Project Management Maturity Model for the Mining Sector: A Focused Analysis in the Colombian Context

Miguel Angel Ospina Usaquen [1], Elkin Edilson Delgado Sua [2], Jorge Hernan Torres Berrio [3].

1. *Universidad Distrital Francisco Jose de Caldas; maospinau@udistrital.edu.co; https://orcid.org/0000-0001-5335-1910*
2. *Universidad El Bosque; eedelgado@unbosque.edu.co; https://orcid.org/0000-0002-7202-9991*
3. *Université de Montreal; jorge.hernan.torres.berrio@umontreal.ca; https://orcid.org/0000-0003-2963-0906*

Abstract: This study aims to evaluate the project management maturity level of the mining department at Acerías Paz del Río S.A., a key steel production company in Colombia [1], using a Project Management Maturity Model (PMMM). The research follows a concurrent triangulation design, according to Creswell (2009) [2], and employs a mixed-methods approach to address the issue of low efficiency in project management within the mining operations of the organization. A comprehensive literature review and state-of-the-art analysis were conducted to identify the most relevant maturity models, ultimately selecting the Prado-MMGP model as a guide for diagnosing and improving the department's maturity level. The diagnostic results reveal the current state of project management processes and propose an improvement plan aligned with the organizational capabilities and needs. The conclusions highlight the necessary actions to increase project management maturity and the implications in terms of time, cost, and profitability of implementing the recommended improvements using the Prado-MMGP model [3].

Keywords: Project management; Project Management Maturity Model; Mining Sector; Strategic Project Management; Organizational Improvement

MODELO DE MADUREZ EN GESTIÓN DE PROYECTOS PARA EL SECTOR MINERO: UN ANÁLISIS ENFOCADO EN EL CONTEXTO COLOMBIANO

Resumen: Resumen: Este estudio tiene como objetivo evaluar el nivel de madurez en la gestión de proyectos del departamento de minería de Acerías Paz del Río S.A., una empresa clave en la producción de acero en Colombia[1], utilizando un Modelo de Madurez en Gestión de Proyectos (PMMM). La investigación se enmarca en un diseño de triangulación concurrente, siguiendo a Creswell (2009)) [2], y emplea un enfoque mixto para abordar el problema de la baja eficiencia en la gestión de proyectos mineros dentro de la organización. Se realizó una revisión exhaustiva de la literatura y un análisis del estado del arte para identificar los modelos de madurez más relevantes, seleccionando finalmente el modelo Prado-MMGP como guía para el diagnóstico y mejora del nivel de madurez del departamento. Los resultados del diagnóstico revelan el estado actual de los procesos de gestión de proyectos y proponen un plan de mejora alineado con las capacidades y necesidades organizacionales. Las conclusiones destacan las acciones necesarias para incrementar la madurez en la gestión de proyectos, así como las implicaciones en términos de tiempo, costo y rentabilidad de implementar las mejoras recomendadas utilizando el modelo Prado-MMGP [3].

Palabras clave: Gestión de proyectos; Modelo de Madurez en Gestión de Proyectos; Sector de Minería; Gestión de Proyectos Estratégicos; Mejora Organizacional.

Introduction

A. Context and Importance

This research is based on Project Management Maturity Models (PMMM), which provide structured responses to deficiencies causing project failures. Initially proposed in 1991 by the Software Engineering Institute (SEI) through its Capability Maturity Model (CMM) [4], PMMMs have evolved significantly. Scholars such as Grant & Pennypacker [5] and Kerzner [6] have identified over 30 PMMMs in the market. Benefits of these models include increased project success probability [7], a formal tool to compare maturity with competitors [5], identification of organizational strengths and weaknesses [6], higher customer satisfaction [8], enhanced employee productivity, cost and rework reduction, stronger alignment between strategy and execution, increased market share, and improved competitive advantage [8]. Kwak et al. [9] highlight three common elements among different models: an evaluation instrument to determine the current organizational level, a body of knowledge serving as a standard, and a plan for sustainable improvement strategies. Among the most recognized frameworks are the Capability Maturity Model Integration (CMMI) [4], the Organizational Project Management Maturity Model (OPM3) by the Project Management Institute (PMI) [8], and the Prado-MMGP model [3].

