causes. An intensive review of significant, frequent factors that had appeared in previous studies about the Saudi Arabia construction industry was then made.

Owner-Related Causes

Owners play an active role in reducing project delays. Therefore, project period is considered to be a delay factor. Owners often cannot predict how long projects will take (Albogamy et al., 2013; Al-khalil & Al-Ghafly, 1999; Mahamid, 2013). Extension time is one of the owner-related delay factors. The owner approved extension time on 87% of projects (Al-khalil & Al-Ghafly, 1999). In addition, owners postpone making progress payments to other parties, which becomes another delay factor (Albogamy et al., 2013; Al-khalil & Al-Ghafly, 1999; Al-Kharashi & Skitmore, 2009; Al-Mudlej, 1984; Al-Sedairy, 2001; Al-Subaie, 1987; Hazmi, 1987; Mahamid, 2013). Another study found that project orders changed by the owner disrupted contractors' schedules, causing project delays (Albogamy et al., 2013; Assaf & Al-Hejji, 2006). Also, reviewing and approving project documents were mentioned as factors leading to the postponement of projects (Assaf & Al-Hejji, 2006). Also, suspension work in construction projects by the owner affects the project's performance (Al-Kharashi & Skitmore, 2009; Assaf & Al-Hejji, 2006). Also, a tendering system can be considered a significant factor that leads to the success of projects. Lowest bidding, which is the system applied in most Middle East countries, is also considered a reason for the prevalence of project delays in Saudi Arabia (Albogamy et al., 2013; Al-khalil & Al-Ghafly, 1999; Mahamid, 2013). Table 1 shows owner-related factors.

Table 1

Important Owner-Related Delay Factors

No.	Owner-Related Causes of Delay
1	Unrealistic project Period
2	Extension of Time
3	Postponing Progress Payments
4	Changes in Project Orders
5	Failure to Review and Approve Project Documents
6	Suspension Work
7	Lowest Bidding Practices

Contractor-Related Causes

Al-Barak noted that the main causes of contractors' failures were skill shortages, poor estimation practices, and poor decision-making (Al-Barak, 1993). Project duration is also a contractor-related delay factor when the contractors have poor planning and scheduling skills (Albogamy et al., 2013; Al-khalil & Al-Ghafly, 1999; Mahamid, 2013). Qualified contractors may prevent project delays because of their experience, knowledge, and ability to field a trained workforce (Al-khalil & Al-Ghafly, 1999, Assa & Al-Hejji, 2006). Assaf and Al-Hejji (2006) found many factors related to contractors, such as conflicting views about subcontractors' schedules in project implementation and poor subsurface conditions. Some contractors do not expect the worst things that could happen on the worksite, for instance, a high water table. Other recent studies found that a lack of experience and a shortage of manpower are major causes of project delays (Al-Kharashi & Skitmore, 2009; Assaf & Al-Hejji, 2006). Poor site management and supervision are also considered factors in the previously mentioned studies in addition to Mahamid's (2013) study, which has many other negative effects on the construction industry. Moreover, when a contractor has cash flow problems, it will naturally affect the project's completion (Albogamy et al., 2013; Al-khalil & Al-Ghafly, 1999; Al-Kharashi & Skitmore, 2009; Assaf & Al-Hejji 2006). Table 2 contains contractor-related factors.

Table 2

Important Contractor-Related Delay Factors

No.	Contractor-Related Causes of Delay
1	Shortage of Skilled Workers
2	Poor Estimation Practices
3	Making Poor Decisions
4	Project's Duration
5	Contractors' Qualification
6	Conflicts with Subcontractors' Schedules
7	Poor Subsurface Conditions
8	Lack of Experience
9	Manpower Shortage
10	Poor Site Management and Supervision
11	Cash Flow Problem

Consultant-Related Causes

The previous studies revealed that some of the delay factors can be linked to a consultant. According to Assaf and Al-Hejji (2006), a consultant is responsible for project delays by producing design documents and reviewing and approving design documents (Albogamy et al., 2013; Assaf & Al-Hejji, 2006). Moreover, consultants are connected with diverse factors that cause project delays, such as failing to find mistakes and discrepancies in design documents and rigidity about deals (Assaf & Al-Hejji, 2006). In addition, consultants need to have high levels of experience in order to perform their roles. Projects also often require hiring of a number of consultants (Albogamy et al., 2013; Al-Kharashi & Skitmore, 2009). Table 3 shows consultant-related factors.

