Data analytics to improve engineering project management office (PMO) performance: The predictive analytics approach [1]

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Abstract

Due to the amount of resources organizations invest in projects and programs, there is a growing emphasis on benefits management as a powerful tool to align projects, programs, and portfolios to the organization's strategy. To boost performance, the organization often undergo business model restructuring as a results of constant environmental changes and competitive globalized markets. Project management office (PMO) and their performance in relation to improve organizational performance is important to achieve strategic goals and increase value of projects in organizations. Project-based information through analytics can permit project managers and executives to measure, observe, and analyze project performance objectively and make decisions and commitments based on facts.

In the 21st century , the high availability of analytical technology can enable project and program managers to use various analytical reports and drill-down charts to break down complex project data and predict their behavior and outcomes in real-time. The objective of this research is to investigate the application of data analytics , tools and technieques to improve project management office performance ensuring that the organisations achive its desired benefits that are mostly absent in today projects and programs. With the huge amount of data available , ensuing requirements for Artificial Intelligence and good machine learning techniques, new problems arise and novel approaches to feature engineering techniques are in demand.

Keywords: Data analytics, Project management office (PMO), Benefits realization

Introduction

According to Russom (2011-7), a data-driven analytics approach enables project teams to analyze the defined data to understand specific patterns and trends which can be used by executives , for analysis to determine how projects and resources perform and what strategic decisions they can take to improve the project and programs success rate. According to Zikopoulos and Eaton (2011-21), an effective project management involves operative management of uncertainty on the project which requires the project managers to use analytical techniques to monitor and control the uncertainty as well as to estimate project schedule and cost more accurately with analytics-driven prediction. Kambatla, Kollias, Kumar and Grama (2014-2562) said that analytics-based project metrics can essentially enable the project managers to measure, observe, and analyze project performance objectively. Tsai, Lai, Chao and

[1] How to cite this paper: Budeli, L. (2021). Data analytics to improve engineering project management office (PMO) performance: The predictive analytics approach. *PM World Journal*, Vol. X, Issue III, March.

Vasilakos (2015-22) said that analytics enables projects teams to analyze the captured data to understand certain patterns or trends. Effective management of projects necessitates efficient management of the uncertainties and risks on the project which requires today's project managers to use analytical techniques to monitor and control the risks as well as to estimate project schedules and costs more accurately with analytics-driven prediction.

Research method

Empirical research is based on observed and measured phenomena and derives knowledge from actual experience rather than from theory or belief. The key characteristics to look for are specific research questions to be answered,definition of the population, behavior, or phenomena being studied, description of the process used to study this population or phenomena, including selection criteria, controls, and testing instruments. The figure below shows the empirical research method followed in this study.

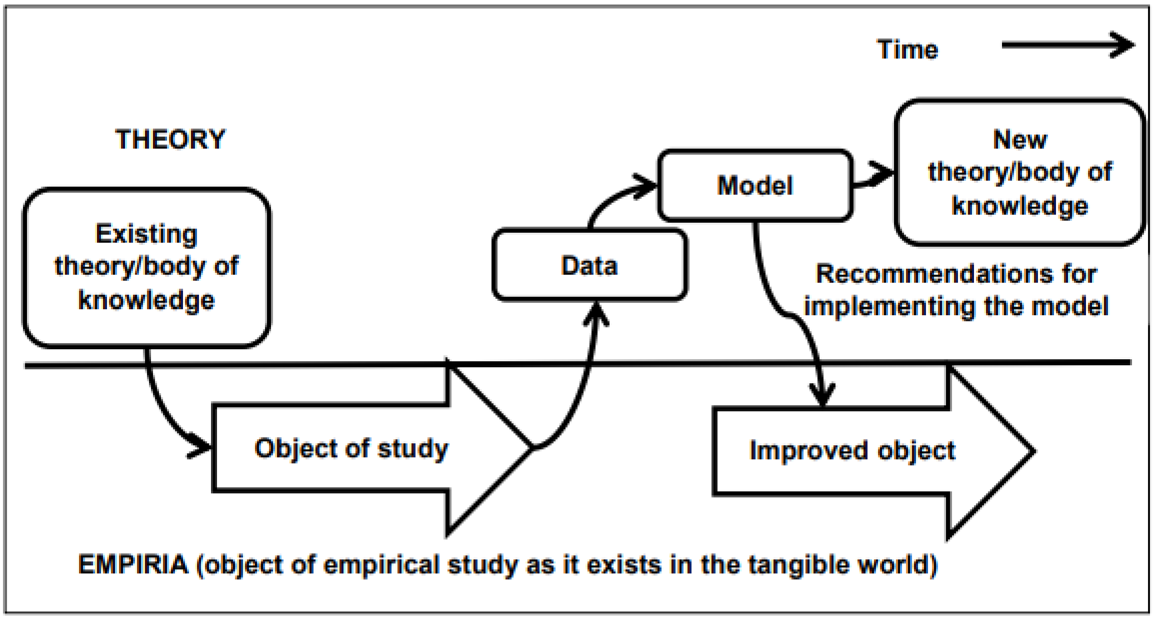

Figure 1 Empirical research study

Existing theory (Body of knowledge)

According to LaValle, Lesser, Shockley, Hopkins and Kruschwitz (2011-28) , the Iron triangle of the project management office (PMO) is people, processes and technology. In traditional terms, the sayings represent the three constraints on a PMO which are people, processes and technology. This like the project management triple constraint or the iron triangle, it is often taught as the iron triangle because if one shifts, one of the other sides must also shift in order to stay balanced. For example , a company can use the lattest technology and not hire very knoledgeble project manager thinking that the technology will correct all issues. The other company may make significant investments in creating the process but then not hire enough project managers to complete the process, but the company will then question the value of each investment.

