WHICH EXPERTISE FACTORS PREDICT OVERALL EXPERTISE AND PERCENT SUCCESS?

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Abstract: This study aims to contribute to the improvement of the project management skill levels. It focuses on exploring the key experience factors that correlate with project manager expertise and project success. This study differs from current literature because it uses project managers' self-assessment of their own expertise in 30 processes and 6 soft-skills as data for regression analysis to examine which factors represent the Overall Expertise levels and how they relate to self-reported rates of project success. The predictive assessment framework identifies strengths and weaknesses to focus improvement of project manager capability in specific areas.

Keywords: capability, career, competency, development, experience, expertise, manage, project, success

1.0 Introduction

Our focus in this study is exploration of key factors that influence project manager Overall Expertise and Percent Success. We also address the lack of such quantitative studies that can identify the key factors that influence Overall Expertise by using self-report assessment. In this study, we present an integrated model for identifying the key factors that influence Overall Expertise in a sample of project managers. Overall Expertise is considered to be a critical factor in project Percent Success, yet 17% of all project managers have less than two years of experience (Bond, 2015; Brandon, 2019). The focus of this phase of the study is the extraction and validation of the factors to develop a framework for measurement of Overall Expertise and their relationship with Percent Success.

1.1 Problem Statement

The problem is very few studies exist clearly identifying the factors contributing to Overall Expertise and Percent Success by using self-report assessment by project managers. By not identifying and compensating for these factors, companies are unable to ensure project managers, especially those with few years of experience, are capable of delivering successful project outcomes. Furthermore, companies risk the cost of project failure, loss of strategic competitive advantage due to project delays, and damage to corporate images due to adoption failures of project products. There is a distinct lack of literature which uses actual project manager self-assessment of their Overall Expertise and career Percent Success.

1.2 Purpose

With the use of this quantitative study, we intended to identify the degree or magnitude that the factors influence Overall Expertise in a large sample of project managers. A survey was developed to collect the data using a 7-point Likert-type scale survey with 36 measures of Overall Expertise and eight numerical measures of Experience. The use of a survey in this study allows for the discovery of relationships of variables or factors. Stated differently, the questions in the survey relate to variables that define the factors leading to or identified as contributing to Overall Expertise and Percent Success. In keeping with common practice, the analysis of the applied survey is used to describe a snapshot of Overall Expertise and Percent Success for a sample population. The population surveyed is a broad spectrum of English-speaking project managers as a comparative random sample of project managers worldwide. A random selection of the population is judged to be a statistically valid sample in identifying the key factors. The personal and professional reason for this study centers on achieving a greater understanding of Overall Expertise and Percent Success as a potential model for identifying the lack of education for inexperienced project managers and insights into how experienced project managers increased their expertise.

1.3 Nature of the Study

In this quantitative study, we sought to identify the key factors that influence Overall Expertise and Percent Success using self-report assessment by project managers. The lack of academic research into this topic provided an opportunity where this study could contribute to the body of knowledge in the project management area.

A survey was deemed the most appropriate method for data collection as it allowed project managers to respond truthfully and anonymously while identifying what key variables significantly influence Overall Expertise. The survey consisted of a number of Likert-type items related to each of the aforementioned factors in order to gather significant data for analysis.

1.4 Research Questions and Hypotheses

The first research question focused on the relationship of the 36 expertise factors and Overall Expertise.

RQ1. What is the relationship of the 36 expertise factors and Overall Expertise?

$H1_0$. There is no statistically significant relationship between the 36 expertise factors and Overall Expertise.

$H1_1$. There is at least one statistically significant relationship between the 36 expertise factors and Overall Expertise.

The second research question focused on the relationship of the 36 expertise factors and project success.

RQ2. What is the relationship of the 36 expertise factors and Percent Success?

$H2_0$. There is no statistically significant relationship with the 36 expertise factors and Percent Success.

$H2_1$. There is at least one statistically significant relationship with the 36 expertise factors and Percent Success.

1.5 Significance of the Study

In this phase of the study, we sought to identify the key factors that influence Overall Expertise and Percent Success using quantitative analyses of self-report assessments by project managers. The selection of this research methodology was chosen to identify the relationships of the key factors that influence Overall Expertise and Percent Success from self-assessed capability on 36 measures of project manager expertise. The lack of academic research into this topic provides an opportunity where this study could contribute to the body of knowledge in the project management area. The results of the study provide a comprehensive measurement scale for the assessment of project manager knowledge levels and an approach for addressing areas of weakness. This assessment scale can be used for self-assessment and management assessment of direct reports with the intent of fashioning development plans to improve the talent of project managers and teams. This is especially important as staff levels are reduced for various reasons and the load of project management is being placed on the shoulders of inexperienced or newly named project managers.

