A Data-Driven Research and Innovation Performance Report Based on IPO Model for Malaysia Higher Education Institutions

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ABSTRACT

This paper demonstrates a systematic method for preparing higher education institution (HEI) a data-driven research and innovation (R&I) performance report based on implementation of the proposed R&I Ecosystem Framework. The ecosystem framework is an Input-Process-Output (IPO) Model and has adopted elements in the Malaysia Research Assessment (MyRA). The method of performance report is designed to present performance achievement levels, enabling relevant stakeholders to plan and implement appropriate action plans. The study begins with mapping MyRA criteria to the proposed ecosystem framework, which encompass input, process, and output, to form a complete and holistic R&I ecosystem view. Data for each criteria were analyzed using Microsoft Excel, and visual representations such as radar charts, statistical graphs, pie charts, and bell curve charts were prepared for reporting. The application of this IPO-based framework, coupled with strategic data visualization techniques, moves data-driven R&I performance reporting beyond descriptive accounting to become a powerful diagnostic and strategic tool. The results identified strengths and weaknesses (gaps) in specific R&I criteria, aiding top management and relevant responsibility R&I offices in formulating actionable plans to bridging the performance gaps and ultimately enhancing the HEI's overall R&I ecosystem, directly supporting the national agenda for improved R&I excellence and global competitiveness.

Keywords: Research and Innovation, Performance Reporting, Data Analysis, Input-Process-Output (IPO) Model, MyRA

INTRODUCTION

Research and innovation (R&I) are fundamental pillars of higher education institutions (HEIs), serving as critical drivers of academic excellence, economic growth, and societal impact [1][2]. The performance of HEIs in these domains is increasingly scrutinized, not only for national ranking purposes but also for their contribution to addressing complex global challenges and fostering sustainable development [3]. In response, governments and educational authorities worldwide have established performance-based research assessment frameworks to evaluate, benchmark, and stimulate the quality and impact of academic research [4] [5].

In Malaysia, this evaluative role is fulfilled by the Malaysia Research Assessment (MyRA), a comprehensive instrument designed to measure Research, Development, Innovation, Commercialization, and Economy (RDICE) activities across HEIs. MyRA is inspired by the growing recognition of the role of knowledge creation and innovation in national socio-economic development [6]. It assesses HEIs across a spectrum of criteria, from input factors like human resources and facilities to output metrics such as publications, citations, innovations and professional services [7]. Consequently, HEIs are under sustained pressure to formulate and implement strategic initiatives that enhance their RDICE excellence and achieve outstanding MyRA ratings to bolster their national and global visibility [8].

A key challenge for HEI management, particularly for the offices of Deputy Vice-Chancellors of Research and Innovation, is the transition from mere data collection to strategic, data-driven decision-making [9]. Effective performance management requires more than periodic reporting; it necessitates a holistic understanding of the entire R&I ecosystem to identify strengths, diagnose weaknesses, and allocate resources efficiently [10] [11]. Traditional reporting methods often present data in silos, failing to illustrate the dynamic interrelationships between inputs, processes, and outputs, which is crucial for strategic intervention [12].

The Input-Process-Output (IPO) model offers a robust theoretical lens to address this gap. As a systems theory framework, it provides a structured overview of how resources (Inputs) are transformed through activities (Process) into results (Outputs) [13] [14]. When applied to R&I management, the IPO model can offer a clear and systematic view of performance, making it easier to pinpoint where gaps originate and where strategic actions are most needed. However, while the IPO model is well-established, its explicit integration with national assessment frameworks like MyRA to create a practical performance reporting tool remains underexplored.

Furthermore, the power of any framework is unlocked through effective data analysis and visualization. Data visualization techniques, such as radar charts and statistical graphs, are proven to enhance the comprehension of complex datasets, enabling stakeholders to quickly grasp trends, comparisons, and gaps that might be obscured in raw data or tabular reports [15]. The synergy of a coherent conceptual framework like IPO with advanced data analytics represents a significant opportunity to improve strategic R&I management in HEIs.

Therefore, this paper demonstrates a systematic method for preparing HEI R&I performance reports by implementing a proposed Research and Innovation Ecosystem Framework based on the IPO model and mapped to MyRA criteria. This study begins by mapping MyRA criteria to the IPO framework to form a complete ecosystem view. Subsequently, it details how data for each criteria were analyzed and visualized using accessible tools like Microsoft Excel to generate actionable insights for top management and relevant responsibility R&I offices. The ultimate aim is to provide a holistic and systematic reporting method that not only tracks performance but also actively informs strategic planning and continuous improvement in the R&I domain.