Process

According to Larson (2018-182), most organizations have some sort of governance (process) that is documented and many times, these consist of templates and mandates of which documents are completed and when. Companies create templates and mandate the completion of the templates in order to address lack of information or quality of information that they receive during project reviews. Batra (2018-262) supposed that an investment in the process is a key factor in the creation of a successful PMO. Saeed and Ahmed (2018-252) said that a data-driven analytics approach enables teams to analyze the defined data to understand specific patterns and trends through out the PMO. Bragen (2018-134) said that organizations must not just invest in templates and mandates but should make sure they invest to educate the executives on the value of project management and the value of the proper process of project management. Ravikumar and Sadhwani (2020-4) said that the other key to proper process is to ensure the right amount of governance in projects.

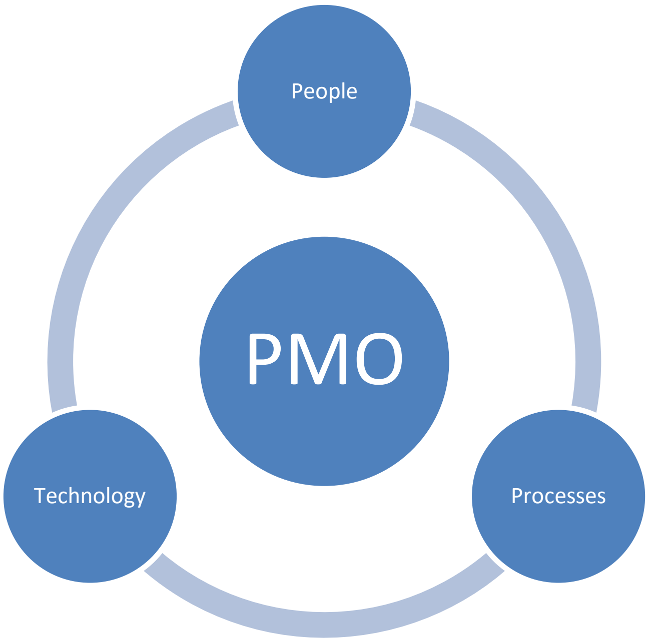

Figure 2 Standard PMO process

People

According to Wamba, Gunasekaran, Akter, Ren, Dubey and Childe (2017-360) , right people in the right positions in a project make a tremendous difference in the quality of project management. Saeed and Ahmed (2018-252) said that projects should be run by trained project managers who have both knowledge and experience to execute the entire project scope. Brijs (2018-194) said that it is important to have enough people to complete the demand for project management which forces companies to select project manager that is fit for purpose, however, if the work is completed with poor quality or the results are not satisfactory , the project manager values are questioned and not the people performing the task. Bucero (2018-63) indicated that if project management is important to a company , they need to invest in project managers because claiming that you do not have the funds to hire a qualified project manager and then turning over the duties to someone who costs three times as much is not only a waste of money, it provides poor quality.

Technology

LaValle, Lesser, Shockley, Hopkins and Kruschwitz (2011-30) said that technology such as clarity, microsoft project, planview, primavera, daptiv, task, and others are all great tools but, they do not solve project management process or people issues. Zikopoulos and Eaton (2011-25) indicated that they will make poor processes run faster or expose the lack of quality of information which are compliance tools that help make company processes and people efficient. Kambatla, Kollias, Kumar and Grama (2014-2567) said that companies must invest in technology that will enable the organization to enforce compliance, each roles data builds on the other roles, and provides key decision metrics to executives. The technology should be invested in that streamlines the process, stops duplicate entry of information, is the single source of the truth, and provides value add activity. Tsai, Lai, Chao and Vasilakos (2015-28) said that if you are entering the same information into three different systems or the system that you are entering information in is not the single source of the truth, then we are adding cost for process, not for results.

Data analytics modeling

According to Larson (2018-189), data analytics is defined as the systematic quantitative analysis of data or statistics to obtain meaningful information for better decision-making which involves the collective use of various analytical methodologies not limited to statistical and operational research methodologies, Lean Six Sigma, and software programming. Jamil and Carvalho (2019-49) indicated that highly complex applications usually utilize sophisticated algorithms based on statistical, mathematical, and computer science knowledge. Saeed and Ahmed (2018-250) indicated that project portfolio analysis is a useful application of analytics which involves evaluating a large number of project proposals and selecting and prioritizing the most viable ones within the constraints of organizational resources and other relevant factors. Bucero (2018-63) said that organizations select projects carefully after complete assessment of each candidate project's feasibility based on the organization's project selection criteria, which might include, but not be limited to, the following factors:

- Economic, legal, technical, political, capacity, and capability constraints
- Cost-benefits analysis using financial models such as Net present value (NPV), Return on investment (ROI) , breakeven analysis and payback period
- Resource requirements which can be external or internal or both
- Training requirements
- Project complexity

- Project risks

According to Zikopoulos and Eaton (2011-31) , data modeling evaluates how an organization manages data and use techniques in data modeling like an entity relationship diagram (ERD) to explore the high-level concepts and how those concepts relate together across the organization's information systems. Brijs (2018-204) said that data dictionary that details the field by field the pieces of information we need to store in the database to meet the features or to implement this business process change. A data map that shows how we're going to move data from one system to another, or how we're going to integrate and make those systems talk to each other on an ongoing basis to make a feature or business process available to our community. There are 4 areas Data analytics can be used at the project management office (PMO)

Use 1 – Learsons learned

Data analytics can be used to transform data into furture insight which will help PMO forecast future outcomes based on historical data and analytics techniques. Tereso, Ribeiro, Fernandes, Loureiro and Ferreira (2019-23) indicated that predictive analytics is aimed at making predictions about future outcomes based on historical data and analytics techniques such as statistical modeling and machine learning will generate future insights with a significant degree of precision. PMO can now use past and current data to reliably forecast trends and behaviors milliseconds, days, or years into the future. Throughout a project's life cycle, we learn lessons and discover opportunities for improvement. Documenting lessons learned helps a project team discover both strengths and weaknesses. It provides an opportunity for team members and/or partners to discuss successes during the project, unintended outcomes, and recommendations for others involved in similar future projects. It also allows the team to discuss things that might have been done differently, the root causes of problems that occurred, and ways to avoid those problems in later project stages. The figure below indicate how knowledge from lessons learned can be applied by PMO.