2.0 Literature Review

The literature included in this review were found using the following search strings and libraries:

Measuring Project Manager Expertise – NCU Alumni Library Search

Measuring Project Manager Competency – NCU Alumni Library Search

Measuring Project Manager Competency – Google Scholar

Measuring Project Manager Skill – NCU Alumni Library Search

2.1 Project Manager Competencies

Ahmed (2017) performed a comparative analysis of eight studies that examined project manager intellectual capacities as common project success factors and identified leadership, strategic perspective, strong vision, and imagination as having significant influence on project success. Blomquist, Farashah, and Thomas (2016) developed a domain-specific scale to measure project manager self-efficacy (PMSE) using five factors and 22 indicators. The five factors were (a) manage project team, (b) manage stakeholder relationships, (c) development of the plan, (d) manage project execution, and (e) evaluation of project performance. They found that the five factors strongly predicted PMSE (loading from 0.77 to 0.84) and that PMSE weakly predicted project management performance (PMP) ($r=0.32$. $r^2=0.10$). Bond (2015) found (a) a significant relationship between transformational and transactional leadership styles and project success, (b) a positive but not statistically significant relationship between years of experience, and (c) a significant relationship between critical success factors and project success. Crawford (2000) found that while schedule and budget alone are inadequate measures of project success, quality and stakeholder satisfaction with the project outcome are critical to perceived project success. They found the five factors that contribute to project success based on Cronbach's alpha measure of reliability are (a) integrative planning (0.83), (b) integrative monitoring and controlling (0.90), (c) risk monitoring and controlling (0.90), (d) team development (0.90), and (e) lessons learned (0.94). de Araújo, Pedron, and de Oliveira (2018) developed a scale with five factors and 37 items and found project manager competencies account for 45% of team commitment. The five factors were (a) team management, (b) business domain knowledge, (c) people skills and communication, (d) project management, and (e) professionalism and personal characteristics.

Richardson, Earnhardt, and Marion (2015) found project management remains a destination by accident and that most professional project managers do not intend to be project managers but "fall into" the profession, indicating the need for project management training and mentorship, and implying the need for an effective assessment tool to indicate the areas needing improvement. Bond (2015) reported that 2.1% of the project managers had less than one year of project management experience. Brandon (2019) reported 15.0% of the project managers had one to two years of project management experience.

Brandon (2019) found a significant relationship between the overall, creating, capturing, and reusing project knowledge management (PKM) processed and project success whereas no significant relationship existed between the transferring PKM process and project success. Garvin (1993) identified the five main activities exhibited by skilled learning organizations as (a) systematic problem solving, (b) experimentation, (c) learning from past experience, (d) learning from others, and (e) transferring knowledge. Measurement of learning was by learning curves and the three stages of organizational learning are (a) cognitive, b) behavioral, and (c) performance improvement. Harpham (2020) suggested a talent management tripod comprise of (a) assessing the skills required for delivering the specific project outcomes and matching the skills of the project team to the project tasks, (b) understand the talents and skills of each team member individually, (c) introduce the growth mindset described by Dweck (2008) to team members to encourage them to expand their capacities beyond their current skill levels by working on new skills during the project. Making the development of new skills and talents a formal outcome of the project is a great way to build bench strength by learning from experience. Burga, LeBlanc, and Rezania (2020) found that students studying project management believe they are ready to succeed at work but need more formal training project management skills. Burga, LeBlanc, and Rezania (2020) observed having the necessary skills and realistic expectations of career adaptability, self-directed career management, and belief in their self-efficacy were career success factors. Floris, Wiblen, and Anichenko (2020) studied 37 leadership skills and 11 career-stalling behaviors that can derail the careers of senior project leaders and found that feedback from the managers who directly impacted the individual was more reliable than that from peers or direct reports and that project leaders have a more modest assessment of their skill levels than their managers assessments.

Burga, LeBlanc, and Rezania (2020) found that students studying project management saw project management as a temporary preparation step on their career path to their preferred role in leadership positions in an organization. Geoghegan and Dulewicz (2008) found eight leadership dimensions were significantly related to usability and project delivery success factors were (a) managing resources, (b) empowering, (c) developing, (d) motivation, (e) critical analysis, (f) influencing, (g) self-awareness, and (h) sensitivity. The two project success factors were (a) usability and (b) project delivery. Marzagão and Carvalho (2016) found that the only two of 11 identified leadership behavior competencies that positively correlated with project performance were innovation and direction. Müller and Turner (2010) found a) a need for training for practitioners in soft factors of leadership, b) the transactional leadership style is appropriate for simple projects, and c) transformational leadership style is appropriate for complex projects.

Enterprisers Project (2020) found that the eight core soft skills most needed in an IT organization are (a) communication, (b) collaboration, (c) consulting, (d) coaching, (e) influence, (f) empathy, (g) networking, and (h) problem solving. Gillard (2009) found technical and management skills are considered minimal requirements whereas excellent interpersonal soft skills and leadership skills are necessary requisites for project manager success. Hamilton (2019) identified the most valuable soft skills that Toronto women in IT share were (a) curiosity, (b) discipline, (c) teamwork and collaboration, (d) self-awareness and humility, (e) influence, (f) communication, (g) adaptability, (h) analytical thinking, (i) empathy, and (j) emotional intelligence. Ibbs and Kwak (2000) studied project manager maturity using a quantitative survey of 38 international organizations consisting of 148 questions based on eight knowledge areas, six processes, schedule and cost indices, percentage of project management spending, and order of magnitude return on investment estimates using a five-point Likert scale and found the overall maturity averaged 3.26 on a 1 to 5 scale with considerable variability within industry and across industries. Khattak, Ur Rehman, Mustafa, and Khattak (2016) found project complexity showed a significant negative correlation with project success ($r=-0.48$) at the 0.01 level while competency showed a significant positive relationship with project success ($r=0.79$) at the 0.01 level. McHenry (2008) identified the 12 key competencies needed by project managers to be highly successful in rank order of importance are (a) communication, (b) decision making, (c) organizational, (d) teambuilding, (e) computer, (f) problem-solving, (g) conflict resolution, (h) management support building, (i) motivation, (j) organizational politics, (k) delegation, and (l) negotiation. Miranda and Ghimire (2007) reported the top four competencies required by employers were (a) communication, (b) project integration management, (c) scope management and (d) balance between hard and soft competencies.