Table 3

Important Consultant-Related Delay Factors

No.	Consultant-Related Causes of Delay Factors
1	Failure to Produce (or Producing Faulty) Design Documents
2	Failure to Approve Design Documents
3	Mistakes and Discrepancies in Design Documents
4	Dealing Rigidly
5	Consultant Performance
6	Inadequate Number of Consultancy Employees

Other Causes

It is hard to classify some factors under the three main categories of owner, contractor, and consultant. For example, a delay in material delivery is considered a factor that has a degree of impact on project duration (Assaf & Al-Hejji, 2006). In construction projects, although it is difficult to coordinate among construction parties, communication and coordination increase the project's chances of success. Conversely, increasing rework—doing a job more than one time—reduces project schedule control (Mahamid, 2013). Table 4 contains other factors that delay projects.

Table 4

Other Important Delay Factors

No.	Other Causes of Delay
1	Material Delivery Problems
2	Communication and Coordination Failures
3	Rework

The literature review showed that there are 27 significant, frequent factors that cause delays in construction projects in Saudi Arabia. There are six factors related to the project's owner, nine factors related to contractors, nine factors related to consultants, and four others that cause of delays in Saudi public projects.

Interview of the Owner at the Case Study University (CSU)

In an interview with the director of department of projects at the CSU was conducted on 14-15 March, 2015 via Skype. It was discovered that of a total of 22 projects at the university, 17 were delayed. There were also 15 projects under construction on the university campus. There are another eight projects that are currently in the design stage. However, the planned operation of the university campus should have begun in 2012. Conversely, two buildings were operational until 2015. Hence, the percentages of delay in overrun time at the university were between 50% and 150%. It was also found that 99% of the university projects overran projected costs. So, the delay of construction projects at the university was caused by many factors that have links to the owner, contractors, consultants, and other factors.

Owner-Related Causes at the CSU

It is obvious that there is no clear vision for projects. Also, there were only incomplete ideas when the university planned its construction projects. As a result, most of the university's projects do not reflect reality. There are huge projects with unrealistic requirements. Because of this, after a contractor delivers a building, it is found that its design is not appropriate for use, which happens because the designers had been controlled by the owner during the design stage. In addition, 88% of the university's projects are not well thought out, and these projects' budgets do not correspond with their design requirements. Consequently, when selecting a contractor, the owner often makes the decision to remove some work from the project in order to get the contractor price closer to the budget. The owner will find someone to complete these works later. This action delayed projects at the university because the removed works were based on work being done by the first contractor. For example, the first contractor may need the air duct system to be completed, which is removed from first contractor's works to another bid, to install a false ceiling. Consequently, the tendering system takes a long time to sing with a contractor and adds to the difficulty of governmental proceedings. Other factors are also related to the owner.

Contractors who want to obtain university projects must have classifications from the Ministry of Municipal and Rural Affairs. There are five classes, and each class shows the highest financial limit within the contractors' abilities. Owners may also make the decision to prevent low-class contractors from partaking in the competition by merging similar projects into one tender. However, that method increases the projects' sizes, which limits the university's ability to monitor them. Additionally, it is clear that there are poor organization within the project management department. Although there is no ability to manage many projects simultaneously, it is clear that there are many too many projects to progress through the implementation process. In addition, some delayed projects were found to need approval in order to use a particular system. However, the holder of authority was not a specialist, which led to slow approval. Also, the owner's employees were responsible for delaying projects at the university because they delayed progressive payments to the contractors. Table 5 shows owner-related delay factors at the CSU.