Figure 3 Application lessons learned knowledge application by PMO

It is important for PMO to have a process to follow to ensure that lessons learned are carried over to fuature projects for continuous improvement because , if we fail to learn from our own mistakes or those of others, we tend to repeat the mistakes. This study discusses lessons learned as important ways of gathering and sharing both formal and informal project knowledge.

Current PMO challenges

- Data is not achieved properly - Capturing lessons learned should be done throughout the life of the project and should encouraged by the project manager. Lessons learned can be used to prepare current projects or for recognizing project management process improvements. Project teams must learn from project successes as well as project failures. If project teams do not learn from project failures , they are doomed to repeat similar mistake in furture. If they do not maximize on project successes, we miss opportunities to implement good processes and practices to successfully complete existing and future project.

- Data accessibility - Data or information is the driving force for almost all of today's business decisions. Project management office (PMO) tools and processes must ensure that access to project data is available when needed. To maximize project team performance and make decisions quaker, project teams must be able to aggregate and correlate data without having to navigate through complex security controls. Decisions about people, processes, and technology are influenced by innovation, compliance and risk, but these drivers can often be in conflict.

- No efforts to find data using data analytics - Data analytics refers to the process of examining datasets to draw conclusions about the information they contain. Data analytic techniques enable project teams to take raw data and uncover patterns to extract valuable insights from it. Data analytics techniques use specialized systems and software that integrate machine learning algorithms, automation and other capabilities.

Use 2 – Project success criteria

If PMO do not measure data, how can they manage or optimize their project management processes? Project effective management entails efficient management of the uncertainties and risks on the project which requires project managers to use analytical techniques to monitor and control the risks as well as to estimate project schedules, duration and costs accurately using analytics-driven prediction. Project data analytics enable project managers and executives to measure, observe, and analyze project performance objectively and make decisions and commitments based on facts. The high availability of analytical technology can enable project managers to identify features of successful project using historical project data and which will assist to predict their behavior and outcomes in real-time. Features can be project management process, planning steps and and type of clients.

Using data analytics in projects and programs will ensure that PMO continuously deliver successful projects which will (1) meet business requirements, (2) are delivered and maintained on schedule, (3) are delivered and maintained within budget, and (4) deliver the expected business value and return on investment. Effective project management and governance practices are particularly critical for the success of the project , but data analytics can be an engine for PMO to take decisions that are factual , only based on objective evidence ensuring that organisational scares resources are used correctly.

Use 3 – Predicting project risk

Project risks are problems with a probability of happening and PMO have to manage those risks. Project risk management entails managing the risk by identifying , monitoring and by controlling it. The most common types of project risk that needs to be predicted by PMO are technical risk, finicial risk and operational risk. Data analytics in projects is an emerging tool which helps in analyzing the unstructured and real time data in large volume, velocity and viriaty. PMO can use predictive analytics to sift through current and historical data to detect trends and forecast events and conditions that should occur at a specific time, based on supplied parameters. When PMO use predictive analytics, organizations find and exploit patterns contained within data in order to detect risks and opportunities. Predictive analytics makes looking into the future more accurate and reliable than previous tools assisting PMO to develop risk triggers to predict upcoming problems.

Use 4 – Feature engineering

Feature engineering is the process of using domain knowledge to extract features from raw data via data mining techniques which can be used to improve the performance of machine learning algorithms. It is the first step in developing a machine learning model for prediction and it involves the application of business knowledge, mathematics, and statistics to transform data into a format that can be directly consumed by machine learning models. The data science team builds features by working with domain experts, testing hypotheses, building and evaluating machine learning models, and repeating the process until the results become acceptable by PMO. Data analytics capabilities allow PMO to collect and process high volumes of complex data to deliver valuable strategic insight which will lead to significance improvemence toward the success of fuature projects. This also assist project manager to improve their decision marking , high custermer service and run a more effitient operations. It also determine what information should be gathered on a project identifiying the type of data that will help us to predict the performance of a project.

Development of new model

According to Singh, Ram and Sodhi (2013-3), value is delivered to organisations through ensuring that the project/program meets the appropriate conditions for its benefits to be realised. In this age of “big data,” the ability to derive meaning from a sea of numbers is becoming more and more valuable to project success and business development.

New theory (body of knowledge)

Data plays a significant role in any organization. Using analytics, management can watch for early signs of slippage in terms of budgets, costs, and timelines and take proactive action, assisting managers capture the rate of work, so that they can easily predict whether the project will be completed on time. Project Management Office (PMO) data analysis is a core requirement to fine-tune process, establish accurate prioritization, and lead the team in fulfilling the schedule and strategy. The Figure below shows a PMO that uses data analytics to improve engineering project portfolio benefits realisation management

