

Understanding design metrics: A theoretical model for application and evaluation

Adilson Luiz Pinto^I, Júlio Monteiro Teixeira^{II}, Jefferson Lewis Velasco^{III}

^I Department Information Science, Pós-Design, Federal University of Santa Catarina, Brazil.
Corresponding author.
Email: adilson.pinto@ufsc.br
ORCID: 0000-0002-4142-2061

^{II} Design Department, Pós-Design, Federal University of Santa Catarina, Brazil.

^{III} Pós-Design, Federal University of Santa Catarina, Brazil.

ABSTRACT

This article presented a theoretical study that aimed to identify applications of metrics in design. The study drew on established experiences from other fields that employed metric studies. It did so in order to propose an appropriate definition for the design discipline. The objective of this study was to conceptualize the phenomenon of design metrics. The scope was developed through a lexicographic analysis of international literature, using the OpenAlex database to map the range of possible metrics applicable to the design. Subsequently, we developed a theoretical framework based on a heuristic approach, employing artificial intelligence to initially identify relevant metric possibilities. Subsequently, clustering techniques were employed to map the associated disciplines and the contexts in which design was subject to quantification. The study identified three core application domains for design metrics. The initial aspect pertained to user experience, with concomitant extensions into the domain of customer behavior analysis. The second involved metrics applied to the development of systems and software, with a focus on improving the management of services and products. The third was directly connected to the second but emphasized the development of systems oriented toward physical objects or artifacts. The study proposed a theoretical model for design metrics, grounded in the tradition of graphic arts, which defined the key elements for its consolidation: the object of analysis, metric methodology, analytical variables, and mathematical application purposes.

Keywords: process metrification in design; user experience; object-oriented design metrics.

1. INTRODUCTION

RESEARCH concentrating on the implementation of indexes and indicators is designated as metric studies (Lima, 2017) and is observed across diverse fields and domains of knowledge. They serve as a global standard (Alder, 2001) for the utilization of mathematical and statistical units, particularly within

the context of data and technology. The most established representations of metric studies are found in the fields of information and documentation. These include approaches such as bibliometrics (Pritchard, 1969), scientometrics (Nalimov & Mul'chenko, 1969), econometrics (Frisch, 1933), informetrics (Nacke, 1979), and sociometrics (Moreno, 1934), among other types of metrics (Figure 1).

How to cite: Pinto, A. L., Monteiro Teixeira, J., & Lewis Velasco, J. (2025). Understanding design metrics: A theoretical model for application and evaluation. AWARI; 6, 1-10. DOI: 10.47909/awari.833.

Received: 16-04-2025 / **Accepted:** 16-06-2025 / **Published:** 24-06-2025

Copyright: © 2025 The author(s). This is an open access article distributed under the terms of the CC BY-NC 4.0 license which permits copying and redistributing the material in any medium or format, adapting, transforming, and building upon the material as long as the license terms are followed.