Table 5

Owner-Related Delay Factors in the CSU

No.	Owner-Related Causes of Delay at CSU
1	Lack of Vision
2	Design Requirements Do Not Reflect Reality
3	Designer is Controlled by Owner
4	Lack of Project Budget
5	Wrong Decision-Making by Owner
6	Not Following the Conditions Solidarity Among Contractors
7	Inadequate Project Management Department
8	Late Review and Approval of Design Documents by Owner
9	Changing Consultant During Implementation
10	Delay in Progress Payments to Contractors

Contractor-Related Causes at the CSU

The literature review found that one common delay on university projects was poor contractor performance. One project is separating itself from its contractor because of poor performance, the contractor's lack of qualifications, and a conflict among company partners. Withdrawing from a construction project sometimes requires procedures that can take up to ten years to complete. In addition, another contractor-related factor is a lack of experience. Although contractors must review the proposal and inform the owner about items that are not mentioned in the proposal, contractors and consultants discovered many items that were not mentioned in the project proposals but were uncovered during implementation. Besides, despite contractors have about two months after selecting a contractors and before signing contracts, the contractor do not utilize that time for reviewing proposals to find any luck of works. Moreover, most contractors on the university's projects lacked project-management skills. For example, risks that could cause damage to projects were not clear to some project managers. The size of these projects often exceeded the contractors' ability. In addition, some contractors had too many projects, and that affected their ability to finish projects on time. Also, contractors suffered from a shortage of manpower. Additionally, contractors delayed the payment of salaries to their laborers, which delayed projects when the laborers stopped working. Table 6 shows contractor-related factors at the CSU.

Table 6

Contractor-Related Delay Factors in the CSU

No.	Contractor-Related Causes of Delay at CSU
1	Poor Contractor Performance
2	Conflict Among Company Partners
3	Contractor's Inadequate Qualifications
4	Lack of Contractor Experience
5	The Proposal Was Not Studied by the Contractor
6	Contactor Lacked Project Management Skills
7	Ability of Contractors
8	Concurrent Projects
9	Shortage of Manpower
10	Delayed Payment to Laborers

Consultant-Related Causes at the CSU

Poor consultant performance was also one of the causes of delay at the CSU. Some consultants would like to extend their contract with the owner and, therefore, delay projects. Hence, some works were suspended by the consultant without a convincing reason. In addition, another delay factor is that many mistakes are often discovered in the blueprints during the implementation stage. Also, it is found that there is lack of consultancy employees and that causes delay construction at the university. However, when the consultants' contracts have been finished and the projects have been delayed, the university's owner has resorted to contracting with an international consultant for all of the university's projects, which will save about $8 million, as opposed to contracting with more than one local consultant. In addition, when the owner contracts with one consultant for all campus projects, it reduces the extension of contracts for each project on campus if one of these projects is delayed. However, when a new consultant begins work, he or she is faced with some difficulties, such as the fact that most construction is already underway and that he or she needs time to understand what is going. Table 7 shows consultant-related factors at the CSU.

Table 7

Consultant-Related Delay Factors at the CSU

No.	Consultant-Related Causes of Delay Factors at CSU
1	Sub-par Consultants
2	Delay Projects to Extend His/Her Contract with Owner
3	Lack of Consultancy Employees

Others Causes of Delay at the CSU

Others causes of delay are some factors that are not related to the three construction parties. Bidder procedure was one of the factors delaying university projects. Also, some parts of the procurement system are not clear, which makes employees spilt projects into multiple stages, which causes delays. Additionally, there are a large numbers of projects around Saudi Arabia that lack the necessary materials. For example, one contractor could not supply granite because there was high demand for it from contractors. Moreover, new regulations from the Ministry of

Labor caused a shortage of manpower, as opposed to older regulations that helped contractors find manpower easily. Table 8 contains other delay factors at the CSU.

Table 8

Other Delay Factors at the CSU

No.	Other Causes of Delay at the CSU
1	Material Delivery Problems
2	The Bidder System
3	Unclear Procurement System
4	New Worker Regulations

The results showed that there were 27 factors that delayed projects at the university. These factors were shown from the owner's perspective. Of the 27 delay factors, nine were owner-related, 10 were contractor-related, four were consultant-related, and four others were also found at the university.