2.2 Theoretical/Conceptual Framework

Project Management Institute (2017) published A guide to the project management book of knowledge (PMBOK guide) which outlines 13 knowledge areas, and 49 processes in five process groups. This theoretical framework has been used as a basis for several project manager competency studies (Bond, 2015; Crawford, 2000; Ibbs & Kwak, 2000; McHenry, 2008; Miranda & Ghimire, 2007). In addition, a subset of the key soft human management skills listed by Enterprisers Project (2020), Gillard (2009), Müller and Turner (2010) are included in the survey structure. Dorst and Reymen (2004) studied the levels of expertise in design education based on a seven-level general skill acquisition model distinguished by Dreyfus (2003a and 2003b). The seven levels (1) Novice, (2) Advanced Beginner, (3) Competent, (4) Proficient, (5) Expert, (6) Master, and (7) Visionary were used as the basis for the 7-point Likert-type measurement scale of Overall Expertise.

3.0 Research Method

The Project Manager Expertise research study was designed as two related studies. The first was a quantitative study and the second was a qualitative study to explore the results of the first study. An online anonymous survey of subjective perceived levels of expertise, collecting categorical and quantitative ordinal data was administered to potential participants. Respondents to the online survey were invited to voluntarily submit their name and email address if they wished to participate in follow-up qualitative interviews. Additional interview candidates were recruited by posting to the LinkedIn group PMLink. The personally identifiable information (PII) of all interview respondents were kept in a separate file accessible only by the co-investigators who have signed confidentiality and nondisclosure statements. Respondent PII was used only for contacting the volunteer respondents to arrange the interviews and was de-identified after the interview data was collected. The quantitative and qualitative data from a respondent were not directly linked. Only the measures of experience and Likert-style expertise self-assessment information were used to compare exploratory qualitative data to quantitative survey response data. The online survey respondents were supplied by the independent survey management services, SurveyMonkey Audience and Qualtrics XM Online Panels. The findings of the study are based on results from aggregated data.

3.1 Population and Sample

The population is the set of experienced project managers, regardless of gender, in the United Kingdom, United States, Canada, India, or Australia. Singh (2016) estimated the size of the population of project managers in the target countries was 1,073,000 compared with the worldwide population of 2,170,000. There were approximately 500,000 certified project management professionals registered with the Project Management Institute (2018) and approximately 369,000 members in the LinkedIn project manager community group (LinkedIn, 2018).

The sample of 500 participants was determined using the guidelines of 10 to 15 participants per factor offered by Field (2000) in Discovering Statistics Using IBM SPSS Statistics. The sample size of 500 for 36 factors would result in 13.9 participants per variable. The sample size of 500 was tested for suitability for multiple linear regression of up to 36 variables. The GPower 3.1 statistical power analysis software for a post-hoc analysis of F test - Linear multiple regression: Fixed model, R^2 deviation from zero with effect set at 0.15 (medium), statistical significance level (α) at 0.05, number of predictors of 36, and sample size 500 resulted in a statistical power of 1.000 virtually guaranteeing detection.

3.2 Data Collection

The web-based survey using SurveyMonkey Audience and Qualtrics XM Online Panels provided a wide reach to members of the population represented by the large sample frame described earlier, a typically higher response rate than emailed or mailed surveys, less expensive approach, and a relatively short duration compared to other methods (Vaux & Briggs, 2006). The survey was field tested by sending it to a purposeful convenience sample of four university professors and 11 professional project managers requesting constructive feedback on ease of use and suggestions for improvement to assure content validity. Quantitative data was collected using the online survey instrument described earlier. Approval for the solicitation of participants was arranged by SurveyMonkey and Qualtrics. The Northcentral University IRB reviewed and approved the online survey before it was released to SurveyMonkey and Qualtrics to contact individuals to partake in the survey.

The initial participants were recruited using the SurveyMonkey Audience tool which allows collectors by country to be defined by targeted selection of employment job function or role. SurveyMonkey provides a pool of pre-qualified potential responders with guaranteed delivery of completed surveys for the quota specified for each collector. For this study five country-based collectors are defined with the selection criteria of employment job function or role being Project Management. SurveyMonkey was not able to supply sufficient respondents for the United States, Canada, and Australia so Qualtrics XM was enlisted to manage collection of the remaining respondents to the anonymous online survey through their Online Panels feature. Because of the need to use Qualtrics as a second source of targeted survey respondents, the lower cost per respondent with Qualtrics provided the opportunity to substantially increase the number of respondents from the original target of 500 to a final sample size of 679 qualified and validated respondents with no missing data in any of the variables.

The data was exported from SurveyMonkey and Qualtrics XM to Excel where it was validated for completeness and reasonability of responses, aligned to a common format, merged into one file, and imported into SPSS for quantitative statistical analysis participants.

The 36 factors were based on five project constraints – Scope, Schedule, Cost, Quality, and Resources - identified in the PMI PMBOK (Project Management Institute, 2017) with six factors per project constraint and a set of six factors related to key soft human management skills (Enterprisers Project, 2020; Gillard, 2009, Müller & Turner, 2010). The seven levels of the Likert-type scale were (1) Novice, (2) Advanced Beginner, (3) Competent, (4) Proficient, (5) Expert, (6) Master, and (7) Visionary (Dorst & Reymen, 2004). In addition, self-report assessments were made of the overall expertise level for each of the five project constraint factors, the soft skill factor, and the overall expertise level of the project manager using the same Likert-type scale, resulting in a hierarchical (36 > 6 > 1) measurement structure.

