

# HYBRID SURVEY TOOL VALIDATION FOR INTERDISCIPLINARY RESEARCH PERFORMANCE MEASUREMENT

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## ABSTRACT

Evaluation of performance within interdisciplinary research and collaboration remains a complex ongoing challenge, as assessing cross-cutting scientific and societal problems is inherently multifaceted. Integrated within a single study, the combined quantitative and qualitative assessment frameworks of collaborative/collective research effort, knowledge synthesis, innovation, and impact guided the development of a hybrid survey interdisciplinary research performance measurement system. The creation of this assessment involved a rigorous, multistep approach consisting of four methodological phases. The development of the survey framework is aligned with the principles of interdisciplinary research encompassing collective factor and criterion development, expert peer review, iterative refinement, and empirical evaluation through a pilot study followed by rigorous statistical validation. Defining the measurement of interdisciplinary impact employed quantitative indicators and qualitative metrics, encompassing integration, collaboration, collective innovation, and impact. To achieve reliability, the study suggested Two metrics of interdisciplinary research performance, the Interdisciplinary Research Performance Score (IRPS) and the Composite Interdisciplinary Index (CII) were developed based on weighted, standardized frameworks and found significant positive results. With a sample of 150 researchers as a pilot, the study achieved positive results showing the frameworks controlled measurement integrity were impactful and valid as constructed. By enabling precise measurement and evaluation, gaining interdisciplinary credibility, and binning indicator thresholds, the frameworks achieved interdisciplinary impact.

**KEYWORDS:** Interdisciplinary Research, Performance Measurement, Hybrid Survey Tool, Validation, Composite Index, Factor Analysis, Research Assessment

## I. INTRODUCTION

Interdisciplinary collaboration is becoming a primary mechanism for dealing with the most intricate problems in the world, which are hard to tackle solely through a single discipline [5]. The expanding interest from various researchers has made the questions concerning the quality, productivity, and impact of the collaboration more pivotal. Evaluation frameworks put in place for interdisciplinary collaboration have systematic challenges. This primarily happens when the performance metrics are overly focused on counting outputs, and on the lack of collaboration, integration, and the dynamic nature of the research. Based on this, there is a need for evaluation frameworks which are qualitative in nature and more relational, tackling the complexities of interdisciplinary research within its design and structure [8]. One of the best ways for closing the evaluation gap is to adopt a mixed method survey framework incorporating both qualitative and quantitative elements. This study concentrates on the design and validation of interdisciplinary research focusing on a hybrid evaluation framework within the qualitative domain [4]. Designed through expert interviews, pilot studies, and rigorous statistical validation, the tool combines qualitative narratives with quantitative frameworks. Some of the key elements include integration of cross disciplinary knowledge, collaborative synergy, innovative

methods, and applicability in real world scenarios [1][6][9]. The validation process ensures the correct functioning of the tool and evaluates its reliability and construct validity while also assessing its relevance and calibration in the domains of science, engineering, social sciences, and the humanities, thus increasing its usefulness [13]. This broad framework of validation enhances the objectivity and trustworthiness of research evaluation and grants, enabling sponsoring institutions and funding organizations to identify and support projects of high visibility and impact with minimal effort.

#### **KEY CONTRIBUTIONS:**

1. Created a combined quantitative-qualitative survey meant to measure interdisciplinary research more holistically.
2. Achieved multiple domain reliability and construct validity as well as overall tool rigor through expert review, pilot testing, and iterative qualitative and quantitative validation, including exploratory factor analysis and internal consistency testing.
3. Developed two standardized scoring systems—Interdisciplinary Research Performance Score (IRPS) and Composite Interdisciplinary Index (CII)—for precise and equitable evaluation of interdisciplinary research outputs, enabling benchmarking.

The paper consists of five sections. The Introduction explains the significance of interdisciplinary research, existing evaluation methods, and why there is a need for a hybrid survey tool. The Related Work section describes how interdisciplinary research is evaluated and the most important gaps in the existing measurement frameworks. The Tool Development and Validation section describes the processes of designing the survey which includes item generation, expert consultations, pilot testing, and validation analyses like exploratory factor analysis and reliability testing. The Results and Discussion section reports the pilot study outcomes, covering factor and reliability based metrics, introducing two performance scoring models IRPS and CII and the interpretations of the models. The paper ends with a section titled Conclusion and Future Work, which addresses the overarching contributions of the study while detailing the the planned tool refinements and additional potential for its use, system of use, and integration into evaluation frameworks.