Data Analysis

The previous study found 131 delay factors. In addition, there were 27 important factors that delayed public projects in Saudi Arabia. An interview was conducted with owner of the CSU, and that interview revealed 27 delay factors that delayed projects at the university, with a rate ranging between 50% and 150%. When the university delay factors were compared with important delay factors in Saudi Arabia, it was found that nine delay factors from the CSU matched important delay factors in Saudi Arabia, as shown in Figure 1. The nine important delay factors are shown in Table 9.

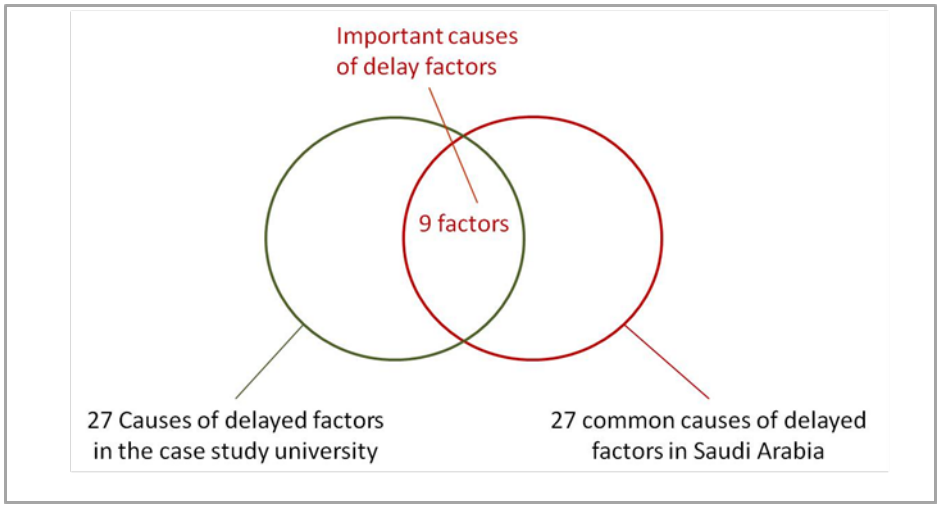

Figure 1: Comparison of the case study university's delay factors with those found in the literature review

Table 9

Important Delay Factors at the CSU

No.	Important Causes of Delay at the CSU	Related to
1	Late in Reviewing and Approving Design Documents	Owner
2	Delay in Progress Payments to Contractors	Owner
3	Poor Contractor Performance	Contractor
4	Contractor's Lack of Qualifications	Contractor
5	Lack of Contractor Experience	Contractor
6	Shortage of Manpower	Contractor
7	Lack of Consultancy Employees	Consultant
8	Material Delivery Problems	Other
9	Bidder System	Other

Definition of Best Value Approach and Performance Information Procurement System (PIPS)

BV PIPS was created at Arizona State University (ASU) in 1991 as part of his PhD dissertation. BV PIPS utilizes expertise in all aspects of life to minimize risk and increase performance through the use of logic and common sense. BV PIPS relies on a special workplace environment that minimizes decision-making, management, direction, and control (Kashiwagi, 1991, 2010). PIPS has been tested over 1,800+ times on $6.3 billion in project value ($4 billion in construction projects and $2.3 billion in non-construction professional service projects), with a 98% success rate in six different countries and 31 states. PIPS increases a project's efficiency and performance while minimizing risk compared to the low-price bid. The PIPS process consists of four phases: pre-qualification (optional), selection, clarification, and execution, as shown in Figure 2.

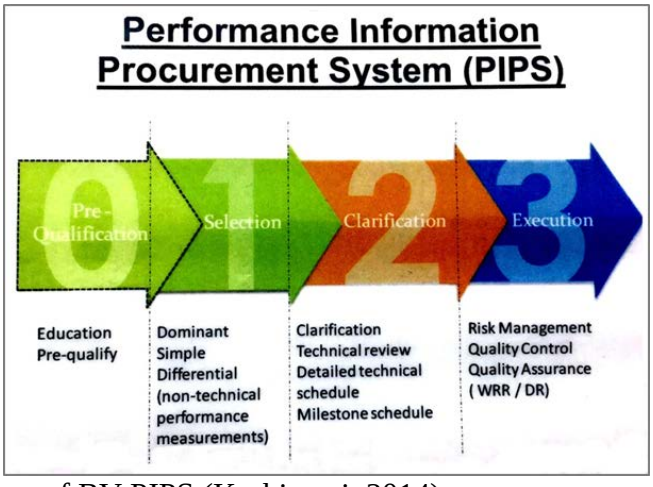

Figure 2: The four phases of BV PIPS (Kashiwagi, 2014).