B. Current Research and Problem Statement

Several studies underscore the relevance of maturity models in project management. Backlund et al. [10] emphasize the importance of selecting appropriate models for comprehensive maturity evaluation. Jamrozy et al. [11] found that project management maturity in Polish mining companies correlates with the ability to select and manage a project portfolio that aligns with strategic objectives.

Given the constant changes and threats faced by mining companies in Colombia, PM maturity is crucial for managing complex situations [10]. Macroeconomic volatility, inefficiencies in Colombian environmental law [12], and legal uncertainties in environmental licensing for mining projects [13] are major concerns for leaders in Colombia and Latin America [14]. The mining industry must adopt strategies to manage project complexity and navigate these uncertainties effectively. Data from the Project Management Institute's Pulse of the Profession report [15] show that "highly mature organizations outperform those that are not." Furthermore, 11.4% of investment is wasted due to poor project performance, and "organizations that underestimate PM as a strategic competence report over 67 percent of their projects fail outright" [15]. Developing or applying PMMMs is crucial for project-intensive organizations, such as engineering teams proposing projects to ensure sustainable mineral exploitation. In the case of Acerías Paz Del Rio S.A., the mining vice presidency is responsible for supplying raw materials to Colombia's only integrated steel mill, producing 22% of the country's steel [16].

C. Objectives and Significance

This study aims to assess the project management maturity level of the mining department at Acerías Paz del Río S.A., a prominent steel producer in Colombia. Utilizing the Prado-MMGP model, the research follows a mixed-methods approach within a concurrent triangulation design [2]. The goal is to identify inefficiencies in project management and propose an improvement plan tailored to the department's capabilities. The study underscores the necessary actions to enhance project management maturity, detailing the implications on time, cost, and profitability of implementing the recommended improvements [3].

Theoretical framework

Fabbro & Tonchia [17] present the most recent comprehensive review of PMMM, based on bibliographic research where they managed to summarize the main models classifying them according to three aspects and also by their level of complexity (See Table 1).

Table 1. *Main maturity models in project management*

Aspect	PMMM Model	Author(s)	Complexity	year
Major PM Organizations	IPMA Delta	IPMA	Medium	2016
	P3M3/P2MM	Axelos/Prince 2	Medium	2006
	OPM3	PMI	High	1998
Number of citations found in databases	CMMI	Humphrey	High	1998
	KPMMM/KPM3	Kerzner	High	2002
	Berkeley/PM2	Ibbs & Kwak	Medium	2000
	PMMM	PM Solution	Medium	2002
	P2M3/MMGP	Prado	Medium	2010
Recently published models	NPM3	Seelhofer & Graf	Low	2018
	MMM	Langston & Ghanbaripour	Low	2016
	SPM3	Silvius & Schiper	Low	2015

Source: [17]

State of the art

As a result of a systematic search in databases and the Google Scholar platform, it was evident that there are very few research studies or articles published that are open to the research community and that have some kind of relationship with mining companies or organizations. Six (6) academic articles were found that describe or analyze the implementation of some type of model to promote maturity in project management in mining companies (see Table 2).

Table 2. *Publications related to the implementation of project management maturity models in mining industry.*

Research Title	Author(s)	Year	Keywords	Country	PMMM
The research of project maturity in mining service enterprises in Poland [11]	Jamrozy, J. Wodarski, K. Sorychta-Wojsczyk, B.	2020	Project Management, Project Maturity, mining service enterprise.	Poland	Spaÿek (2013)
Project Management Maturity: An assessment of Maturity for Developing Pilot Plants [18]	Mittermaier, HK. Steyn, H	2009	Project Management, Maturity Assessment, Pilot Plants	South Africa	"Project Management Maturity Model" by J. Kent
Project Management Maturity Models – A critical Review A case study within Swedish engineering and construction organizations [10]	Backlund, F. Chronéer, D. Sundqvist, E	2014	Project maturity, project management maturity, project management maturity models	Sweden	P3M3 model
Gerenciamento De Projetos: Uma Análise Da Maturidade Do Setor De Mineração [19]	Rago Cardoso, D. Ziviani, F. Borges Duarte, L. O.	2017	Engineering, Project Management, Mining, Maturity Models.	Brazil	Prado MMGP
Grado De Madurez Organizacional En La Gestión De Proyectos De La Corporación JKYS S.A.C-2019:	Zurita Neira, R. E.	2020	Project Management, Maturity Assessment, Construction Companies	Peru	PMI - OPM3