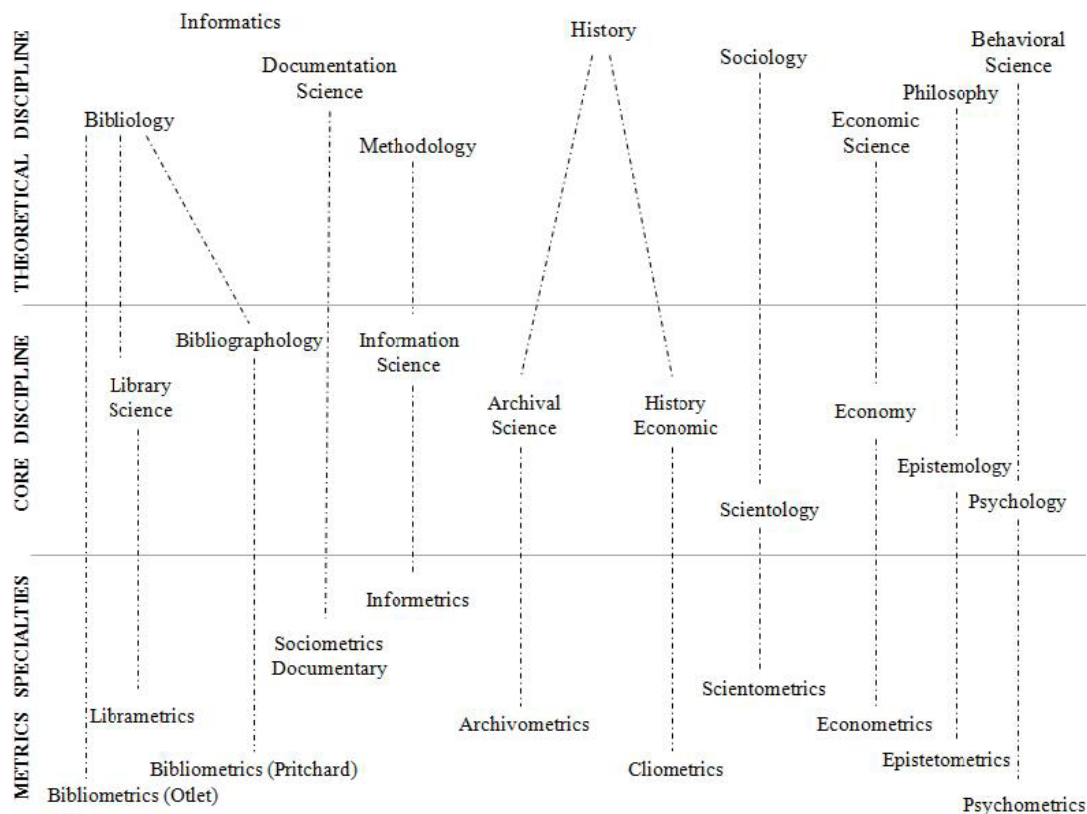


Figure 1. Typologies of information metric studies, disciplines, and fields of knowledge. **Source.** Inspired by Gorbea Portal (2005, p. 127).

Traditional metric study typologies are characterized by shared attributes, which are generally comprised of three primary components: a theoretical domain, a core discipline, and one or more metric specializations (Tague-Sutcliffe, 1992). It is noteworthy that some of these typologies may demonstrate a more extensive scope, not necessarily confined to a single theoretical domain. Webometrics, for example, employs mathematical and statistical methodologies within the web environment, frequently without a cohesive theoretical framework, although computer science often serves as a point of reference. Similarly, altmetrics, which are a means of measuring scientific activity in social media, extend beyond the boundaries of sociology, reflecting a broader interdisciplinary scope. In sum, the model proposed by Gorbea Portal (2005) furnishes a valuable framework for the structuring of metric typologies. However, it must be noted that this classification does not fully encompass all possible variations, particularly those that transcend a single field of knowledge. Another fundamental

aspect of metric studies is their recurring structure, which is predicated on four dimensions: the object of analysis, the method that defines the metric typology, the application variables, and the purpose of the application.

In the context of bibliometrics, the object of analysis encompasses bibliographic information, including books and journals. The analysis encompasses both input and output data, their usability, authority (authors and sources), and publication impact. The bibliometric method is predicated on frequency analysis, ranking construction, and the distribution of bibliographic data. The application variables encompass information circulation, the implementation of bibliometric laws (Lotka, Bradford, and Zipf), and citation networks (Price and Platz). The primary objective of bibliometrics is to quantitatively examine bibliographic activities, thereby supporting resource allocation, staff management, and time planning (McGrath, 1989). It is important to note that other typologies can also be structured following this same framework, as presented in Table 1.

Activities	Object	Method	Variables	Objective
Scientometrics	Disciplines, fields of knowledge, departments, and institutions	Set analysis and co-occurrence analysis, bibliographic coupling, and co-word analysis	Differentiation of subdisciplines, collaboration networks, and scientific communication	Quantitative analysis of scientific activity
Informetrics	Information retrieval, informational communication, and database content	Vector space model, Boolean model, programming languages, and use of thesauri	Keyword extension, information retrieval rates, relevance measures, and recall	Quantitative analysis of information retrieval
Webometrics	Websites, domains, links, URLs, and interaction systems between institutions	Web impact factor, link density, inbound and outbound links, and web mentions	Number of pages per site, number of links per site, and number of retrieved websites	Quantitative analysis of web activity
Altmetrics	Blogs, social media, chats, and the effectiveness of media systems	Open data analysis, monitoring of online publication access, and open scientific communication	Number of downloads, number of accesses, number of social media sources, and country of origin of accesses	Quantitative analysis of audience, social impact, and online presence
Sociometrics	Relationships between words, documents, content, and people	Average of direct and indirect relationships, invisible college concept, and social capital analysis	Relationships between actors, direct and indirect centrality, betweenness, proximity, and metrics such as PageRank	Quantitative analysis of relationships among individuals, groups, and networks