- Pre-qualification phase: This phase is optional. The pre-qualification phase educates vendors about BV PIPS and how to submit performance information via metrics.
- Selection phase: There are four filters to find the Best Value vendor for a project. In filter 1, vendors should submit their price and project capability, which consists of three documents:

level of expertise (LE), risk assessment (RA), and value added (VA). Additionally, each of these documents should be a maximum of two pages. Filter 2 is an interview filter to determine the vendor's expertise. It should be used to interview those who will do the work, such as the project manager, to see if he/she can see into the future. The interview assists the committee in determining if a vendor has a clear vision for the work. This interview should be as short as possible. In Filter 3, the committee prioritizes criteria, giving weighing them a specific amount. Weighting could use percentages or numbers from 1–10. Filter 4 is a dominance check to find the BV vendor who provides lowest cost and information to minimize risk.

- Clarification phase: The vendor should clarify their offer and plan. Moreover, this phase should show what is outside of the project's scope and simplify the proposal to be clear about what will be done and what will be accomplished. The vendor should submit a detailed technical schedule and a milestone schedule. In this phase, the owner and vendor should clarify everything related to the project.
- Execution phase: During implementation work, the vendor should submit a weekly risk report (WRR) and a director's report (DR). The WRR is submitted as an Excel document that outlines the project's pathways and any deviation from the initial plan in terms of cost, time, and quality. In addition, this report provides a milestone schedule, risk management plan, and performance measurements. The DR consists of a set of multiple WRRs and details for each vendor's performance and any risk that needs attention.

BV PIPS vs. Important Delay Factors in the Case Study in Saudi Arabia

This study shows that there are nine important delay factors that can be considered common to projects in Saudi Arabia. However, these nine important delay factors can be solved via BV PIPS. This analysis shows that BV PIPS can deal with these delay factors, as shown in Table 10.

Table 10

How BV PIPS Can Solve Important Delay Factors in Saudi Arabia

Important Causes of Delayed Projects in Saudi Arabia (CSU)	**Treating the Important Causes of Delayed Projects**					
	BV	**Performance Information Procurement System (PIPS)**				**How the Solutions Prevent Delay Factors**
		P-Q	**S**	**C**	**E**	
Bidder System (Low Price)		√	√	√	√	PIPS Relies on Performance
Poor Contractor Performance			√	√		Level of Experience, Interview, Risk Assessment
Lack of Experienced Contractors			√			Level of Experience, Interview, Risk Assessment
Shortage of Manpower			√			Risk Assessment,
Contractor's Qualifications		√	√			Qualification of Vendor, Level of Experience
Material Delivery			√	√		Risk Assessment, Show Plan B
Approval of Design Documents by Owner	√					Creating Best Value Environment
Delay in Progress Payments to Contractors	√		√	√		Creating Best Value Environment, Risk Assessment
Lack of Consultancy Employees			√			Experience of Vendor Mitigates Factor

BV: Best Value Environment in Organization **P-Q**: Pre-Qualification **S**: Selection **C**: Clarification. **E**: Execution

The first of these delay factors is the bidder system, which based on lowest price. This factor can be solved by changing the bidder system to PIPS, which uses many phases to select the highest-performing vendor who is the best value. PIPS is a procurement system that relies on performance to find the best value vendor, contrary to the current bid system in Saudi Arabia that relies on lowest price.

The second and third delay factors are poor contractor performance and lack of experienced contractors, which can be solved in the selection phase of PIPS. This phase has many filters that determine the level of vendor experience. Also in this filter, vendors should submit risk-assessment documents that show the vendors' capability to see risks that could affect projects and how the vendor can mitigate risks. Moreover, the interview with the people who will do the work—or the project manager—will show if vendors have poor contractor performance or lack experience. The interview assists owner to recognize if contractors have clear vision of projects. Additionally, poor contractor performance can be reduced by implementing the clarification phase. In this phase, a vendor who has already been selected clarifies their offerings and planning process. The vendor should identify the scope of the work and submit a detailed technical schedule and a milestone schedule. That will show if the vendor can complete the work.