Propuesta De Diseño De Una Project Management Office (PMO)[20]	Neira Neira, K. D. Pinto Velasquez, R. Artega Rojas, J. S. A. Ibarra Fierro, J. A.				
Case Study on Project Management at a Mineral Sand Organization[21]	Nhlengethwa , N. Van der Lingen, E.	2014	Project Management, Maturity Model, mining Industry	South Africa	Combination of several PMMM

Methodology

Methodological Approach

A mixed-methods research approach was adopted to obtain a comprehensive and in-depth understanding of the studied phenomenon, integrating both quantitative and qualitative data [22]. This approach was selected to achieve a more complete and enriched perspective on the subject, employing a concurrent triangulation strategy that allows for simultaneous collection of quantitative and qualitative information, thereby achieving cross-validation of the results [2].

Research Design

The research design was structured in several phases to ensure rigorous and coherent data collection and analysis.

Phase 1: Literature Review: A comprehensive literature review and state-of-the-art analysis were conducted to identify the most relevant maturity models, ultimately selecting the Prado-MMGP model as a guide for diagnosing and improving the department's maturity level [3].

Phase 2: Data Collection Instruments: Several carefully selected and validated data collection instruments were employed: Diagnostic Questionnaire: Specifically designed to evaluate organizational maturity variables in project management and organizational success, based on recognized models such as that proposed by Prado and according to the knowledge areas established in the PMBOK of PMI [23]. The primary data collection document used was the questionnaire proposed by Dr. Darci Prado in his MMGP model, adapted and configured in "Google Forms" to facilitate distribution and collection. Face-to-Face Interviews: To complement and enrich the quantitative data, face-to-face interviews were conducted with 6 professionals selected based on Prado's recommendations [3]. These interviews recorded strengths and weaknesses identified by the respondents, providing additional insights and clarifications of any doubts or ambiguities that might arise in the questionnaires.

Phase 3: Sample Selection: The target population of this study was the mining vice presidency of Acerías Paz del Río S.A., consisting of 41 professionals, 80% of whom are dedicated to mining engineering and geology topics, and 72% have over five years of experience in mining projects. Initially, a sample of 25 individuals was selected for the diagnostic questionnaire, achieving a response rate of 60%. Subsequently, a more specific selection of 6 professionals was made based on their profile and experience.

Phase 4: Data Analysis: Descriptive statistical methods and qualitative thematic analysis were used for data analysis. The diagnostic results revealed the current state of project management processes and allowed for the proposal of an improvement plan aligned with organizational capabilities and needs.

Phase 5: Validation: The validation of results was conducted through the triangulation of data obtained from questionnaires and interviews, following methodological guidelines to ensure the reliability and validity of the results.

Results

As part of the methodological process for the development of this project, information collection was carried out at two different moments. In the first, inquiries were made regarding the overall perception of the population regarding basic and general knowledge related to project management. Secondly, the qualitative and quantitative results obtained after applying the questionnaire suggested by Prado's model in its 2.3.0 version from 2021 [24] are presented.

Diagnostic Questionnaire Results

In the diagnostic questionnaire it was possible to identify that the majority of the vice presidency workers do not recognize the existence of an established methodology to manage projects, however, they also agree that the efficiency, effectiveness and maturity of the vice presidency is fair to good giving a score of 7 out of 10.