3.3 Analysis

The descriptive statistics for the 36 expertise factors and the two independent variables Overall Expertise and Percent Project Success were run and examined. The descriptive statistics included the frequency distribution, measures of central tendency, variability, and ranking. The data was analyzed for reliability using Cronbach's alpha (Laerd, 2015a) and average variance extracted (AVE) (Grande, 2016).

To address RQ1, the 36 measured expertise factors as independent variables were applied against the measured Overall Expertise (q15_Ove) value as the dependent variable within the context of a predictive model with the goal of identifying only the significant ($p \leq .05$) predictors of Overall Expertise. The data was analyzed for statistical test assumption compliance for stepwise linear regression (SWR) (Laerd, 2015b). The relative Pratt index (RPI) (Ochieng & Zumbo, 2001) was used to determine the degree of contribution of each independent variable to the dependent variable. The ordinal logistic regression (OLR) method using both the polytomous universal model (PLUM) and the generalized linear model (GENLIN) methods to identify the significant the dependent variables and the average Exp(B) value was used as an estimator of relative the degree of contribution of each independent variable to the dependent variable. Since the relative Pratt index is based on the standardized regression coefficient (Beta) and the correlation coefficient of the independent variables in linear regression, the relative importance index (RII) (Johnson & LeBreton, 2004); Liu, Zumbo, & Wu, 2014) was computed for all 36 factors to provide a common framework for comparing the significant and nonsignificant independent variables of the ordinal regression where needed.

To address RQ2, the 36 measured expertise factors as independent variables were applied against the measured Percent Success (q07_PerSuc) value as the dependent variable within the context of a predictive model with the goal of identifying only the significant predictors of Percent Success ($p \leq .05$). The data was analyzed for statistical test assumption compliance for stepwise linear regression (SWR) (Laerd, 2015b). The relative Pratt index (RPI) (Ochieng & Zumbo, 2001) was used to determine the degree of contribution of each independent variable to the dependent variable.

3.4 Validity of Self-Report Assessments

Self-report assessments are widely used in psychological tests and are valuable tools in assessing abilities (Leong & Austin, 2006). To test internal consistency Cronbach's alpha is often used to compare all items with one another and a value of at least 0.70 is considered acceptable and value of 0.80 is considered satisfactory because it indicates that most of the variance is accounted for by the self–reported assessment values as opposed to random measurement error (Leong & Austin, 2006). Even though self-assessment is used by large numbers of researchers, the validity and accuracy are considered by some to be questionable due to potentially inflated perception and self-interest which introduce construct-irrelevant variance (Ross, 2006). However multiple research studies of psychometric properties indicate self-assessment is a reliable technique with consistent results across items and contexts (Ross, 2006). To address any concerns of the validity of self-reported assessments from professional project managers, the data was analyzed for reliability using Cronbach's alpha (Laerd, 2015a) and average variance extracted (AVE) (Grande, 2016) and for internal validity using both stepwise linear regression (Laerd, 2015b) and ordinal logistic regression (Laerd, 2015c).

3.5 Validity of Likert-Type Ordinal Data

When it comes to validity of using Likert-type ordinal data as interval data, there are two theoretical camps, (a) the strict interpreters like Stevens (1946), Bürkner and Vuorre (2019) and Owuor (2001) and (b) the practical interpreters like Abelson and Tukey (1963), Velleman and Wilkinson (1993), and Pasta (2009). Owuor (2001) studied the implications of using Likert-type data in multiple regression analysis and found the practice resulted in substantial loss of information and biased regression coefficients and recommended ordinal regression, and logistic regression models when using Likert-type data. Pasta (2009) argued that it was nearly always useful to treat ordinal variables as continuous and examine the linear component of ordinal variables for possible useful relationships under the assumption that an underlying continuous latent variable exists behind any ordered construct. To accommodate both viewpoints, this study used both stepwise linear regression and ordinal logistic regression to identify the significant key factors related to project manager level of expertise and success rate.

3.6 Validity of the Data Collected for the Study

The threats to internal validity of history, maturation, testing, mortality, regression to the mean, and selection were controlled because the survey data were collected over a relatively short period of a few weeks and the study sample was randomly selected from the pool of respondents. The threat of instrumentation was controlled by field testing the survey for accuracy before being actually released for automated delivery and data collection by a respected independent third party. The threats to external validity were addressed by targeting the broad population of experienced project managers who were members of professional associations in the United Kingdom, United States, Canada, India, and Australia and randomly selecting a sample from the pool of respondents of a size large enough to detect with high power (1.00) a medium effect (0.15) with a statistically significant alpha level (0.05). Sample bias was addressed by randomly selecting a large sample of 679 participants from the population, however there was still a possibility of sample bias due to the voluntary nature of the sample, the use of self-report assessment, and the limitation of the sample to individuals who were English-speaking project managers.

4.0 Results

4.1 Selection and Filtering of Outliers

Prior to running the SWR and OLR regressions for Overall Expertise, the observation data were tested for outliers which would have caused the residuals (errors) of the regression line to not be normally distributed. There were 54 cases out of 679 observations with residual outliers greater than 1.500 which were excluded from the predictive models for Overall Expertise resulting in 625 observations. A variable (New_Out_Lie) was added to identify the outliers and was used by the Select Cases function to exclude the outliers..