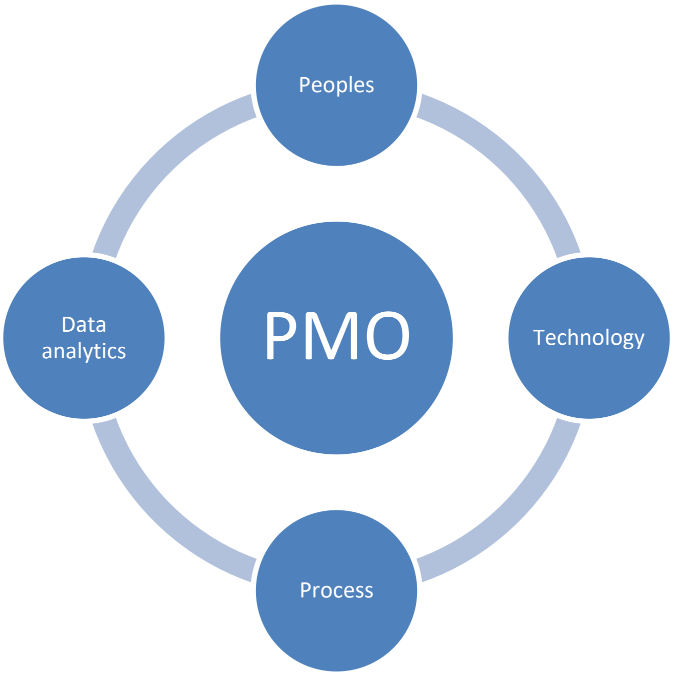

Figure 4 Data analytics qpplication in PMO

Benefits realisation management

According to Larson (2018-192) , A PMO is uniquely positioned and well equipped to add significant organizational value by focusing on effective benefits realization management techniques. Bucero (2018-73) said that a PMO is uniquely positioned and well equipped to potentially add significant organizational value by focusing on effective benefits realization management techniques. Zikopoulos and Eaton (2011-37) indicated that benefits realization mapping enables the identification and analysis of benefit dependencies and linkage. This critical practice helps PMOs evaluate and understand how benefits will be achieved; how benefits elements are linked to key project and program processes, inputs and deliverables; and the associated linkage between desired outcomes, strategic goals and overall milestones.

Project management process re-engineering

A PMO is a function within an organization that defines the standards for project management. The main purpose of a PMO is to make sure that projects and programs are run in a repeatable, standardized way. A PMO is a function that provides decision support information, although it doesn't make any decisions itself. It is the backbone of a successful project management approach at an organization and underpins the project delivery mechanisms by ensuring that all business change in an organization is managed in a controlled way. A very basic level PMO supports the project management teams, and the people make decisions about funding, prioritization and resourcing. The most mature PMOs provide governance, transparency , reusability, delivery support and traceability. The figure below show a basic PMO framework linking goals to outcomes.

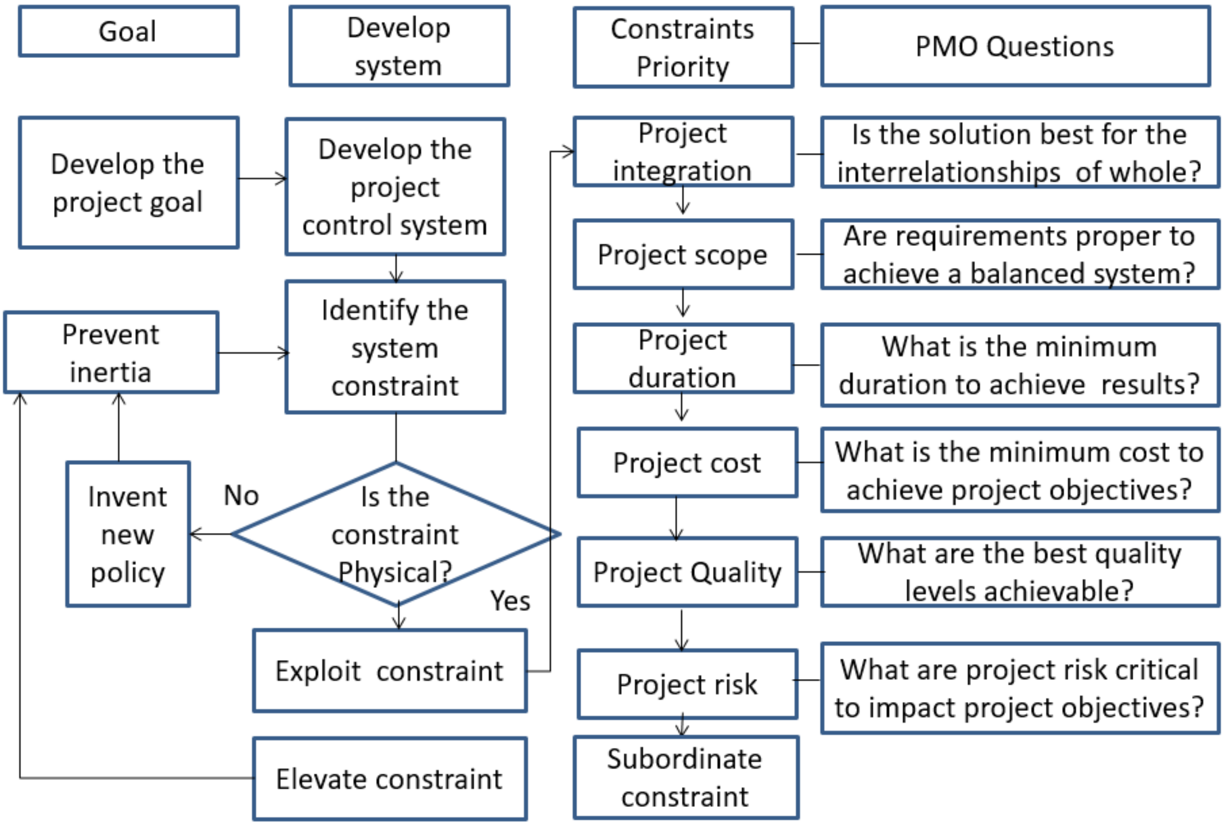

Figure 5 Data analytics Linking organisational goals to project outcomes through constraint management

There are a lot of benefits for running projects and programs in a standardized way because there are economies of scale that come with introducing standardization but it's also more efficient. Lessons learned on one project can be captured and incorporated into the way PMO do things so that other projects benefit from that knowledge too. The PMO is the source of documentation, guidance, oversight, training and performance metrics on the good practice of project management and execution. The PMO supports the strategic objective of the organisation and fulfils a key organisation management and/or oversight role in programme and project management and governance processes. The figure below how PMO apply data analytics from business vision to project outcomes.