## **II. RELATED WORK**

Analyzing interdisciplinary work has become increasingly important in relation to social and scientific research due to its growing relevance, but measuring performance in interdisciplinary research still poses challenges [3][10]. Citation and publication counts alongside journal impact factors, which are staple to traditional academic evaluation, ignore the integration of knowledge in interdisciplinary work. Moreover, traditional metrics interdisciplinary research in collaboration, application, and integration [2]. These metrics fail in evaluating collaboration, discipline-specific communication, in relation to interdisciplinary research. Consequently, these tools inadequately portray the true impact and value of interdisciplinary work. To address these issues, scholars are looking into hybrid or mixed-methods frameworks which include quantitative data alongside qualitative reasoning. Some interdisciplinary team evaluation frameworks combine survey tools and performance indicators to assess collaborative processes and outcomes [7]. Other frameworks that evaluate research contribution include self-assessment and peer evaluation alongside innovation-centric metrics [11]. These methodologies show the interdisciplinary work complexity and scope are not easy to measure [12]. All this adds to the existing research gap on there not being universally adaptable and validated tools spanning multiple research fields [14][15]. This emphasizes the development and validation gap of interdisciplinary research frameworks, especially with the lack of a reliable hybrid survey tool to measure interdisciplinary research performance systematically and accurately. Without this tool, institutions and policymakers won't have a reliable basis for evaluation and strategic planning.

## **III. TOOL DEVELOPMENT AND VALIDATION**

This study's methodology focused on the systematic creation, development, and validation of a hybrid instrument designed for interdisciplinary research assessment, which combines a survey and other evaluation methods. The development and validation processes were organized into four distinct phases: item creation, expert review, pilot testing, and statistical validation. To address the evaluation of interdisciplinary research, a comprehensive research-

based evaluation framework and a rigorous qualitative review were conducted to identify relevant quantitative and qualitative interdisciplinary collaboration indicators. The rigor of content relevance and interconceptual clarity was ensured through expert validation in a multidisciplinary academic panel. Afterwards, the refinement was claimed, and interdisciplinary researchers from multiple institutions were surveyed. Respondent data were scrutinized through EFA (Exploratory Factor Analysis) to uncover underlying constructs and refine the scale by dropping weakly loading items while retaining those with strong factor loadings. Reliability in consistency across a multi-dimensional structure was verified and scored through Cronbach's alpha. Chaque respondent's interdisciplinary research performance was measured using a weighted scoring model:

$$IRPS = \sum_{i=1}^n w_i \cdot x_i$$

In this equation, IRPS represents the Interdisciplinary Research Performance Score. Here,  $x_i$  is the response value for the  $i$ th survey item, and  $w_i$  is the corresponding weight assigned based on its factor loading. The total number of survey items is denoted by  $n$ . This equation produces a performance score by summing the product of each item's response and its respective weight, thereby emphasizing the most statistically significant dimensions of interdisciplinary performance. This approach ensures a balanced evaluation that integrates both the strength of item contributions and the depth of participant responses.

To establish the construct validity of the tool, both convergent and discriminant validity tests were carried out. Convergent validity is confirmed when all theorized relevant factors check out and load onto a single factor, while discriminant validity checks that items meant to capture different constructs do not overlap. For all constructs the model's measurement adequacy were tested through calculating average variance extracted (AVE) and composite reliability (CR). Constructs that had AVE values of more than 0.50 and CR scores above 0.70 were deemed acceptable. Also, the tool's internal architecture was examined through item total and inter-item correlations to capture all pertinent concepts while removing weak and redundant items. In order to evaluate the validity and reliability of the tool, the instrument was administered to students from varying disciplines including natural sciences, engineering, humanities, and social sciences. Responses were stratified and analyzed for cross-disciplinary consistency and sensitivity. In addition, the clarity, relevance, and completeness of the survey were evaluated through open-ended questions, with respondents providing feedback. This allowed for some adjustments to be made to the survey and refined through minor changes to the phrasing and structure of some items. The last edit of the hybrid survey tool is an agile instrument which intersects with advanced measures of interdisciplinary cursive and is targeted towards academic institutions, funding bodies and policy makers which are keen on enhancing interdisciplinary collaboration.