Input-Process-Output (IPO) Model and MyRA Criteria Mapping

Research is an important element in the excellence of a university. It plays a significant role in exploring new knowledge and innovations. Outstanding research and innovation outcomes have a profound impact, not only on the advancement of knowledge but also on societal progress and well-being. Additionally, they address challenges faced by industries and communities. MyRA evaluates three main aspects: input, process, and output, covering eight criteria as outlined in Table 1. Consequently, HEIs have formulated and implemented strategic initiatives to enhance RDICE excellence and achieve outstanding MyRA ratings.

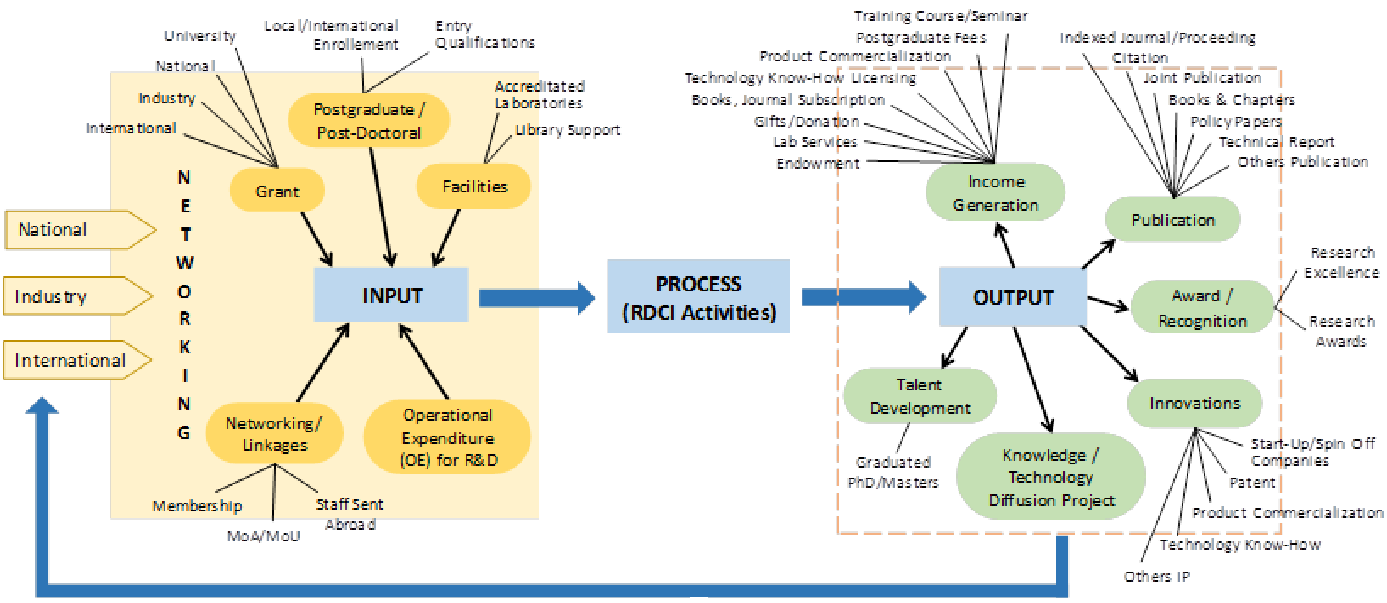

Fig. 1 Summary of the research and innovation ecosystem based on MyRA criteria mapping, covering input, process, and output (IPO)

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Table 1 MyRA Criteria (2023 Amendment) by Section

Sections	**MyRA Criteria**
A	General Information
B	Quality and Quantity of Researchers
C	Quality and Quantity of Research
D	Quality and Quantity of Postgraduates
E	Innovation
F	Professional Services and Awards
G	Networking and Outreach
H	Support Facilities

The IPO model provides an overview of how a system or process functions [14]. It aids in planning, analyzing, and improving effectiveness by clearly outlining the inputs required to initiate a process, how the process operates, and the outputs generated. Applied to research and innovation, the IPO model offers a clear and systematic view of performance achievements, facilitating strategic actions for reducing gaps and enhancing strengths.