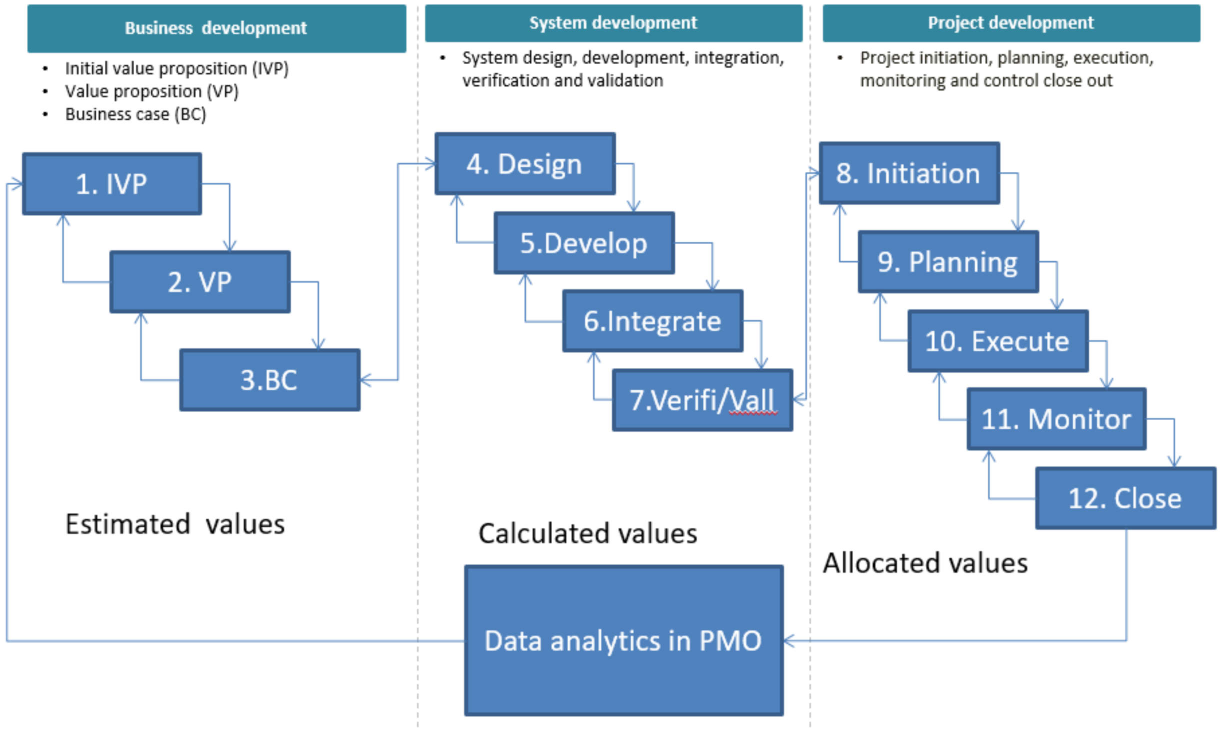

Figure 6 Data analytics application from project business case to project operations and support

Feature engineering

According to Sun, Chen, Wang and Chen (2016-94), machine learning fits mathematical models to data in order to derive insights or make predictions. Feature engineering takes in the label times from the first step, which means building features for each label while filtering the data used for the feature based on the label's cutoff time to make valid features which are passed to modeling where they will be used for training a machine learning algorithm. According to Suresh, and Dillibabu (2018-3144) , feature engineering can assist PMO to ensure that they determining what information to gather in a project , what features predict project performance for current and furture projects and to identify which data type is more usefull to predict the performance of engineering project and programs.

Shah and Singh (2012-436) said that features in a Naive Bayes Classifier, or any general machine learning (ML) classification algorithm, are the data points we choose to define our input and parameters in Naive Bayes are the estimates of the true distribution of whatever we're trying to classify. The figure below indicate how feature are used as classifier parameters.

Feature engineering vital role in big data analytics

Feature engineering plays a vital role in big data analytics because machine learning and data mining algorithms cannot work without data and little can be achieved if there are few features to represent the underlying data objects, and the quality of results of those algorithms largely depends on the quality of the available features. Feature engineering for machine learning and data analytics provides a comprehensive introduction to feature engineering, including feature generation, feature extraction, feature transformation, feature selection, and feature analysis and evaluation.

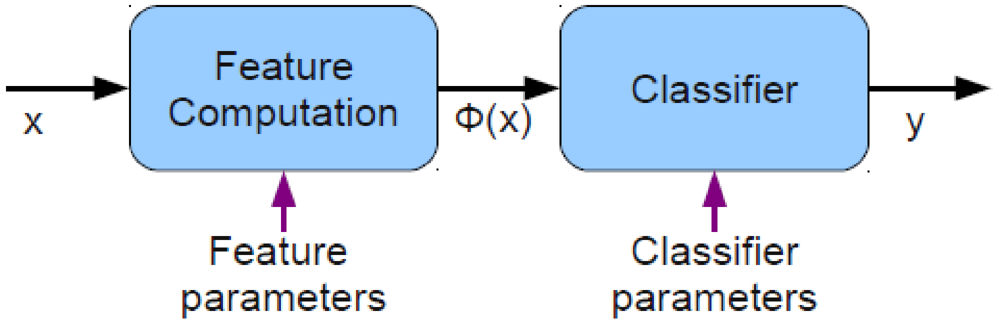

Figure 7 Feature engineering important part for data analytics

Development of new roles

In the next three years, most project management offices will require a data science capability either permanently assigned to them or available when needed. The world already is facing a global shortage of data science professionals. Although many people have IT skills transferable to the data science world, very few have the five required data skill sets:

- Business acumen and domain knowledge,
- Computer programming,
- An understanding of statistics,
- The ability to build and maintain databases, and
- Storytelling.