Table 1. Theoretical model of selected metric studies.

Source. Adapted from McGrath's (1989) methodology.

The representation of metric study typologies, extending beyond the documental and informational contexts, has gained prominence when applied to other fields, including Computer Science, Information Systems, and even Visual Programming. Another pertinent context pertains to the application of metrics in the domain of design, a subject that has yielded a substantial corpus of literature addressing its practical applications. However, a conspicuous lacuna exists within the extant literature concerning the conceptual characterization and foundational explanation of the elements constituting this particular metric. Accordingly, this study considers design metrics to be the quantification of the efficiency of product or service design processes. These processes aim to represent solutions within systems and guide their development (Chidamber & Kemerer, 1994). Design metrics have been employed to assess user experience (UX) (Benavides, 2012) and to evaluate the performance of

objects and artifacts, with a focus on ensuring efficient control that balances quality and resources (Fenton, 1991).

This study will examine this perspective on design metrics through an exploration of its forms, applications, reproducibility, and the key elements that should be considered in its formulation. In light of the prevailing metric typologies, it is imperative to delineate the phenomenon of design metrics and address the following fundamental questions: At what point did this phenomenon first appear? What are the primary domains of application? Who are the key stakeholders? Which research fronts should be prioritized? The objective of this study is fourfold: first, to provide a theoretical definition of design metrics; second, to identify the relevant fields; third, to map the methods that have been employed thus far; and fourth, to determine which variables should be prioritized in shaping this particular typology of metric studies.

4

resulting in the retrieval of $n=2007$ records. These records were then cross-referenced with the previous searches to eliminate duplicates. To facilitate data processing and analysis, two specialized software tools were employed: VOSviewer, which maps concept relationships based on co-occurrence and applies algorithms such as PageRank to highlight the most relevant terms, and Iramuteq, which was used to perform semantic relationship analyses among concepts, generating lexical clusters that support the identification of objects of analysis and quantitative objectives within the field of design metrics (Figure 2).

2.1. Heuristic support using artificial intelligence in the metric qualification process

In the metric identification stage, a specific qualification process was conducted that focused on UX and customer experience (CX). The emphasis of this process was on metrics derived from web analytics and data analytics applicable to design. This emphasis is substantiated by the paucity of attention accorded to these metrics within the confines of academic discourse despite their pronounced practical pertinence. To this end, we employed ChatGPT (OpenAI, GPT-4, paid version) as an additional support tool, thereby acting as a semi-autonomous co-analyst. Through structured interactions, the AI assisted in expanding the theoretical and terminological repertoire under the curation and critical validation of the researchers. The employment of AI functioned as a heuristic instrument, thereby enhancing but not supplanting the researchers' analytical judgment. Subsequently, the suggested metrics were cross-checked with the scientific literature to validate and consolidate their applications. The interaction process followed iterative protocols of textual and conceptual refinement. In this process, researchers formulated structured prompts based on previously defined methodological criteria. These criteria included relevance to design, practical applicability, alignment with contemporary practices in digital environments, and instrumentation feasibility through established analysis tools such as Google Analytics and Hotjar.

The AI-generated responses were then subjected to a qualitative evaluation, with the evaluation focused on three key aspects: relevance to the subject matter, theoretical consistency, and alignment with the research objectives. Subsequent to this screening, the researchers selected a subset of the most representative metrics, which was then submitted to a second round of validation by the research group. This second round of validation incorporated terminological adjustments and conceptual refinements as needed. In this context, the employment of generative AI did not supplant the researchers' critical analysis; rather, it served as a heuristic and cognitive amplification instrument. This enabled a more extensive search for pertinent metrics and more agile and in-depth conceptual refinement. This approach is congruent with the emerging discourse surrounding the role of generative models in scientific research, particularly in interdisciplinary domains such as data-driven design.