#### IV. RESULT AND DISCUSSION

The pilot survey was given to 150 interdisciplinary researchers from different fields of science, engineering, social sciences, and humanities. Their data was analyzed with a survey-based evaluation to analyze the hybrid survey tool, and its reliability, validity, and structural soundness using appropriate statistical software. Through conducting the preliminary Exploratory Factor Analysis (EFA), a definitive four-factor structure was found which was labeled as "Collaborative Engagement, Knowledge Integration, Innovation Potential, and Impact Orientation," and together these factors explained 72.8% of the total variance. All factor loadings were above the 0.60 mark, which reinforces the strength of the item associations within the constructs. Each dimension ranged from 0.78 to 0.89, and the factors loaded to the survey tool, thus confirming strong internal validity using Cronbach's alpha coefficients.

For further model validation, a Composite Interdisciplinary Index (CII) was created to represent normalized performance metrics for all the dimensions for the participants. The formula for the CII is given as follows:

$$CII = \frac{1}{n} \sum_{i=1}^n \left( \frac{x_i - \mu_i}{\sigma_i} \right)$$

The Composite Interdisciplinary Index (CII) is a standardized metric used to compare interdisciplinary research performance across individuals and groups. In this equation,  $x_i$  represents the individual score on the  $i$ th survey item,  $\mu_i$  is the mean score of that item across all respondents, and  $\sigma_i$  denotes the standard deviation of the same item. The summation goes from  $i$  equals 1 to  $n$ , where  $n$  denotes the total number of items. By calculating the z-score of each item and then averaging them, the CII provides a normalized performance index which considers the variability in item distributions. This method reduces systematic errors resulting from differences in scales or the distribution of items and enables unbiased and accurate comparisons of interdisciplinary performance in diverse research participants.

**Table 1: Summary of Reliability and Validity Metrics for Survey Dimensions**

| Dimension                       | Number of Items | Cronbach's Alpha | AVE  | CR   | Variance Explained (%) |
|---------------------------------|-----------------|------------------|------|------|------------------------|
| <b>Collaborative Engagement</b> | 6               | 0.81             | 0.57 | 0.85 | 18.2                   |
| <b>Knowledge Integration</b>    | 5               | 0.78             | 0.53 | 0.82 | 17.5                   |
| <b>Innovation Potential</b>     | 4               | 0.84             | 0.61 | 0.86 | 19.3                   |
| <b>Impact Orientation</b>       | 5               | 0.89             | 0.66 | 0.90 | 17.8                   |
| <b>Total</b>                    | <b>20</b>       | —                | —    | —    | <b>72.8</b>            |

These results affirm that the hybrid survey tool is both reliable and valid an evaluation of interdisciplinary research performance could be conducted. Psychometric evaluation of the tool provided strong factor loadings and high reliability coefficients with the AVE and CR values deemed acceptable which demonstrated the instrument's psychometric strength. The CII's incorporation improves overall evaluation by providing a singular and straightforward metric that is accessible to all researchers irrespective of their academic hierarchy facilitating comparison across all disciplines which is valid and metric driven. The further validation of the results of the tool across different disciplines provides additional proof of the interdisciplinary evaluation relevance in academic and policy decision making.

## V. CONCLUSION AND FUTURE WORK

This study designed and validated a specialized hybrid survey tool aimed at measuring interdisciplinary research collaboration across various fields of academia. The tool's integration of quantitative and qualitative elements helps to address one of the major flaws within interdisciplinary research evaluations – the limitation of many traditional evaluation methods which are overly simplistic. The comprehensive tool also demonstrated robust internal consistency and construct validity with clear factor structure through expert evaluations, pilot testing, and comprehensive statistical validation. With the introduction of two scoring models, the two metrics Interdisciplinary Research Performance Score

(IRPS) and Composite Interdisciplinary Index (CII) provided comprehensive, standardized measurements of individual and collective achievement while incorporating hierarchical importance of specific items to the evaluation and normalization between items. Such results demonstrate the tool's efficacy and usefulness within academic and research institutions, funding bodies, and other organizations that aim to equitably and constructively assess and promote interdisciplinary research activities. As for the next steps, the focus of the work shifts towards the expanding scope and scaling of the tool. It is also expected that a multicultural and multi-institutional dataset will be gathered to broaden the scope and improve the generalizability of the tool. Real-time evaluation and feedback are also envisioned through integration with digital research management platforms. Additionally, other researchers could investigate incorporating longitudinal metrics to assess changing trends of interdisciplinary research performance over extended periods. Last of all, transforming the instrument for application in non-academic settings, like partnership collaborations between industry and academia, as well as in policy research initiatives, would greatly enhance its impact and usability in practical, multidimensional contexts.

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