MyRA criteria as outlined in Table 1 evaluates three main aspects: input, process, and output. However, the sections are not organized according to these aspects. Thus, a detailed study was conducted to map each MyRA criterion to the IPO model, forming a comprehensive research and innovation ecosystem as shown in Fig. 1.

Outputs also feedback into inputs. For example, research collaborations with industries to develop products and the revenue generated from sales can fund new research projects. Additionally, technologies derived from such projects can be transferred to local communities through Knowledge Transfer Programs.

Inputs for research and innovation include four key elements: funding (Research Grant), human resources (Postgraduate/Post-Doctoral), collaboration (Networking), and research infrastructure (Facilities) is depicted as Fig. 2. The process involves research and innovation activities conducted by researchers using these inputs. Outputs are categorized into publications, innovations, awards and recognitions, income generation, knowledge or technology diffusion project, and talent development.

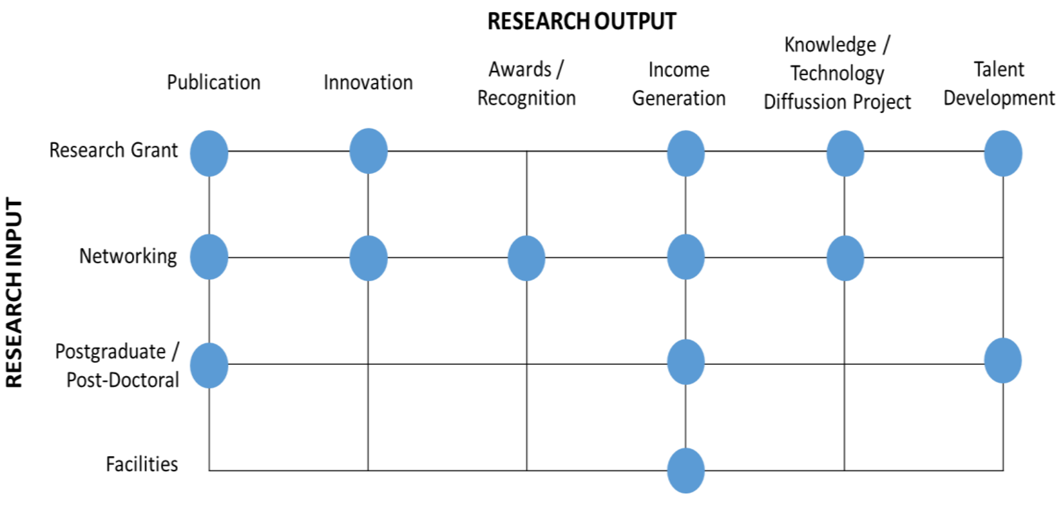

Fig. 2 Relationship between input and output in research and innovation based on MyRA criteria mapping

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Through Strategic Plan based on IPO Model in Fig. 1, HEI in Malaysia aims to achieve a higher MyRA rating to elevate RDICE excellence and enhance its national and global visibility. Typically, Office of Deputy Vice-Chancellor for Research and Innovation is responsible for planning and implementing strategic initiatives to meet this target. To achieve this, current performance must be reported periodically to accurately identify strengths and weaknesses. Based on these gaps, appropriate action plans can be developed, and improvements can be implemented by relevant responsibility office. Therefore, a comprehensive and systematic method for reporting research and innovation performance is essential.

Data Analysis

Data analysis in the context of research performance management is not merely a procedural task of processing numbers, it is a critical exercise in transforming raw data into strategic intelligence. A systematic approach to data analysis, comprising collection, validation, cleaning, transformation, and modelling, is paramount for extracting meaningful insights, drawing valid conclusions, and supporting evidence-based decision-making at both operational and strategic levels [9].

In this study, data pertaining to the mapped MyRA criteria were meticulously collected by appointed Data Managers from various offices and subsequently validated during official MyRA audit sessions as mandated by the Ministry of Higher Education (MoHE). This rigorous process ensures the integrity and reliability of the dataset.

The subsequent analytical phase focused on translating this validated data into accessible and actionable visualizations using Microsoft Excel. The selection of specific chart types was deliberate, each serving a distinct purpose in communicating different dimensions of performance, from holistic overviews to detailed, and criteria specific analyses. The following figures exemplify this approach.