Table 1 Descriptive Statistics

	N	Mean	Std. Deviation	Variance	Skewness	Kurtosis
Plan Scope Management (5.1)	625	4.12	1.410	1.987	-0.276	-0.249
Collect Requirements (5.2)	625	4.30	1.346	1.812	-0.285	-0.322
Define Scope (5.3)	625	4.28	1.434	2.056	-0.334	-0.218
Create Work Breakdown Structure (WBS) (5.4)	625	4.19	1.476	2.179	-0.271	-0.378
Validate Scope (5.5)	625	4.24	1.457	2.123	-0.347	-0.275
Control Scope (5.6)	625	4.29	1.499	2.247	-0.408	-0.320
Plan Schedule Management (6.1)	625	4.35	1.505	2.265	-0.321	-0.438
Define Activities (6.2)	625	4.46	1.441	2.076	-0.399	-0.327
Sequence Activities (6.3)	625	4.48	1.386	1.920	-0.428	-0.238
Estimate Activity Durations (6.4)	625	4.32	1.420	2.015	-0.352	-0.375
Develop Schedule (6.5)	625	4.43	1.446	2.092	-0.358	-0.359
Control Schedule (6.6)	625	4.38	1.397	1.952	-0.388	-0.259
Plan Cost Management (7.1)	625	4.07	1.509	2.277	-0.252	-0.450
Estimate Costs (7.2)	625	4.10	1.532	2.347	-0.269	-0.546
Determine Budget (7.3)	625	4.15	1.535	2.357	-0.291	-0.386
Control Costs (7.4)	625	4.17	1.498	2.243	-0.398	-0.427
Understand Enterprise Environmental Factors (2.2)	625	4.04	1.502	2.255	-0.274	-0.509
Understand Organizational Process Assets (2.3)	625	4.09	1.534	2.352	-0.239	-0.581
Plan Quality Management (8.1)	625	4.23	1.422	2.022	-0.337	-0.335
Plan Communications Management (10.1)	625	4.37	1.434	2.056	-0.396	-0.183
Plan Risk Management (11.1)	625	4.25	1.488	2.216	-0.395	-0.355
Plan Stakeholder Engagement (13.2)	625	4.32	1.532	2.346	-0.361	-0.398
Manage Quality (8.2)	625	4.40	1.458	2.127	-0.310	-0.361
Control Quality (8.3)	625	4.35	1.476	2.179	-0.406	-0.314
Plan Resource Management (9.1)	625	4.26	1.425	2.030	-0.360	-0.309
Estimate Activity Resources (9.2)	625	4.23	1.432	2.051	-0.356	-0.323
Acquire Resources (9.3)	625	4.24	1.438	2.069	-0.371	-0.313
Develop Team (9.4)	625	4.44	1.511	2.282	-0.403	-0.416
Manage Team (9.5)	625	4.60	1.510	2.279	-0.476	-0.371
Control Resources (9.6)	625	4.36	1.469	2.159	-0.432	-0.270
Leadership	625	4.51	1.451	2.106	-0.376	-0.358
Communications	625	4.63	1.419	2.013	-0.457	-0.251
Conflict resolution	625	4.41	1.422	2.022	-0.355	-0.310
Attitude	625	4.69	1.433	2.054	-0.476	-0.148
Ambiguity tolerance	625	4.38	1.442	2.079	-0.374	-0.329
Change Tolerance	625	4.48	1.441	2.077	-0.331	-0.312
Overall expertise	625	4.36	1.296	1.680	-0.438	-0.206
Valid N (listwise)	625					

Prior to running SWR regression for Percent Success, the observation data were tested for outliers which would have caused the residuals (errors) of the regression line to not be normally distributed. There were 53 cases out of 679 observations with residual outliers greater than 1.500 which were excluded from the predictive model for Percent Success resulting in 626 observations. A variable (Suc_Out_Lie) was added to identify the outliers and was used by the Select Cases function to exclude the outliers.

4.2 Descriptive Statistics

The descriptive statistics for the 36 factors and the Overall Expertise factor included the mean, standard deviation, variance skewness, and kurtosis as shown in Table 1. The mean, standard deviation, and variance of all 36 factors appear to be consistent. The negative skewness and negative kurtosis indicate the distribution is less extreme than a normal distribution and more data is concentrated to the right with the tail extended towards the left. The absolute values of both the skewness and the kurtosis for all 36 factors are within the generally accepted value of 0.80 (Trafimow et al., 2019)

4.3 Reliability and Convergent Validity

The data was analyzed for reliability using Cronbach's alpha (Laerd, 2015a) and convergent validity using average variance extracted (AVE) (Grande, 2016). The scale had a very high level of internal consistency, as determined by a Cronbach's alpha of 0.988 which far exceeded the recommended acceptance level of 0.70. The scale had average variance extracted (AVE) of 0.564 which exceeded the recommended acceptance level of 0.50 indicating the scale measured more variance in the constructs than errors. The scale had composite reliability of .977 which far exceeded the recommended acceptance level of 0.70 indicting all the items consistently measure their corresponding construct.

4.3 Regression Analyses

4.3.1 RQ1 – Stepwise Linear Regression of 36 Expertise Factors versus Overall Expertise Factor

A stepwise regression (SWR) was run to predict Overall Expertise from the 36 expertise factors. After 14 steps, 12 factors were identified as significant contributors to Overall Expertise. There was linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.938. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values, by insignificant results in Kolmogorov-Smirnov and Shapiro-Wilk tests of normality, and by Q-Q plots for unstandardized residuals, standardized residuals, and studentized residuals. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ±3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met, as assessed by a Q-Q Plot. The stepwise regression model statistically significantly predicted Overall Expertise, $F(12, 612)=355.619$, $p < .0005$, adj. $R2=.874$. Twelve variables added statistically significantly to the prediction, $p < .05$.