3. METRICS IN DESIGN TOPICS

Metrics in design activities are defined as quantifiable measures used to evaluate the success, impact, and effectiveness of a design. The applicability of these metrics can be linked to the user's behavior when interacting with products or services and to the level of customer engagement (Schramade, 2017) with system information (Briand *et al.*, 1999). These systems may encompass a spectrum of post-purchase solutions, including loyalty programs, which are designed to enhance the maturity and continuous improvement of products and services. Another salient aspect pertains to the utilization of metrics for the evaluation of conversion rates (CRs) for product or service acquisition. This evaluation encompasses a multitude of factors, including access, the duration of usage, the intuitiveness of the system, user interaction with the design, the percentage of users who successfully complete tasks, and the level of satisfaction that results in recommendations. Metrics offer invaluable data concerning the performance and effectiveness of a given design, thereby supporting data-driven decision-making processes and fostering the continuous improvement of systems (Fenton, 1991) toward achieving positive outcomes.

Key metrics applicable to UX and design performance include: (a) “system usability scale (SUS)” is a technique for evaluating the overall usability of a system (Bangor *et al.*, 2008); (b) “net promoter score (NPS)” measures the likelihood that a user would recommend a product or service (Sasmito *et al.*, 2019); (c) “customer effort score (CES)” assesses the effort required for a user to solve a problem or complete a task within a system (Baba Gnanakumar *et al.*, 2024); (d) “customer satisfaction score (CSAT)” measures the customer’s satisfaction with a specific product or service (Mkpojiogu & Hashim, 2016); (e) “CR” calculates the percentage of users who perform a desired action, such as completing a purchase (Kantalainen, 2018); (f) “time to complete the task” measures the time users take to complete a specific task (Kokubo *et al.*, 2018).

In the context of UX and CX, we also identified a set of metrics widely used in market-driven and digital environments, such as: (a) “task success rate” measures the percentage of tasks that users successfully complete within a system, product, or service (Albert & Tullis, 2013); (b) “customer retention rate” measures the percentage of customers who continue using a product or service over time, which is critical for CX management (Lemon & Verhoef, 2016); (c) “customer lifetime value (CLV)” estimates the net profit generated by a customer throughout their relationship with the company, widely applied in purchase journeys and CX analysis (Kumar & Reinartz, 2016); (d) “time on task” measures the average time users take to complete a specific task (while similar to “time to complete the task,” it is treated as a distinct metric in UX literature, focusing on the average time aggregated per task; Albert & Tullis, 2013); (e) “drop-off rate” identifies at which point in the journey the user abandons the process, such as forms, shopping carts, or registration flows (Ismail & Abdulkareem, 2024); (f) “churn rate” calculates the percentage of users or customers who cancel or stop using a product or service within a given period (Hadden *et al.*, 2007); (g) “customer journey completion rate” measures the percentage of users who complete the entire purchase or service journey as intended, from consideration to conversion (Triolopa, 2022).

Regarding user behavior analysis, additional metrics are equally relevant for assessing design and experience quality: (a) “bounce rate” measures the percentage of visitors who leave the website without interacting (a high rate may indicate issues with design, irrelevant content, or a frustrating experience; Farris *et al.*, 2010); (b) “exit rate” indicates which pages users leave the website from, helping identify critical exit points (Argyres *et al.*, 2013); (c) “pages per session” calculates the average number of pages viewed per session, reflecting the level of user engagement (Schroth, 2025); (d) “session duration” measures the average time a user spends during a session, serving as an indirect indicator of experience quality (Rizzi *et al.*, 2021); (e) “click-through rate (CTR)” evaluates the effectiveness of interactive elements such as banners, buttons, and call-to-actions (CTAs; Meinel *et al.*, 2012); (f) “scroll depth” measures how far users scroll down a page, indicating the level of engagement with the presented content (Cabrera, 2017).