Fig. 3 presents a radar chart, which is instrumental for providing a holistic, multi-dimensional performance profile. This visualization allows for the simultaneous comparison of all key R&I categories against predefined targets or benchmark values. The enclosed area visually represents the overall performance strength, while the asymmetries in the web's shape instantly reveal relative strengths and weaknesses across the ecosystem. Gaps between the achieved performance (the plotted line) and the target (the outer ring) are immediately apparent, directing management's attention to areas requiring strategic intervention, such as 'Innovation' or 'Networking', which may be lagging behind strengths in 'Publications'.

Fig. 3 Radar chart for holistic R&I performance assessment. This chart compares strengths and weaknesses across evaluated categories and highlights gaps from targets or full marks

Fig. 4 utilizes a bar chart to effectively display trends over time. This temporal analysis is crucial for tracking progress, evaluating the impact of past initiatives, and forecasting future performance. For instance, a chart depicting the annual number of postgraduate students or research grants over a five-year period can reveal growth

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trajectories, stagnation, or decline, enabling management to assess the effectiveness of talent development or research culture initiatives.

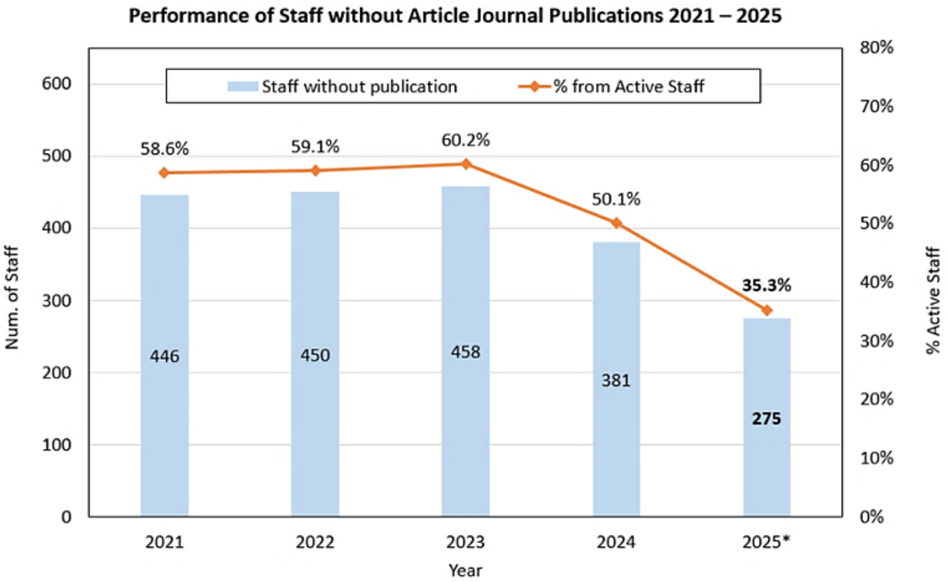

Fig. 3 Bar chart for trend analysis. This chart visualizes performance data over multiple periods (years), revealing growth patterns, stability, or declines in key metrics.

Fig. 5 combines a stacked bar chart with a dot plot to offer a sophisticated analysis of composite scores. The stacked bar can break down an overall score into its constituent sub-criteria, showing the contribution of each to the total. The dot plot, positioned alongside, clearly marks the target value for each category. This side-by-side comparison allows stakeholders to not only see the current achievement level but also to precisely quantify the performance gap for each sub-criterion, facilitating more nuanced and targeted action plans.