Improved object

Traditional analytics models have always used patterns from the past to predict the future. Naturally, previous behaviors, events, and trends not only shape what we believe will happen, but also the forecasts conducted by machine-learning models. The improved objective believes that new reality and new date. Traditional forecasting methods use time-series approaches that pull data at certain pre-determined moments. An organization can predict outcomes based on the most recent data in a continuous basis when using real-time forecasting. Forecasting models are based on new data driven by the new reality in order to be more accurate and react more quickly, given the very fast-paced changes we're seeing. Retraining machine-learning models at a high frequency makes them more resilient to potential future disruptions. This continuous testing and updating limits the amount of data drift, which occurs when PMO run models with data that was relevant several months or years ago. Those models pull in outdated and irrelevant information.

Exampes of analytics in project

Predictive analytics uses historical data to predict future events. Typically, historical data is used to build a mathematical model that captures important trends. The figure below shows analytics used for project planning.

WBS Level 2 Activity	Labor Category	Labor ID Code	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	DIRECT COST
Activity "A"	Project Manager	100	0,33	$9 438	0,33	$9 438	0,33	$9 438	0,33	$9 438	0,33	$9 816	0,33	$9 816	0,00	$0	0,00	$0	$57 383
	Sr. Systems Engineer	110	0,33	$7 722	0,33	$7 722	0,33	$7 722	0,33	$7 722	0,33	$8 031	0,33	$8 031	0,00	$0	0,00	$0	$46 950
	Systems Engineer	112	0,50	$11 180	0,70	$15 652	0,80	$17 888	0,80	$17 888	0,50	$11 627	0,30	$6 976	0,00	$0	0,00	$0	$81 212
	Sr. Design Engineer	120	0,50	$11 700	2,00	$46 800	2,00	$46 800	2,00	$46 800	0,50	$12 168	0,40	$9 734	0,00	$0	0,00	$0	$174 002
	Software Engineer	122	0,25	$5 720	0,75	$17 160	1,00	$22 880	1,00	$22 880	0,25	$5 949	0,50	$11 898	0,00	$0	0,00	$0	$86 486
	Quality Control	124	0,33	$5 834	0,33	$5 834	0,50	$8 840	0,50	$8 840	0,33	$6 068	1,00	$18 387	0,00	$0	0,00	$0	$53 804
	Design Engineer	125	2,00	$44 200	2,00	$44 200	3,00	$66 300	2,00	$44 200	1,00	$22 984	1,00	$22 984	0,00	$0	0,00	$0	$244 868
	Associate Design Engineer	127	2,00	$36 400	3,00	$54 600	3,00	$54 600	3,00	$54 600	2,00	$37 856	1,00	$18 928	0,00	$0	0,00	$0	$256 984
	Sr. Test Engineer	130	0,00	$0	0,00	$0	1,00	$23 920	1,00	$23 920	1,00	$24 877	3,00	$74 630	0,00	$0	0,00	$0	$147 347
	Test Engineer	135	0,00	$0	0,00	$0	2,00	$45 760	2,00	$45 760	4,00	$95 181	5,00	$118 976	0,00	$0	0,00	$0	$305 677
	Project Coordinator	140	0,33	$6 349	1,20	$23 088	1,50	$28 860	1,50	$28 860	1,00	$20 010	0,70	$14 007	0,00	$0	0,00	$0	$121 174
	Configuration Management	142	0,33	$6 349	0,70	$13 468	1,00	$19 240	1,00	$19 240	0,50	$10 005	0,70	$14 007	0,00	$0	0,00	$0	$82 309
	Business Manager	150	0,33	$6 521	0,50	$9 880	1,00	$19 760	1,00	$19 760	0,50	$10 275	0,50	$10 275	0,00	$0	0,00	$0	$76 471
	Activity "A" Subtotal		7,23	$151 414	11,84	$247 842	17,46	$372 008	16,46	$349 908	12,24	$274 845	14,76	$338 649	0,00	$0	0,00	$0	$1 734 666

			1Q06		2Q06		3Q06		4Q06		1Q06		2Q06		3Q06		4Q06		TOTAL
WBS Level 2 Activity	Labor Category	Labor ID Code	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	DIRECT COST
Activity "B"	Project Manager	100	0,33	$9 438	0,33	$9 438	0,33	$9 438	0,33	$9 438	0,33	$9 816	0,33	$9 816	0,00	$0	0,00	$0	$57 383
	Sr. Systems Engineer	110	0,33	$7 722	0,33	$7 722	0,33	$7 722	0,33	$7 722	0,33	$8 031	0,33	$8 031	0,00	$0	0,00	$0	$46 950
	Systems Engineer	112	0,50	$11 180	0,70	$15 652	0,80	$17 888	0,80	$17 888	0,50	$11 627	0,30	$6 976	0,00	$0	0,00	$0	$81 212
	Sr. Design Engineer	120	0,50	$11 700	2,00	$46 800	2,00	$46 800	2,00	$46 800	0,50	$12 168	0,40	$9 734	0,00	$0	0,00	$0	$174 002
	Software Engineer	122	0,25	$5 720	0,75	$17 160	1,00	$22 880	1,00	$22 880	0,25	$5 949	0,50	$11 898	0,00	$0	0,00	$0	$86 486
	Quality Control	124	0,33	$5 834	0,33	$5 834	0,50	$8 840	0,50	$8 840	0,33	$6 068	1,00	$18 387	0,00	$0	0,00	$0	$53 804
	Design Engineer	125	2,00	$44 200	1,00	$22 100	3,00	$66 300	3,00	$66 300	2,00	$45 968	1,00	$22 984	0,00	$0	0,00	$0	$267 852
	Associate Design Engineer	127	2,00	$36 400	2,00	$36 400	3,00	$54 600	3,00	$54 600	2,00	$37 856	1,00	$18 928	0,00	$0	0,00	$0	$238 784
	Sr. Test Engineer	130	0,00	$0	0,00	$0	1,00	$23 920	1,00	$23 920	1,00	$24 877	3,00	$74 630	0,00	$0	0,00	$0	$147 347
	Test Engineer	135	0,00	$0	0,00	$0	2,00	$45 760	2,00	$45 760	4,00	$95 181	5,00	$118 976	0,00	$0	0,00	$0	$305 677
	Project Coordinator	140	0,33	$6 349	0,33	$6 349	0,33	$6 349	0,33	$6 349	0,33	$6 603	0,33	$6 603	0,00	$0	0,00	$0	$38 603
	Configuration Management	142	0,33	$6 349	0,33	$6 349	0,33	$6 349	0,33	$6 349	0,33	$6 603	0,33	$6 603	0,00	$0	0,00	$0	$38 603
	Business Manager	150	0,33	$6 521	0,33	$6 521	0,33	$6 521	0,33	$6 521	0,33	$6 782	0,33	$6 782	0,00	$0	0,00	$0	$39 646
	Activity "B" Subtotal		7,23	$151 414	8,43	$180 326	14,95	$323 367	14,95	$323 367	12,23	$277 528	13,85	$320 348	0,00	$0	0,00	$0	$1 576 350