The fourth delay factor is shortage of manpower, and that should be clarified in the risk assessment as a risk. Vendors should show how they can deal with this problem in the selection phase.

The fifth delay factor is a contractor's qualifications, and that can be solved in the pre-qualification phase that informs vendors about Best Value and shows them that BV PIPS relies on performance and how they must check their level of performance through numbers and matrices. In addition, during the selection phase, the vendor's experience level is discovered, which solves the contractor's qualification delay factor.

The sixth delay factor is material delivery, and that can be solved in the selection and clarification phases. Risk assessment documentation in the selection phase should solve this delay factor. Expert vendors can see this problem and provide a plan B if necessary. Also, in the clarification phase, vendors should give detailed plans to show how they can mitigate the material delay factor.

The seventh and eighth delay factors are the approval of design documents by the owner and delay in progress payments to the contractors. These two delay factors can be solved via building a Best Value environment within the organization. Best Value depends on penalty principles related to common sense. Best Value decreases management, decision-making, and control by utilizing expertise and increasing transparency. These are principles that assist owners in utilizing expert opinion to increase the approval rate of design documents. When an organization increases transparency and decreases control, the organization's progress increases, which solves delays in progress payments to contractors. Also, expert vendors will identify this problem as a risk in their risk assessment documents during the selection phase and clarify it in clarification phase, which assists in the solution of delays in progress payments to contractors.

Finally, the ninth delay factor is a lack of consultancy employees, and this problem is solved in the selection phase. In this phase, the owner finds an expert vendor who has a high performance level and can complete works that already prove his or her abilities during the selection phase. So, expert vendors do the work well, which reduces the need for consultancy employees.

Conclusion

Important delay factors, which caused delays to projects in Saudi Arabia, can be solved via the application of BV PIPS. Most importantly, delay factors are solved through phases. These phases have many filters that help owners find good vendors based on their performance. These filters prevent delays in the construction of public projects in Saudi Arabia by using only select, high-quality contractors. Nine important delay factors were found by comparing important delay factors found in a literature review with those found at the CSU. One of these factors is the low bidder system, which caused the delay of many projects in Saudi Arabia. So, when the bidding system is changed to PIPS, it will prevent other delays from happening. Seven of these important delay factors can be prevented when the level of experience and risk assessment documents are submitted via vendors. This study introduces BV PIPS to stakeholders at the CSU to implement PIPS in the CSU projects.

Appendix

Client-related causes of delay

1. Owner's interference
2. Owner's personality
3. Negotiation by knowledgeable people
4. Delay in progress payments by owner
5. Late in revising and approving design documents by owner
6. Poor coordination by owner with the various parties during construction
7. Excessive bureaucracy by owner's administration
8. Clarity of scope of change
9. Delay in the settlement of contractor claims by owner
10. Poor coordination by owner and other parties
11. Conflicts between joint-ownership of the project
12. Delay to furnish and deliver the site to contractor by owner
13. Difficulties in obtaining work permits
14. Variations in quantities
15. Suspension of work by owner
16. Delay in approving sample materials by owner
17. Delay in approving shop drawings by owner
18. Uncooperative owner with contractor complicating contract administration
19. Delay in issuance of change orders by owner
20. Owner's failure to coordinate with Government authorities during planning
21. Non-payment of contractor claim
22. Interference by owner in the construction operations
23. Poor communication by owner and other parties
24. Lack of finance to complete the work by client
25. Slow decision making by owner
26. Owner's poor communication with construction parties and government authorities
27. Key personal replaced

Contractor-related causes of delay

28. Rework due to errors during construction
29. Delay in site mobilization
30. Internal company problems
31. Company organization
32. Other work on hold
33. Loose safety rules and regulations within the contractor's organization
34. Ineffective scheduling of project by contractor
35. Cash flow management
36. Improper construction methods implemented by contractor
37. Inefficient quality control by contractor
38. Increased number of projects
39. Increase in contractor's overheads