Continuing the same logic of process metrification in design, we also highlight metrics applied to software and system development, aimed at improving the efficiency of product and service management, such as: (a) “quality metrics” are responsible for assessing aspects such as design quality, usability, accessibility, performance, and maintainability (Zage & Zage, 1993); (b) “productivity metrics” measure the efficiency of the design process, considering factors such as time to complete tasks, number of iterations, and development costs (Shaik, 2010); (c) “effectiveness metrics” evaluate whether the design meets user needs and whether the proposed solutions are effective (Shah *et al.*, 2000); (d) “performance metrics” measure the speed and efficiency of the system, including response time, data throughput, and resource utilization (Palmer, 2002); (e) “maintenance metrics” assess the ease of maintaining and updating the system, taking into account factors such as code complexity, readability, and documentation quality (Rombach, 1987).

In parallel with software development and systems engineering, the field of object- or product-oriented metrics (Chidamber & Kemerer, 1994) also plays a crucial role, focusing on evaluating structural and functional properties such as: (a) “encapsulation” measures the ability of

classes to protect their internal data from unauthorized external access, promoting modularity and flexibility (O’Keeffe & Cinnéide, 2003); (b) “cohesion” evaluates the degree to which elements within a class are related, ensuring that classes have well-defined responsibilities (Quah & Thwin, 2003); (c) “coupling” assesses the level of interdependence between classes, aiming to reduce coupling to improve maintainability and reusability (Xia, 1996); (d) “cyclomatic complexity” measures the complexity of control flow within a method, indicating the ease of testing and susceptibility to errors (Selby & Hihn, 2006); (e) “heritage” evaluates the use of inheritance between classes, aiming for a well-structured class hierarchy and avoiding excessive inheritance, which can hinder maintainability (Hess, 2015); (f) “polymorphism” measures the use of polymorphism, which allows different objects to respond differently to the same method, enhancing flexibility and extensibility (Brito e Abreu & Melo, 1996).

4. EXPLAINING THE THEORETICAL MODEL OF DESIGN METRICS AND CONCLUSIONS

The foundation of this typology of metric studies applied to design emerges from three seminal studies: Kitchenham and Linkman (1990) concentrate on the application of metrics for the development of market-oriented software systems. Fenton (1991) broadens the analytical scope by proposing new models for assessing system effectiveness. Chidamber and Kemerer (1994) direct their efforts toward metrics in object- or artifact-oriented systems. A thorough bibliographic analysis reveals that it is during this period that the initial currents and interests in design-related metrics emerge. This framework was subsequently expanded to encompass UX and its associated disciplines. As the construction of this framework progressed, it became evident that the theoretical basis of metrics applied to design is firmly rooted in the fields of software engineering and computer systems development. However, it is imperative to acknowledge that the foundational theoretical discipline are “graphic” and “visual design,” which are oriented toward the creation of products and services, with methodological support from “industrial design.” Systems engineering and computer science provide the technical and

conceptual foundations for metric development. In considering the central discipline, the field of design emerges as a prominent area of focus, characterized by its specialization in metrification, which forms the foundational basis of the discipline known as “design metrics.”

The objective of the analysis is to evaluate the quality and effectiveness of product, service, or system design. To this end, the analysis employs both quantitative and qualitative metrics to assess UX and design performance. In regard to the methodological approach, design metrics utilize a variety of techniques, including CRs, user engagement, task completion time, success rates, NPS, user behavior analysis, interaction with interface elements, response times, error tracking, qualitative feedback, usability testing, user interviews, questionnaires, and other applicable research methods and tools. From a technological standpoint, it is imperative to employ tools capable of tracking and analyzing website traffic and user behavior, recording user interactions, identifying areas for improvement, integrating traditional web analytics with product experience insights, and defining and monitoring UX and design performance metrics. The model’s variables are categorized into four primary classifications: engagement metrics, usability metrics, attitudinal metrics, and business metrics. The latter category is inherently associated with the object- or product-oriented perspective. The primary objective of design metrics is to quantitatively and qualitatively assess design performance, focusing on usability, customer satisfaction, and commercial success (Figure 3).