Table 3. *recognition of a methodology to manage projects*

Question	Yes	No
Do you consider that the Vice Presidency has a standardized and structured methodology for planning and executing projects?	44%	56%

Table 4. *Perception of the level of effectiveness, efficiency and maturity of the vice presidency to manage projects on a scale of 1 to 10, where 1 is low and 10 is high.*

Variable	Frequency								Total Results	
	3	4	5	6	7	8	9	10	average	mode
Effectiveness		1	1	5	11	6	1	0	**6.9**	**7**
Efficiency	1	3	2	3	6	7	3	0	**6.7**	**7**
Maturity	1	2	1	3	8	6	2	2	**7.0**	**7**

Prado-MMGP Model Questionnaire Results

Applying the Prado questionnaire as per the described methodology yielded a project management maturity level of 1.98. This suggests that the vice presidency has a foundational understanding and implementation of project management tools, falling short of the desired level of 3.0, which is considered optimal by the vice presidency's team members. Upon reviewing adherence by maturity levels, a more significant gap is evident in levels 1 and 2 compared to the desired benchmarks. Similarly, when assessing adherence by dimensions, comparable gaps are found across each dimension.

Table 5. *Quantification of the maturity level achieved according to the Prado MMGP model.*

Variable	Current	Wanted
Level of organizational maturity in project management according to the Prado MMGP model	**1,98** (Known)	**3,0** (Standardized)

Figure 1. *Adherence by maturity levels in the MMGP model*

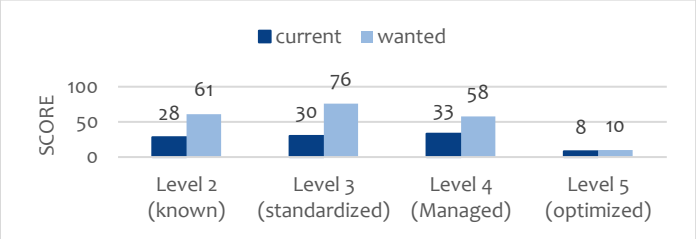
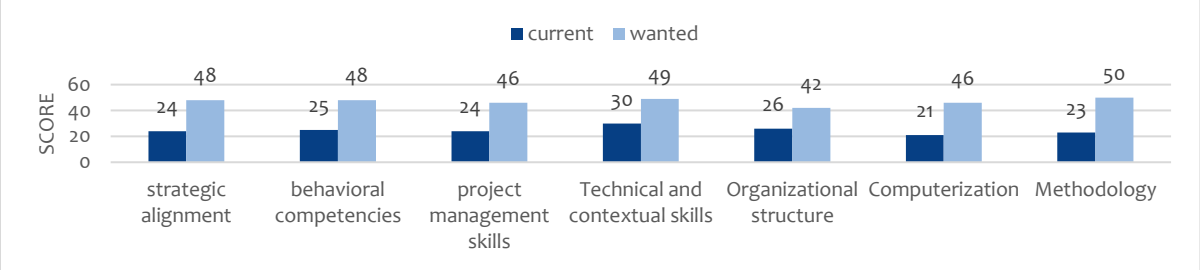
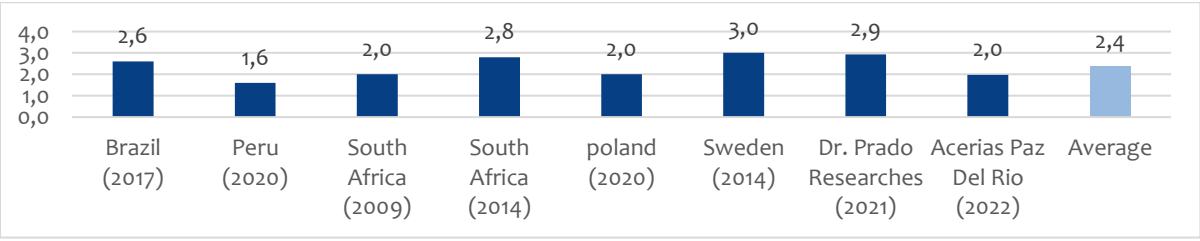


Figure 2. *Adherence by Dimensions of Maturity in the MMGP Model*



By leveraging the consistent 5-level maturity structure across various project management maturity models, we can effectively compare them. Based on this comparison, the mining vice presidency of Acerías Paz del Rio falls below the average maturity level of the organizations referenced in the literature. The average maturity level across these organizations is determined to be 2.4.

Figure 3. *Benchmarking vs previous research*



Source: [10], [11], [19], [20], [21], [25]

Conclusions

In the realm of international mining projects, there is a notable lack of published works or case studies focusing on project management processes through maturity models. Most organizations examined display a medium to low maturity level, underscoring the need to bolster maturity in this domain.