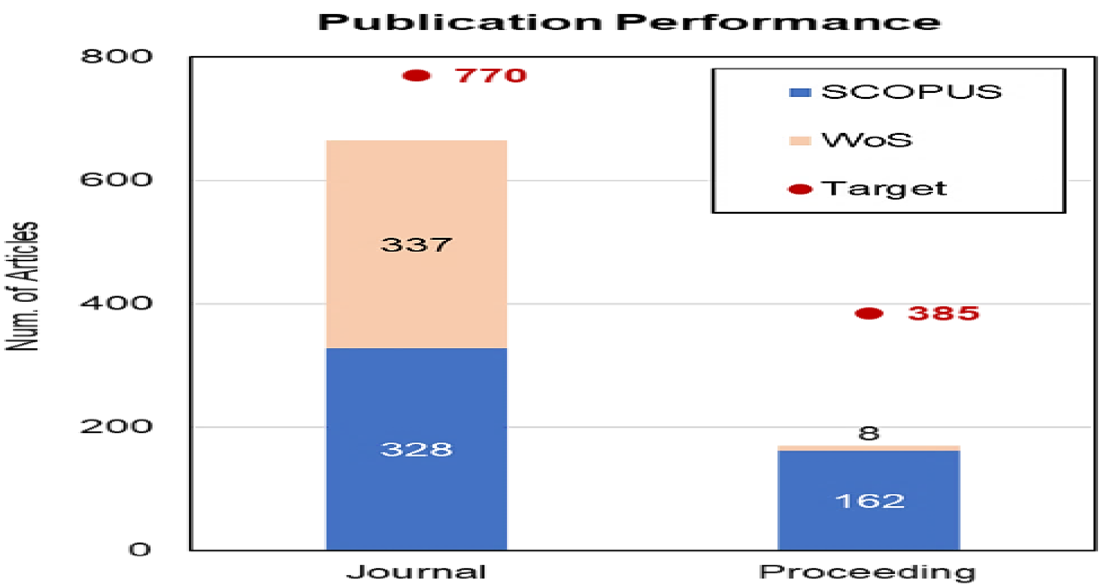

Fig. 5 Composite analysis using a stacked bar chart. This visualization breaks down overall scores into sub-criteria contributions and explicitly marks the target for each, enabling precise gap analysis

Fig. 6 employs a pie chart to illustrate the composition or distribution of a particular R&I output. This is particularly useful for showing proportional contributions, such as the percentage distribution of publications across different faculties, the share of research income from various sources (example, government grants, industry contracts), or the breakdown of innovation types (example, patents, copyrights, prototypes). This helps in understanding the structure of the research portfolio and resource allocation.

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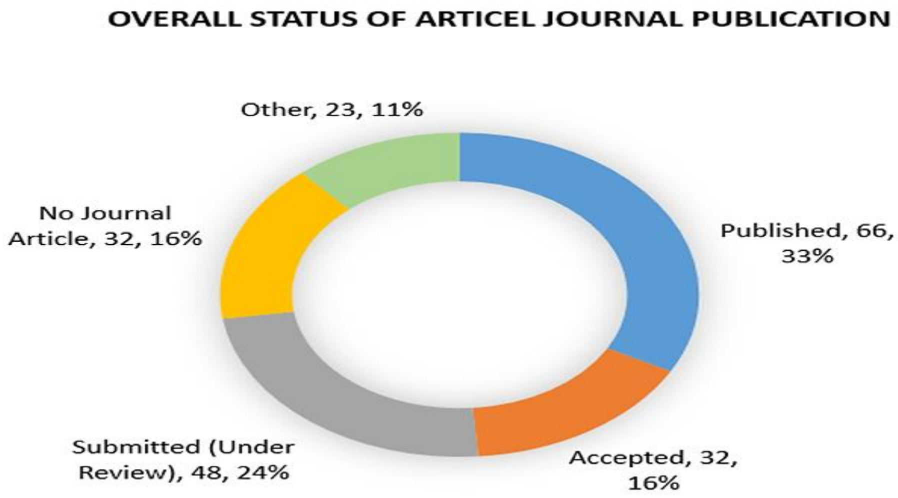

Fig. 6 Pie chart shows the percentage breakdown of a whole into its constituent parts, useful for understanding the composition of different categories

Finally, Fig. 7 features a bell curve chart (normal distribution graph). This statistical visualization is used to analyze the distribution of a dataset, such as the research publication output among academic staff. The chart plots the frequency of individuals against their performance level. It helps identify the mean performance, the variation within the research community, and the presence of high performers (the right tail) and those who may need more support (the left tail). This analysis is vital for designing equitable and effective capacity-building programs and research leadership strategies.