			1Q06		2Q06		3Q06		4Q06		1Q06		2Q06		3Q06		4Q06		TOTAL
WBS Level 2 Activity	Labor Category	Labor ID Code	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	Equivalent People Rq'd	Direct Cost	DIRECT COST
Activity "C"	Project Manager	100	1,00	$28 600	1,00	$28 600	1,00	$28 600	1,00	$28 600	1,00	$29 744	1,00	$29 744	0,00	$0	0,00	$0	$173 888
	Sr. Systems Engineer	110	1,00	$23 400	1,00	$23 400	1,00	$23 400	1,00	$23 400	1,00	$24 336	1,00	$24 336	0,00	$0	0,00	$0	$142 272
	Systems Engineer	112	0,50	$11 180	0,70	$15 652	0,80	$17 888	0,80	$17 888	0,50	$11 627	0,30	$6 976	0,00	$0	0,00	$0	$81 212
	Sr. Design Engineer	120	0,50	$11 700	2,00	$46 800	2,00	$46 800	2,00	$46 800	0,50	$12 168	0,40	$9 734	0,00	$0	0,00	$0	$174 002
	Software Engineer	122	0,25	$5 720	0,75	$17 160	1,00	$22 880	1,00	$22 880	0,25	$5 949	0,50	$11 898	0,00	$0	0,00	$0	$86 486
	Quality Control	124	0,20	$3 536	0,33	$5 834	0,50	$8 840	0,50	$8 840	0,33	$6 068	1,00	$18 387	0,00	$0	0,00	$0	$51 505
	Design Engineer	125	1,00	$22 100	2,00	$44 200	3,00	$66 300	3,00	$66 300	1,00	$22 984	0,50	$11 492	0,00	$0	0,00	$0	$233 376
	Associate Design Engineer	127	2,00	$36 400	2,00	$36 400	3,00	$54 600	3,00	$54 600	2,00	$37 856	1,00	$18 928	0,00	$0	0,00	$0	$238 784
	Sr. Test Engineer	130	1,00	$23 920	0,00	$0	1,00	$23 920	1,00	$23 920	1,00	$24 877	3,00	$74 630	0,00	$0	0,00	$0	$171 267
	Test Engineer	135	0,00	$0	0,00	$0	2,00	$45 760	2,00	$45 760	2,00	$47 590	5,00	$118 976	0,00	$0	0,00	$0	$258 086
	Project Coordinator	140	0,33	$6 349	0,33	$6 349	0,33	$6 349	0,33	$6 349	0,33	$6 603	0,33	$6 603	0,00	$0	0,00	$0	$38 603
	Configuration Management	142	0,33	$6 349	0,33	$6 349	0,33	$6 349	0,33	$6 349	0,33	$6 603	0,33	$6 603	0,00	$0	0,00	$0	$38 603
	Business Manager	150	0,33	$6 521	0,33	$6 521	0,33	$6 521	0,33	$6 521	0,33	$6 782	0,33	$6 782	0,00	$0	0,00	$0	$39 646
	Activity "C" Subtotal		8,44	$185 775	10,77	$237 266	16,29	$358 207	16,29	$358 207	10,57	$243 187	14,69	$345 090	0,00	$0	0,00	$0	$1 727 732
	PROJECT TOTAL		22,90	$488 602	31,04	$665 434	48,70	$1 053 582	47,70	$1 031 482	35,04	$795 560	43,30	$1 004 087	0,00	$0	0,00	$0	$5 038 748
																		Budgetary Minimum	$4 282 936
																		Budgetary Maximum (NTE)	$6 550 372