Specifically, for the Mining Vice Presidency of Acerías Paz del Río S.A., this research revealed a project management maturity level of 1.98, which is considered low. The analysis of the quantitative and qualitative data collected showed that 56% of respondents do not perceive a standardized and structured methodology for project management. Additionally, the scores for effectiveness, efficiency, and maturity were all below 7, indicating significant areas for improvement.

Using Prado's maturity model [3], key deficiencies in project management were identified, including insufficient staff training, lack of standardized policies and governance structures, and poor integration of project-related information. The implementation of an Integrated Project Management System (PMIS) is recommended to address these issues and improve project management processes.

Despite these challenges, the department's technical and contextual capabilities stand out as strengths, likely due to the extensive experience of its staff in mining. Compared to other international mining organizations, Acerías Paz del Río has a maturity level of 2.4, below the average of 2.8-3.0 observed in other reference companies, highlighting the need to improve its project management practices.

A project proposal is thus put forward to elevate project management practices, aiming to enhance the efficiency and effectiveness of project delivery. The goal is to reach maturity level 3 within 2 years and 4 months, based on the Prado-MMGP model. This initiative focuses on four pillars: training, governance, standards and policies, and PMIS implementation. A dedicated team led by a project management expert will oversee the project's execution. It is estimated that an investment of $210,000 will be required for the implementation of this project, with the expectation of achieving a return on investment (ROI) of 40%. This significant investment reflects the commitment to ensuring adequate resources are allocated to support the project's success and maximize its long-term benefits.

References

[1] ANDI, «El Acero Colombiano - Columna Vertebral Para el Progreso del País, » Bogotá, Oct. 2018. Accessed: Jun. 28, 2022. [Online]. Available: http://www.andi.com.co/Uploads/LIBRO%20ACERO%20FINAL%20-%20BAJA.pdf

[2] J. W. Creswell, «The Research Design: : Qualitative, Quantitative, and Mixed Methods Approaches, » 3rd ed. SAGE Publications, Inc., 2009.

[3] D. Prado, «Maturidade em Gerenciamento de Projetos, » 3rd ed., vol. 7. FALCONI Editora, 2015.

[4] M. C. Paulk, B. Curtis, M. B. Chrissis, and C. V Weber, «Capability Maturity Model SM for Software, Version 1.1, » 1993. [Online]. Available: http://www.rai.com

[5] K. P. Grant and J. S. Pennypacker, «Project management maturity: An assessment of project management capabilities among and between selected industries, » *IEEE Trans Eng Manag*, vol. 53, no. 1, pp. 59–68, Feb. 2006, DOI: https://doi.org/10.1109/TEM.2005.861802

[6] H. Kerzner, «Using the Project Management Maturity Model: Strategic Planning for Project Management, » 3rd ed. Hoboken, New Jersey : John Wiley & Sons, Inc., 2019.

[7] R. D. Archibald, D. Prado, W. Agnelo De Oliveira, and D. Von Sperling, «Project Management Maturity: General Report 2012 Summary Version, » 2013. [Online]. Available: www.maturityresearch.com

[8] Project Management Institute., «Organizational project management maturity model, » Third Edition. Newtown Square, Pennsylvania 19073-3299 USA, 2013.

[9] Y. H. Kwak, H. Sadatsafavi, J. Walewski, and N. L. Williams, «Evolution of project based organization: A case study, » International Journal of Project Management, vol. 33, no. 8, pp. 1652–1664, Nov. 2015, DOI: https://doi.org/10.1016/j.ijproman.2015.05.004

[10] F. Backlund, D. Chronéer, and E. Sundqvist, «Project Management Maturity Models – A Critical Review - A case study within Swedish engineering and construction organizations, » Procedia Soc Behav Sci, vol. 119, pp. 837–846, Mar. 2014, DOI: https://doi.org/10.1016/j.sbspro.2014.03.094

[11] J. Jamrozy, B. Sorychta-Wojsczyk, and K. Wodarski, «The research of project maturity in mining service enterprises in Poland, » Organization & Management Scientific Quartely, vol. 2020, no. 49, 2020, DOI: https://doi.org/10.29119/1899-6116.2020.49.5