A comparison of design metrics with other types of metrics discussed in the initial part of this study indicates that design metrics function as a mathematical relationship applied to business contexts. However, it shares a similar level of complexity with webometrics and altmetrics. This phenomenon is primarily attributable to its reliance on data, preferably in digital environments, and tools associated with social media platforms. This study constitutes an inaugural investigation into the application of metrics in diverse contexts pertaining to design. It also signifies an inaugural effort to delineate the measurement and analytical potential of design through the lens of metrics. In order to advance this line of research in an ideal future scenario,

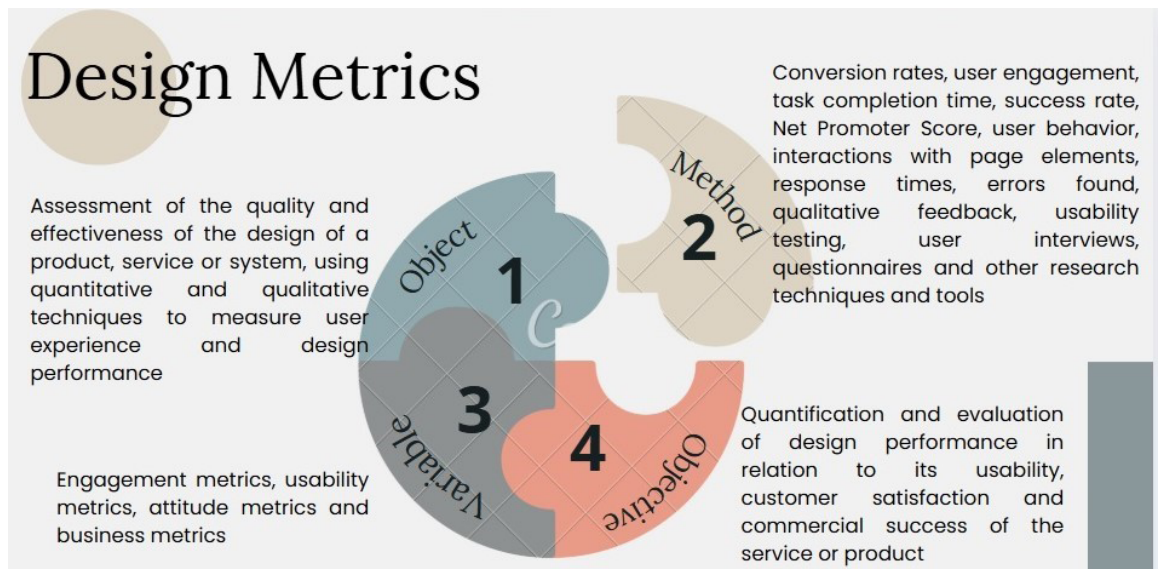


Figure 3. Theoretical model for design metrics. **Source.** Research data (2025).

there is a need for the development of specific indicators and metric frameworks that are tailored to each identified context. This includes the following: a dedicated study on UX and CX metrics; another focused on the development of indices for software processes, particularly to track user access, interactions, and navigation paths across digital environments; and a third one aimed at analyzing object- or artifact-oriented behavior, with real-time monitoring of actions performed by devices, applications, or connected products. Finally, there is an intent to expand the application of metrics to other domains, such as branding (Hinton & Lambert, 2022; Šperková *et al.*, 2015), to assess dimensions such as brand awareness, mention volume, brand sentiment, social media reach, customer satisfaction, share of voice, NPS, brand loyalty, brand value, CR, return on investment (ROI), customer acquisition cost (CAC), and CLV.

Conflict of interest

The authors declare that there is no conflict of interest related to this study.

Contribution statement

Theoretical basis, data curation and writing — original draft: Adilson Luiz Pinto.

Artificial intelligence and writing — review & editing: Júlio Monteiro Teixeira.

Data management and writing — review & editing: Jefferson Lewis Velasco.