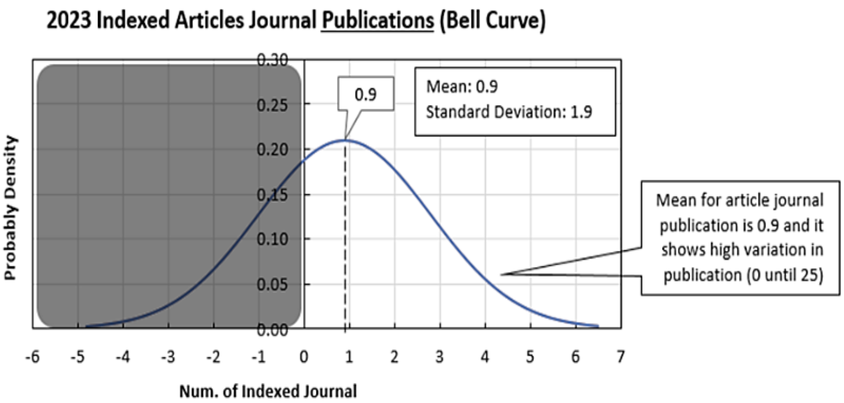

Fig. 7 Bell curve chart for performance distribution analysis. This chart shows the distribution of a performance metric (example., publication count per researcher) across a population, indicating the mean, variation, and the presence of high and low performers

In summary, this multi-faceted data analysis approach moves beyond descriptive statistics. By employing a suite of complementary visualizations, it provides a deep, multi-layered understanding of the university's R&I ecosystem, forming a robust evidence base for the performance reporting discussed in the following section.

Performance Reporting

The final stage is preparing research and innovation performance reports. The ultimate objective of the systematic data analysis is to facilitate strategic performance reporting that directly informs decision-making and action. The transition from analyzed data to an actionable performance report is critical; it is at this stage that insights are contextualized and translated into tangible intervention plans for top management and the relevant responsibility R&I office. The reports generated through this methodology are designed not as static historical records, but as dynamic management tools focused on the MyRA evaluation criteria and the university's strategic plan.

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The integrative approach of this study, which combines the conceptual structure of the IPO model with granular data analysis, empowers stakeholders to answer two fundamental questions: (a) Where in the research and innovation ecosystem (example, in which input, process, or output category) are the most significant weaknesses or gaps? and (b) What is the detailed nature of these performance gaps to inform corrective measures?

Fig. 8 exemplifies this high-level diagnostic function. It displays a performance profile for a specific domain in this case, research project management using a radar chart. This visualization provides an immediate, at a glance assessment of health and performance across key indicators. Management can instantly identify which aspects of project management are strong (example, "Proposal Submission") and which are critical vulnerabilities (example, "Timeframe Management" and "Publication Output"). The distorted shape of the web graphically underscores imbalances in the process, signaling that while the university is effective at initiating research projects, it faces challenges in seeing them through to completion and translating results into market-ready innovations. This high-level gap analysis is the crucial first step that directs managerial attention to the areas of greatest need.

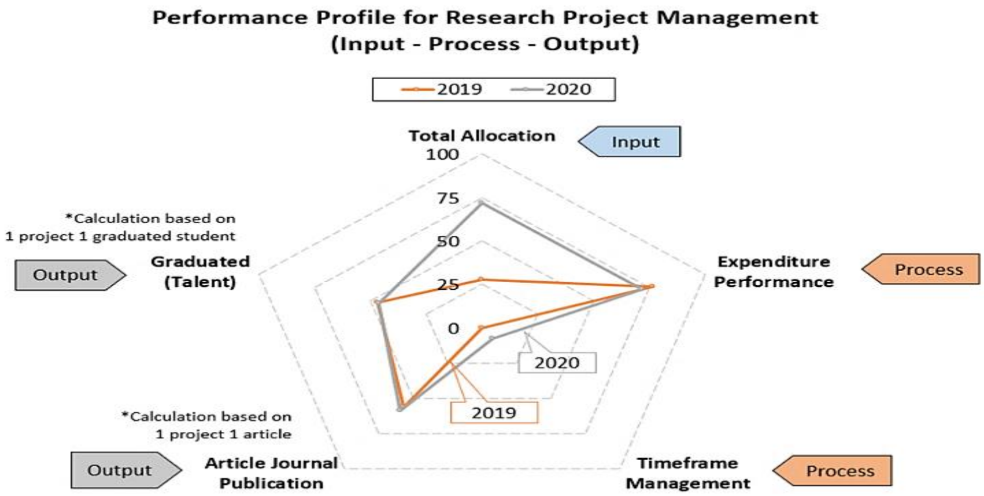

Fig. 8 Performance profile for research project management using a radar chart. This high-level diagnostic tool visually identifies strengths and critical gaps across key process indicators, guiding strategic prioritization.