[12] C. M. Gafner-Rojas, «El Derecho Internacional Ambiental y su reflejo en Colombia, » Departamento de Publicaciones Universidad Externado de Colombia, 2018. Accessed: Jun. 28, 2022. [Online]. Available: https://publicaciones.uexternado.edu.co/gpd-el-derecho-internacional-ambiental-y-su-reflejo-en-colombia-9789587729689.html

[13] C. A. Zárate Yepes, N. A. Gómez Quintero, D. Castaño Torres, and V. Gil Hernández, «Análisis de los tiempos para el otorgamiento de la licencia ambiental en Colombia, » *Estudios de Derecho*, vol. 73, no. 161, pp. 205–225, Jun. 2016, DOI: https://doi.org/10.17533/udea.esde.v73n161a10

[14] PwC, "Encuesta Global Anual de Presidentes PwC 2022, » Publicaciones CEO Survey, 2022. Accessed: Jun. 28, 2022. [Online]. Available: https://www.pwc.com/co/es/publicaciones/ceo-survey-colombia.html

[15] Project Management Institute, «PMI 2020 Pulse of the Profession ® Report 2 In-Depth Report: A New Way Forward, » 2020.

[16] ANDI, «Informe del Sector Siderúrgico 2019 - 2020, » Bogotá, May 2021. Accessed: Jun. 28, 2022. [Online]. Available: http://www.andi.com.co/Uploads/ISS%202019%20-2020%20(2)_637707766668934393.pdf

[17] E. Fabbro and S. Tonchia, «Project Management Maturity Models: Literature Review And New Developments, » Journal of Modern Project Management, vol. 8, no. 3, pp. 31–45, 2022, DOI: https://doi.org/10.19255/JMPM02503

[18] H. K. Mittermaier and H. Steyn, «PROJECT MANAGEMENT MATURITY: AN ASSESSMENT OF MATURITY FOR DEVELOPING PILOT PLANTS, » The South African Journal of Industrial Engineering, vol. 20, no. 1, Nov. 2011. DOI: https://doi.org/10.7166/20-1-86

[19] D. R. Cardoso, F. Ziviani, and L. O. B. Duarte, «Gerenciamento de Projetos: Uma Análise da Maturidade do Setor de Mineração, » Revista de Gestão e Projetos, vol. 08, no. 01, pp. 01–15, Apr. 2017, DOI: https://doi.org/10.5585/gep.v8i1.438

[20] R. E. Zurita Neira, K. D. Neira Neira, R. Pinto Velazquez, J. S. A. Arteaga Rojas, and J. A. Ibarra Fierro, «Grado de Madurez Organizacional en la gestión de proyectos de la corporación JKYS S.A.S - 2019: Propuesta de Diseño de una Project Management Office (PMO), » Universidad Tecnológica del Perú , Lima, 2020. Available: https://repositorio.utp.edu.pe/handle/20.500.12867/3400

[21] N. Nhlengethwa and E. Van Der Lingen, «Case Study on Project Management at a Mineral Sand Organization, » Proceedings of PICMET '14 Conference: Portland International Center for Management of Engineering and Technology; Infrastructure and Service Integration, Kanazawa, Japan, 2014, pp. 2524-2529.

[22] R. Hernández Sampieri, C. Fernández Collado, and P. Baptista Lucio, «Metodología de la Investigación», 6th ed. Mexico: Mac Graw Hill, 2014.

[23] Project Management Institute, «A Guide to the Project Management Body of Knowledge (PMBOK® Guide)–Sixth Edition (SPANISH),» 6th ed. Project Management Institute, 1800.

[24] D. Prado, «Cuestionario de Evaluación de Maduréz: Modelo de Maduréz Prado-MMGP, » 2021. Accessed: Jul. 11, 2022. [Online]. Available: https://maturityresearch.com/wp-content/uploads/2021/06/MADUR%C3%89Z-Modelo-Prado-MMGP-V-2.3.0.pdf

[25] D. Prado, «Pesquisa Maturidade em Gerenciamento de Projetos 2021: Maturidade em Gerenciamiento de Projetos-Brasil 'Indústria da Construção' Indicadores de Desempenho, » 2021. [Online]. Available: www.maturityresearch.com