4.3.2 RQ1 – Ordinal Logistic Regression of 36 Expertise Factors versus Overall Expertise Factor

An ordinal logistic regression (OLR) was run to predict Overall Expertise using both the PLUM and the GENLIN methods from 36 expertise factors. There was no collinearity as assessed by the Tolerance values which were all greater than 0.100 and the variance inflation factors (VIF) which were all less than 10. There were proportional odds, as assessed by a full likelihood ratio test comparing the fit of the proportional odds model to a model with varying location parameters, $\chi 2=0.000$, $p=.1.000$. The probability distribution was multinomial and the link function was cumulative logit. The Omnibus Test indicated that the model outperformed the null model, $\chi 2=1607.474$, $df=216$, $p < .0005$. The tests of model effects identified 17 significant factors.

4.3.3 RQ2 - Stepwise Linear Regression of 36 Expertise Factors versus Percent Success Factor

A stepwise regression (SWR) was run to predict Percent Success from 36 expertise factors. After 3 steps, 3 factors were identified as significant contributors to Percent Success. There was linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.966. There was homoscedasticity, as assessed by visual inspection of a plot of standardized residuals versus standardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were 2 studentized deleted residuals greater than ±3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met, as assessed by a Q-Q Plot. The stepwise regression model statistically significantly predicted Overall Expertise, $F(3, 622)=10.863$, $p < .0005$, adj. $R2=.045$. Three variables added statistically significantly to the prediction, $p < .05$.

4.4 Comparison of Regression Results

The ordinal logistic regression (OLR) results were compared to the results of the stepwise linear regressions (SWR) to select the key factors that appeared in at least two of the three regression models as shown in Table 2.

Table 2 Selection of 10 Significant Expertise Factors

Rank	Factor Label	# Models	Overall Expertise (SWR) Beta	Overall Expertise (SWR) R Square	Percent Success (SWR) Beta	Percent Success (SWR) R Square	Overall Expertise (OLR) Avg Exp(B)	Overall Expertise (OLR) R Square
	Model Correlation Coefficients			0.875		0.050		0.963
1	Change Tolerance	2	0.191				0.317	
2	Leadership	2	0.169				0.255	
3	Communications	2	0.157				0.187	
4	Determine Budget (7.3)	2	0.093				0.353	
5	Validate Scope (5.5)	2	0.081				1.073	
6	Define Activities (6.2)	2	0.066				6.890	
7	Plan Schedule Management (6.1)	2	0.060				0.620	
8	Plan Communications Management (10.1)	2	-0.116				21.958	
9	Attitude	2			0.175		7.948	
10	Control Costs (7.4)	2			0.165		2.170	
11	Control Quality (8.3)	1	0.145					
12	Control Scope (5.6)	1	0.104		-0.127			
13	Create Work Breakdown Structure (WBS) (5.4)	1	0.099					
14	Plan Cost Management (7.1)	1	0.055					
15	Collect Requirements (5.2)	1					6.360	
16	Control Schedule (6.6)	1					1.662	
17	Understand Enterprise Environmental Factors (2.2)	1					1.624	
18	Understand Organizational Process Assets (2.3)	1					0.790	
19	Conflict resolution	1					0.636	
20	Develop Schedule (6.5)	1					0.580	
21	Plan Scope Management (5.1)	1					0.236	

Note 1: Sorted by # Models, Overall Expertise SWR Beta, Percent Success SWR Beta, and Overall Expertise OLR Average Exp(B) descending

Note 2: The top 10 factors were selected because they were significant in both the OLR and the SWR regression results