Figure 8 Using Data analytics to pridict furture project cost for PMO

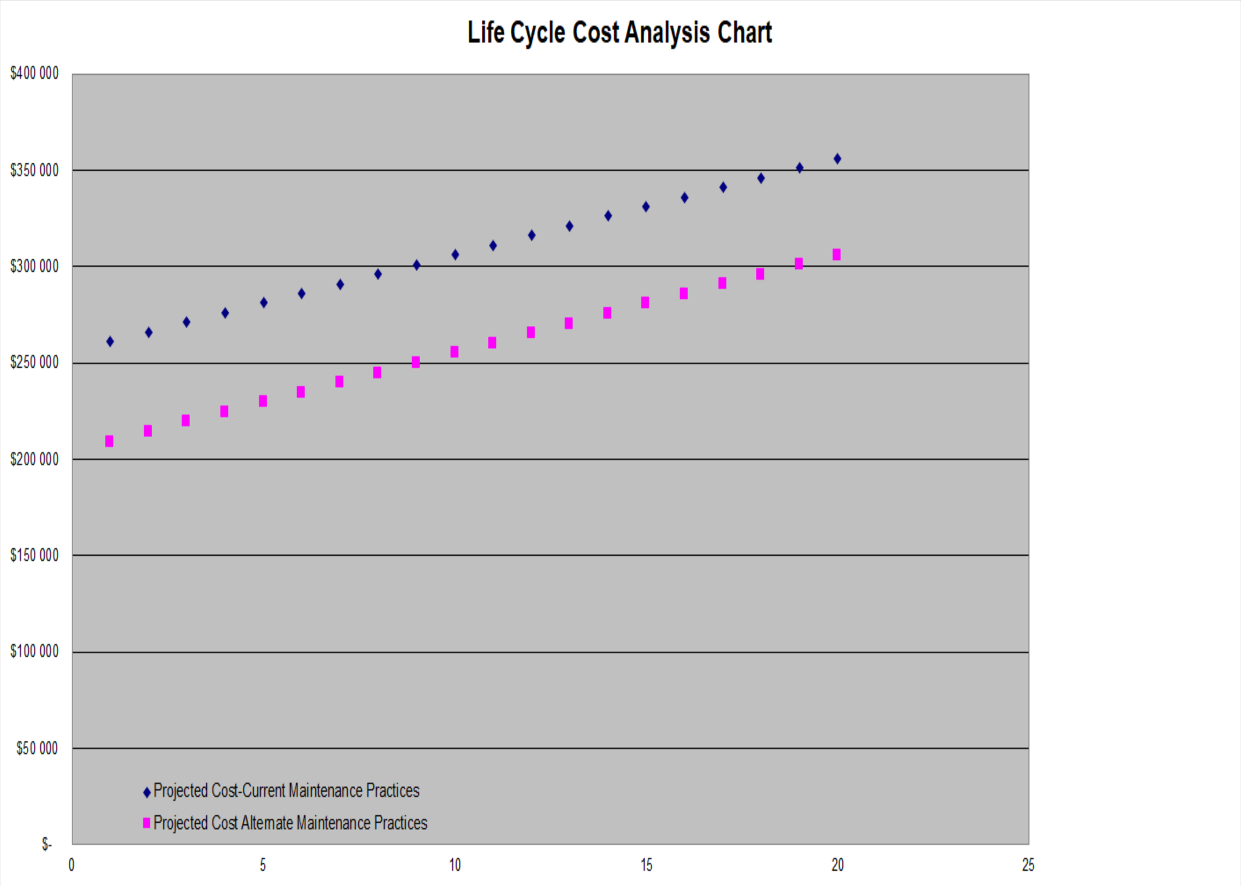

Figure 9 PMO using data analytics to predict project life cycle cost for two alternatives

Data analytic applications in engineering projects

The project management office (PMO) can use project analytics in a lot of areas throuout the project life cycle and project management life cycle. The following area can use data analtics to improve PMO performance:

- Feasibility assessment – Data analytics can be used to analyse various alternatives in order to determine the best solution for the project manager to consider. This can be linked to engineering modelling resulting in a more optimal solution to use for selection purposes.

- Data visibility – A model can be developed to measure all progect processes and present the project and program manager with an overview which will assist him to determine focus area. This will assist him to refocus his team to address the underperforming areas on time improving the overall success by ensuring that lessons learned are build in on the next projects improving PMO effitiecy.

- Project portfolio selection – Data analytics can assist PMO by evaluating a large number of project proposals by selecting and prioritizing the most viable ones within the constraints of organizational resources.

- Management of stakeholders – From stackeholders management plan, data analytics can assist a PMO to predict stakeholder responses to various project decisions. Project managers can use analytics to predict the outcomes of the execution of their strategic plans for stakeholder engagement management and to guide their decisions for appropriate corrective actions if they find any discrepancy (variance) between the planned and the actual results of their efforts.

- Project risk management – Project risk identification, ranking, and prioritization depends on the size and complexity of the project , Risk probability impact and horizon, organization's risk tolerance and competency of the project or risk manager. Predictive analytics models can be used to analyze those multiple factors for making rational decisions to manage the risks effectively.

- Predict cost overruns and schedule delays – Data analytics can assist project manager to predidct the impact of various completion dates on the bottom line, helping them proactively discover trends in project schedule and cost performance.

- Project processes improvement – Project management include the execution of multitudes of processes as sumerized by the project management body of knowledge which is s essential for eliminating waste and improving the quality of the processes and the product of the project or program.

Conclusion

To most project managers, using the available analytical tools makes perfect sense and switching to a data driven PMO will definately improve project and program effitiency by moving away from traditional legacy approach to project management decision-making towards objective decision marking only using data to support decisions. Project managers can use analytical tools in complex engineering project and programs by breaking down processes and systems using this predictive information to make better decisions and keep projects on schedule and on budget. Data analytics enables project teams to analyze captured data to observe parterns or trends informing the project manager how projects or project portfolios are performing, and what strategic decisions they need to make to improve the success rate. The data systems Integration offers a data management solution and technology agnostic services enabling PMO to make data-driven decisions in realising real project or program insights resulting in stackeholders satisfaction. This ensure that the PMO receives well managed large influx of data in real time which allow productivity improvement and manage resources.

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About the Author

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Dr Lalamani Budeli obtained his degree in Electrical Engineering at the Vaal University (VUT), BSc honours in Engineering Technology Management at University of Pretoria (UP), Master in engineering development and Management at North West University (NWU), Master of business administration at Regent Business School (RBS) and a Doctor of Philosophy in Engineering Development and Management at North West University (NWU), Potchefstroom, South Africa. Currently, he is a managing director of BLIT, an engineering, research, and project management company based in South Africa.

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