Once a high-priority gap is identified from the radar chart, Fig. 9 demonstrates the subsequent drill-down analysis. It takes one specific weak item from the performance profile which is Timeframe Management, and provides a detailed breakdown using a stacked bar chart. This moves the analysis from diagnosing what is wrong to understanding why it is wrong.

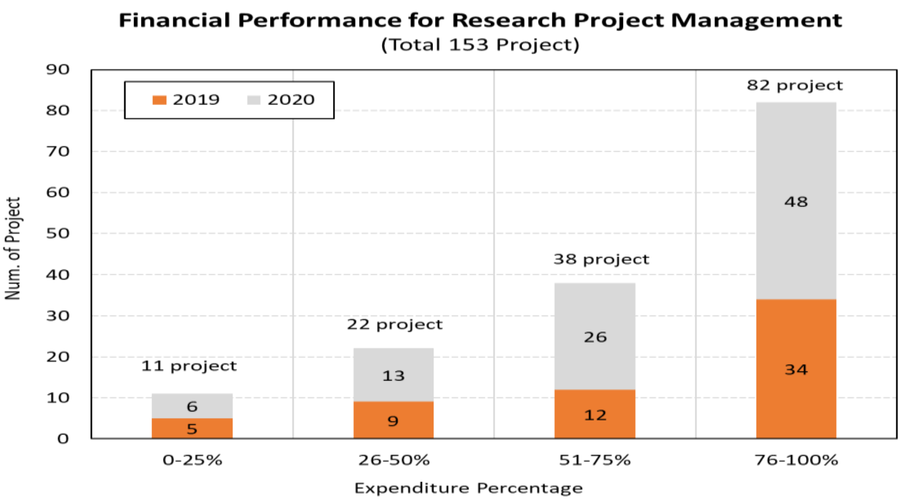

Fig. 9 Detailed analysis of a performance gap using a stacked bar chart. This drill-down visualization deconstructs a key indicator to reveal the underlying causes, enabling the formulation of precise and actionable improvement plans.

The chart reveals the composition of the failure to meet the completion target, breaking it down by the status of ongoing projects. It might show, for instance, a significant portion of projects stalled at the experimental work or data analysis stages, with fewer than expected at the manuscript preparation stage. This granular detail is invaluable for the relevant office, it moves the discussion from a generic "we need to improve project completion" to a specific, actionable insight: "We need to implement targeted research support services, such as data analysis workshops and scientific writing retreats, to help researchers progress from the mid-to-late stages of their projects."

In conclusion, the performance reporting methodology illustrated by Fig. 8 and Fig. 9 creates a powerful feedback loop for research management. The holistic view of the radar chart enables strategic prioritization, while the detailed stacked bar chart facilitates operational planning. This two-tiered reporting structure ensures that improvement efforts are not only data-driven but are also precisely targeted, increasing the likelihood of successfully bridging performance gaps and enhancing the university's overall R&I ecosystem.

CONCLUSIONS

This study has demonstrated the efficacy of a holistic and systematic approach to research and innovation performance reporting by integrating the Input-Process-Output (IPO) model with robust data analysis and visualization. The proposed framework, mapped directly from the MyRA criteria, successfully reframes disparate performance metrics into a coherent ecosystem narrative. This provides a critical structural understanding of how strategic inputs such as search grants, human capital, networking, and facilities are transformed through research activities into a spectrum of outputs, from publications and innovations to talent development and income generation.

The application of this IPO-based framework, coupled with strategic data visualization techniques, moves performance reporting beyond descriptive accounting to become a powerful diagnostic and strategic tool. The multi-level reporting from the holistic overview offered by radar charts to the granular, root-cause analysis enabled by stacked bar charts empowers university management and responsibility R&I office with actionable intelligence. It allows them to not only identify that a gap exists but to pinpoint where in the ecosystem it originates and what its specific nature is, enabling the formulation of precise and effective intervention plans.

In essence, this method bridges a critical gap between raw performance data and strategic action. It provides a replicable model for HEIs to transition from reactive data collection to proactive, evidence-based management of their research and innovation ecosystem. By offering a clear line of sight from inputs to outputs, this approach ensures that improvement efforts are strategically aligned, efficiently targeted, and ultimately, more effective in enhancing institutional research performance and impact in line with national and global benchmarks.

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