Table 3 Expertise Strength and Weakness by Expertise Level

Expertise Level / Factor	1 Nov	2 Adv	3 Com	4 Pro	5 Exp	6 Mas	7 Vis	Ove
Change Tolerance	1.4	2.5	3.4	4.2	5.1	5.6	5.7	4.4
Leadership	1.6	2.7	3.4	4.2	5.1	5.8	6.1	4.5
Communications	1.6	2.8	3.5	4.4	5.2	5.8	6.0	4.6
Determine Budget (7.3)	1.5	2.4	2.8	3.9	4.6	5.4	5.9	4.1
Validate Scope (5.5)	1.4	2.5	3.0	3.9	4.8	5.5	5.6	4.2
Define Activities (6.2)	1.6	2.7	3.2	4.2	5.0	5.8	5.9	4.4
Plan Schedule Management (6.1)	1.8	2.6	3.0	4.1	4.9	5.5	5.5	4.3
Plan Communications Management (10.1)	1.6	2.7	3.2	4.1	4.9	5.5	5.5	4.3
Attitude	1.7	3.2	3.6	4.4	5.2	5.8	5.7	4.7
Control Costs (7.4)	1.5	2.5	2.8	3.9	4.7	5.5	5.8	4.2
Manage Team (9.5)	1.8	2.9	3.2	4.3	5.2	5.9	5.9	4.6
Sequence Activities (6.3)	1.4	2.8	3.4	4.2	5.1	5.5	5.8	4.4
Develop Team (9.4)	1.6	2.6	3.2	4.2	5.0	5.7	5.8	4.4
Develop Schedule (6.5)	1.9	2.7	3.2	4.2	5.0	5.8	6.0	4.4
Conflict resolution	1.4	2.9	3.2	4.1	5.0	5.6	6.0	4.4
Manage Quality (8.2)	1.6	2.8	3.1	4.1	5.0	5.7	6.0	4.4
Control Schedule (6.6)	2.1	2.7	3.3	4.1	4.8	5.6	5.7	4.4
Ambiguity tolerance	1.5	2.6	3.3	4.2	4.9	5.5	6.0	4.4
Control Resources (9.6)	1.7	2.5	3.1	4.1	4.8	5.6	5.7	4.3
Control Quality (8.3)	1.6	2.6	3.0	4.1	4.9	5.7	5.7	4.3
Plan Stakeholder Engagement (13.2)	1.5	2.5	3.0	4.0	4.9	5.5	5.9	4.3
Estimate Activity Durations (6.4)	1.5	2.5	3.2	4.0	4.9	5.5	5.6	4.3
Collect Requirements (5.2)	1.8	2.7	3.3	4.0	4.8	5.2	5.4	4.3
Control Scope (5.6)	1.4	2.4	3.1	4.0	4.8	5.6	5.9	4.3
Define Scope (5.3)	1.2	2.4	3.2	4.0	4.8	5.4	5.5	4.2
Plan Resource Management (9.1)	1.5	2.4	3.0	4.0	4.8	5.4	5.4	4.2
Plan Risk Management (11.1)	1.8	2.6	2.9	4.0	4.8	5.4	5.8	4.2
Acquire Resources (9.3)	1.2	2.5	3.1	4.0	4.7	5.4	5.5	4.2
Plan Quality Management (8.1)	1.4	2.6	3.1	4.0	4.7	5.4	5.7	4.2
Estimate Activity Resources (9.2)	1.7	2.6	2.9	4.0	4.7	5.5	5.8	4.2
Create Work Breakdown Structure (WBS) (5.4)	1.4	2.4	3.1	3.8	4.7	5.4	5.3	4.1
Plan Scope Management (5.1)	1.6	2.6	3.1	3.8	4.7	5.1	5.5	4.1
Estimate Costs (7.2)	1.6	2.3	2.8	3.8	4.6	5.4	5.9	4.1
Understand Organizational Process Assets (2.3)	1.5	2.4	2.9	3.7	4.6	5.4	5.5	4.1
Plan Cost Management (7.1)	1.5	2.3	2.9	3.8	4.6	5.4	5.7	4.1
Understand Enterprise Environmental Factors (2.2)	1.4	2.5	3.1	3.6	4.6	5.2	5.4	4.0
Average	1.6	2.6	3.1	4.0	4.9	5.5	5.7	4.3
Standard Deviation	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Average - Standard Deviation (Weakness)	1.4	2.4	2.9	3.9	4.7	5.3	5.5	4.1
Average + Standard Deviation (Strength)	1.7	2.8	3.3	4.2	5.0	5.7	5.9	4.5
N	17	52	97	166	206	119	22	679

Note: Nov=Novice, Adv=Advanced, Com=Competent, Pro=Proficient, Exp=Expert, Mas=Master, Vis=Visionary, Ove=Overall

4.5 Comparison of Likert Expertise Level Strengths and Weaknesses

To illustrate how expertise varied by factor and Likert-type expertise level, the average values of all 36 factors were calculated for each level of expertise and Overall Expertise The values above one standard deviation (Strength) were highlighted light green and the values below one standard deviation (Weakness) were highlighted in yellow as shown in Table 3.

5.0 Discussion

5.1 Regression Analyses

The purpose of the regression study was to identify which of the measured 36 expertise factors significantly correlated and predicted the measured Overall Expertise and measured Percent Success variables. It is important to remember the measured values of the 36 expertise factors represent self-reported assessments by 625 project managers of their skill levels at a point in time. Cronbach's alpha of 0.988, average variance extracted of 0.564, composite reliability of 0.977 indicated internal consistency and significant correlations indicated close alignment between the 36 expertise factors and the Overall Expertise and Percent Success variables.

5.1.1 RQ1 – Stepwise Linear Regression of 36 Expertise Factors versus Overall Expertise Factor

Twelve of the 36 expertise factor variables predicted the Overall Expertise variable (q15_Ove) with statistical significance. The null hypothesis $H1_0$ was rejected and the alternate hypothesis $H1_1$ was accepted. This means that the Overall Expertise level of a project manager can be significantly predicted by accurately measuring only twelve of the 36 expertise factors. The regression equation for the model was:

Predicted Overall Expertise=0.086 + (0.151 * Leadership) + (0.090 * Control Scope (5.6)) + (0.171 * Change Tolerance) + (0.059 * Define Activities (6.2)) + (0.127 * Control Quality (8.3)) + (0.144 * Communications) + (0.087 * Create Work Breakdown Structure (WBS) (5.4)) + (-0.105 * Plan Communications Management (10.1)) + (0.079 * Determine Budget (7.3)) + (0.072 * Validate Scope (5.5)) + (0.052 * Plan Schedule Management (6.1)) + (0.047 * Plan Cost Management (7.1))

When the regression equation was applied to the filtered 625 cases, it predicted the self-reported overall expertise with accuracy rate of μ=1.016, σ=0.136, 80% confidence interval of 1.010 to 1.022, and 95% confidence interval of 1.006 to 1.026.