Statement of data consent

The bibliographic data used in this study, including data from OpenAlex, have been processed and analyzed as described in the methodology. The datasets generated during this research are available upon request and can be provided to interested researchers for further review. ●

REFERENCES

- ALBERT, B., & TULLIS, T. (2013). *Measuring the user experience: Collecting, analyzing, and presenting usability metrics* (2nd ed.). Morgan Kaufmann.
- ALDER, K. (2001). *The measure of all things: The seven-year odyssey that transformed the world*. Abacus.
- ARGYRES, N., BIGELOW, L., & NICKERSON, J. A. (2013). Dominant designs, innovation shocks, and the follower's dilemma. *Strategic Management Journal*, 36(2), 216-234. <https://doi.org/10.1002/smj.2207>
- BABA GNANAKUMAR, P., ULAGANATHAN, S., & BABY, M. K. (2024). Debunking Indian neo-banks' customer effort score and ESG values. *ASEAN Journal on Science and Technology*

- for *Development*, 41(2), Article 4. <https://doi.org/10.61931/2224-9028.1565>
- BANGOR, A., KORTUM, P. T., & MILLER, J. T. (2008). An empirical evaluation of the System Usability Scale. *International Journal of Human-Computer Interaction*, 24(6), 574-594. <https://doi.org/10.1080/10447310802205776>
- BENAVIDES, E. M. (2012). Metric design. In *Advanced engineering design: An integrated approach* (pp. 133-258). Woodhead Publishing. <https://doi.org/10.1533/9780857095046.133>
- BRIAND, L., MORASCA, S., & BASILI, V. R. (1999). Defining and validating measures for object-based high-level design. *IEEE Transactions on Software Engineering*, 25(5), 722-743. <https://doi.org/10.1109/32.815329>
- BRITO E ABREU, F., & MELO, W. (1996). Evaluating the impact of object-oriented design on software quality. In *Proceedings of the 3rd international software metrics symposium* (pp. 90-99). <https://doi.org/10.1109/METRIC.1996.492446>
- CABRERA, J. (2017). *Modular design frameworks: A projects-based guide for UI/UX designers*. Apress.
- CHIDAMBER, S. R., & KEMERER, C. F. (1994). A metrics suite for object-oriented design. *IEEE Transactions on Software Engineering*, 20(6), 476-493. <https://doi.org/10.1109/32.295895>
- FARRIS, P., BENDLE, N., PFEIFER, P., & REIBSTEIN, D. (2010). *Marketing metrics: The definitive guide to measuring marketing performance*. Pearson Education.
- FENTON, N. E. (1991). *Software metrics: A rigorous approach*. Chapman & Hall.
- FRISCH, R. (1933). Propagation problems and impulse problems in dynamic economics. In *Economic essays in honour of Gustav Cassel* (pp. 171-205). Allen & Unwin.
- GORBEA PORTAL, S. (2005). *Modelo teórico para el estudio métrico de la información documental*. Trea.
- HADDEN, J., TIWARI, A., ROY, R., & RUTA, D. (2007). Computer assisted customer churn management: State-of-the-art and future trends. *Computers & Operations Research*, 34(10), 2902-2917. <https://doi.org/10.1016/j.cor.2005.11.007>
- HESS, M. (2015). *A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts* [Doctoral dissertation, University College London].
- HINTON, A., & LAMBERT, W. M. (2022). Moving diversity, equity, and inclusion from opinion to evidence. *Cell Reports Medicine*, 3(4), 1-4. <https://doi.org/10.1016/j.xcrm.2022.100619>
- ISMAIL, A. A. H. E., & ABDULKAREEM, A. M. (2024). Data-driven techniques for quantitative analysis of customer journey mapping in digital commerce. *Emerging Trends in Machine Intelligence and Big Data*, 16(4), 1-8.
- KANTALAINEN, E. (2018). *Conversion rate optimization with UI & UX design* [Master's thesis, University of York].
- KITCHENHAM, B. A., & LINKMAN, S. J. (1990). Design metrics in practice. *Information and Software Technology*, 32(4), 304-310. [https://doi.org/10.1016/0950-5849\(90\)90064-X](https://doi.org/10.1016/0950-5849(90)90064-X)
- KOKUBO, N., YOKOI, Y., SAITOH, Y., MURATA, M., MARUO, K., TAKEBAYASHI, Y., SHINMEI, I., YOSHIMOTO, S., & HORIKOSHI, M. (2018). A new device-aided cognitive function test, User eXperience-Trail Making Test (UX-TMT), sensitively detects neuropsychological performance in patients with dementia and Parkinson's disease. *BMC Psychiatry*, 18(220), 1-10. <https://doi.org/10.1186/s12888-018-1795-7>
- KUMAR, V., & REINARTZ, W. (2016). Creating enduring customer value. *Journal of Marketing*, 80(6), 36-68. <https://doi.org/10.1509/jm.15.0414>
- LEMON, K. N., & VERHOEF, P. C. (2016). Understanding customer experience throughout the customer journey. *Journal of Marketing*, 80(6), 69-96. <https://doi.org/10.1509/jm.15.0420>
- LIMA, E. L. (2017). *Metric spaces* (5th ed.). IMPA.
- MCGRATH, W. (1989). What bibliometricians, scientometricians and informetricians study; a typology for definition and classification; topics for discussion. In: *2nd International conference on bibliometrics, scientometrics and informetrics*, Ontario, 1989. The University of Western Ontario.
- MEINEL, C., PLATTNER, H., & LEIFER, L. (2012). *Design thinking research: Measuring performance in context*. Springer.
- MKPOJIOGU, E. O. C., & HASHIM, N. L. (2016). Understanding the relationship between Kano model's customer satisfaction scores and self-stated requirements importance. *SpringerPlus*, 5(197), 1-22. <https://doi.org/10.1186/s40064-016-1860-y>