40. Poor site management and supervision by contractor
41. Delays in sub-contractors' work
42. Delay in the preparation of contractor submissions
43. Improper technical study by contractor during the bidding stage
44. Ineffective planning by contractor
45. Ineffective contractor head office involvement in the project
46. Replacement of key personal
47. Delay of field survey by contractor
48. Conflicts between contractor and other parties (consultant and owner)
49. Conflicts in sub-contractors' schedules in execution of project
50. Contractor's poor coordination with the parties involved in the project
51. Inadequate contractor's work
52. Poor communication by contractor with the parties involved in the project
53. Poor communication by contractor with other parties
54. Poor coordination by contractor with other parties
55. Difficulties in financing project by contractor
56. Ineffective control of the project progress by the contractor
57. Frequent change of sub-contractors because of their inefficient work
58. Frauds
59. Inefficient Work-break down structure
60. Poor qualification of the contractor's technical staff
61. Contractor experience

Consultant-related causes of delay

62. Delay in performing inspection and testing by consultant
63. Delay in approving major changes in the scope of work by consultant
64. Poor coordination between consultant and other parties
65. Poor communication between consultant and other parties
66. Late in reviewing and approving design documents by consultant
67. Inflexibility (rigidity) of consultant
68. Company organization
69. Replacement of key personnel
70. Conflicts between consultant and design engineer
71. Frauds
72. Internal company problems
73. Inadequate experience of consultant

Materials-related causes of delay

74. Delay in materials delivery
75. Late procurement of materials
76. Damage of sorted material while they are needed urgently
77. Changes in materials prices
78. Changes in materials specifications
79. Shortage of materials required

80. Late in selection of finishing materials due to availability of many types in market
81. Shortage of construction materials in market
82. Delay in manufacturing special building materials

Labor-related causes of delay

83. Low productivity level of labor
84. Shortage of contractor's administrative personnel
85. Personal conflicts among labor
86. Nationality of labor
87. Inadequate equipment used for the works
88. Shortage of technical professionals in the contractor's organization
89. Shortage of equipment required
90. Failure of equipment
91. Shortage of supporting and shoring installations for excavations
92. Low productivity and efficiency of equipment
93. Low level of equipment-operator's skill
94. Lack of high-technology mechanical equipment
95. Shortage of manpower (skilled, semi-skilled, unskilled labor)
96. Poor qualification of the contractor's technical staff assigned to the project
97. The required labor skills are not available
98. The required equipment and tools are not available
99. Low skill of manpower

Contract/relationships-related causes of delay

100. Ineffective delay penalties
101. Unavailability of incentives for contractor for finishing ahead of schedule
102. The objective of the project is not well defined
103. Legal disputes between various parties
104. The scope of work is not well defined
105. Type of construction contract
106. Conflict between contract documents
107. Type of project bidding and award (negotiation, lowest bidder)
108. Inadequate definition of substantial completion
109. Lack of communications between the parties
110. Original contract duration is too short
111. Inappropriate overall organization structure linking all parties to the project
112. Major disputes and negotiations

Others

113. Quality management system and assurance control
114. The consultant attempting to hide their mistake when the quantity amount changes
115. Insufficient allowance for employees' holidays in the schedule
116. Inadequate original contract duration

117. Lack of clarity of drawings and specifications
118. Client need to analyze the causes of change
119. The lack of experienced engineers engaged by consultants for high-tech work
120. Insufficient numbers of contractors to build the increasing number of construction projects in Saudi Arabia
121. Insufficient consideration of the behavior of people
122. Lack of regular meetings
123. Unclear scope of work to be done by staff contractors
124. High turn-over of personnel in Saudi Arabia
125. Insufficient study of all the details and capacity of the contractor before selection by client
126. Overdependence on the lowest tender amount in contractor selection
127. Discrepancies between bill of quantities, specifications and drawings
128. Level of salary of consultant staff
129. Lack of ethics
130. Delayed salary payments to staff
131. Designer engineer selection of special building materials not available in the local market.

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