5.1.1 RQ2 - Stepwise Linear Regression of 36 Expertise Factors versus Percent Success Factor

Three of the 36 expertise factor variables predicted the Percent Success variable (q07_Per_Suc) with statistical significance. The null hypothesis $H2_0$ was rejected and the alternate hypothesis $H2_1$ was accepted. This means that the Percent Success level of a project manager can be significantly predicted by accurately measuring only three of the 36 expertise factors. The regression equation for the model was:

Predicted Percent Success=80.044 + (1.399 * Attitude) + (1.256 * Control Costs (7.4)) + (-0.955 * Control Scope (5.6))

When the regression equation was applied to the filtered 626 cases, it predicted the self-reported percent success with accuracy rate of μ=1.019, σ=0.149, 80% confidence interval of 1.012 to 1.025, and 95% confidence interval of 1.007 to 1.030.

5.1.3 RQ1 – Ordinal Logistic Regression of 36 Expertise Factors versus Overall Expertise Factor

To address the implications of using Likert-type data in multiple regression analysis potentially resulted in substantial loss of information and biased regression coefficients, an ordinal regression was run to independently identify which of the measured 36 expertise factors significantly correlated and predicted the measured Overall Expertise and measured Percent Success variables. Sixteen of the 36 three expertise factor variables predicted the Overall Expertise variable (q15_Ove) with statistical significance. The null hypothesis $H1_0$ was rejected and the alternate hypothesis $H1_1$ was accepted. This means that the Overall Expertise level of a project manager can be significantly predicted by accurately measuring only sixteen of the 36 expertise factors.

5.2 Comparison of Regression Results

By comparing the results of the three regressions, 21 significant factors were identified as shown in Table 2. Eleven factors were eliminated by identifying the intersection of the stepwise (SWR) and ordinal (OLR) regression results, resulting in the selection of 10 factors that appeared in both the stepwise and the ordinal regression results.

The 10 selected factors represented five of the original six expertise factor categories.

- Scope management (1)
- Schedule management (2)
- Cost management (2)
- Quality management (1)
- Resource management (0)
- Soft interpersonal skills (4)

The 10 selected factors of Overall Expertise and Percent

Success were surprisingly disjoint as shown in Table 2. Factors Attitude and Control Costs (7.4) were positively correlated with Percent Success SWR but not correlated with Overall Expertise SWR. Factors Change Tolerance, Leadership, Communications, Determine Budget (7.3), Validate Scope (5.5), Define Activities (6.2), Plan Schedule Management (6.1), and Plan Communications Management (10.1) were positively correlated with Overall Expertise SWR but not correlated with Percent Success SWR.

5.3 Comparison of Likert Expertise Level Strengths and Weaknesses

The average values of all 36 factors were calculated for each Likert level of expertise and overall. The values above one standard deviation (Strength) were highlighted light green and the values below one standard deviation (Weakness) were highlighted yellow as shown in Table 3.

The 7 key areas of strength that were represented in 3 or more Overall Expertise levels in order of importance were Leadership, Communications, Attitude, Manage Team (9.5), Sequence Activities (6.3), Develop Schedule (6.5), and Conflict Resolution.

The 6 key areas of weakness that were represented in 3 or more skill levels in order of importance were Determine Budget (7.3), Create Work Breakdown Structure (WBS) (5.4), Estimate Costs (7.2), Understand Organizational Process Assets (2.3), Plan Cost Management (7.1), and Understand Enterprise Environmental Factors (2.2).

6.0 Conclusion and Recommendations

6.1 Conclusion

The goal of this study to extract key expertise factor variables and to test to what degree they predicted the measured Overall Expertise and Percent Success variables was accomplished. Both stepwise linear regression and ordinal logistic regression were used to identify the significant factors and only those factors identified by both methods were selected as the top 10 key expertise factors. The self-assessed expertise levels of a broad sample of project managers indicated 8 of 36 expertise factors significantly predicted Overall Expertise while a different 2 of 36 expertise factors significantly predicted Percent Success.

An analysis of the average strengths and weaknesses for each Overall Expertise level showed how the strengths and weaknesses varied as the self-assessed skill level of the participants increased. Most strengths and weaknesses identified in the Advanced Beginner level were passed on to the Competent, Proficient, and Experienced Overall Experience levels. At the Master and Visionary level, totally new strengths and weaknesses appeared, supporting the description by Dorst and Reymen (2004) of the Master as experiencing uneasiness upon realizing standards do not always apply and a nuanced approach is needed based on context and the Visionary as striving to extend the domain by developing and adopting new practices from other domains.

The primary contribution of this paper to the body of knowledge is using project managers' self-assessments of theirs technical and interpersonal expertise to derive a reliable and accurate psychometric framework which can be generalized to predict the Overall Expertise level of project managers. The framework can be applied to self-assessment, peer-assessment, manager-assessment, stakeholder-assessment or a combination of all four in a 360 degree review.

The secondary contribution of this paper is the identification of common areas of strength and weakness in a large sample of project managers of all level of expertise which can be used to support a generalized capability improvement program by which the strengths and weaknesses of an individual project manager are used to prescribe focused skill learning to quickly advance Novice and Advanced Beginners to the Competent and Proficient levels by addressing specific technical process and interpersonal skill areas. This is especially important as, during our qualitative interviews, "accidental" project managers reported they were thrown into new responsibilities for which they have had no training and little or no management guidance.

6.2 Recommendations

Recommendations for future study are the development of an independent web-based tool for expertise assessment to be used to compare subjective assessments to empirical scores for use by all members of the project organization to learn about their blind spots. The tool would provide a quick 15 minute spot-check of project management expertise without the need for hours-long certification tests. The tool could also provide a basis for reconciling the perceptions of project employees and their managers as well as providing a baseline and longitudinal measure of career development needs and progress.

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