- MORENO, J. L. (1934). *Who shall survive? A new approach to the problem of human interrelations*. Nervous and Mental Disease Publishing.
- NACKE, O. (1979). Informetrie: eine neuer Name für eine neue Disziplin. *Nachrichten für Documentation*, 30(6), 219-226.
- NALIMOV, V. V., & MUL'CHENKO, Z. M. (1969). *Naukometriya: Izucheniye razvitiya nauki kak informatsionnogo protsessa*. Nauka.
- O'KEEFE, M., & CINNEIDE, M. Ó. (2003). A stochastic approach to automated design improvement. In *Proceedings of the 2nd international conference on principles and practice of programming in Java* (pp. 59-62). <https://doi.org/10.5555/957289.957308>
- PALMER, J. W. (2002). Website usability, design, and performance metrics. *Information Systems Research*, 13(2), 151-167. <https://doi.org/10.1287/isre.13.2.151.88>
- PRITCHARD, A. (1969). Statistical bibliography or bibliometrics? *Journal of Documentation*, 25(4), 348-349. <https://doi.org/10.1108/eb026482>
- QUAH, T. S., & THWIN, M. M. T. (2003). Application of neural networks for software quality prediction using object-oriented metrics. In *International conference on software maintenance* (pp. 116-125). <https://doi.org/10.1109/ICSM.2003.1235412>
- RIZZI, C., CAMPANA, F., BICI, M., & GHERARDINI, F. (2021). Design tools and methods in industrial engineering II. In *Proceedings of the second international conference on design tools and methods in industrial engineering, Rome, September 9-10*. Springer.
- ROMBACH, H. D. (1987). A controlled experiment on the impact of software structure on maintainability. *IEEE Transactions on Software Engineering*, 13(3), 344-354. <https://doi.org/10.1109/TSE.1987.233165>
- SASMITO, G. W., ZULFIQAR, L. O. M., & NISHOM, M. (2019). Usability testing based on System Usability Scale and Net Promoter Score. In *International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)* (pp. 540-545). <https://doi.org/10.1109/ISRITI48646.2019.9034666>
- SCHRAMADE, W. (2017). Investing in the UN Sustainable Development Goals: Opportunities for companies and investors. *Journal of Applied Corporate Finance*, 29(2), 87-99. <https://doi.org/10.1111/jacf.12236>
- SCHROTH, S. (2025). *Design a digital product that sells daily: The passive income blueprint for creators*. Recorded Books.
- SELBY, R., & HIHN, J. (2006). Enabling early life-cycle predictive models of software systems. In *Space 2006 conference proceedings*. <https://doi.org/10.2514/6.2006-7218>
- SHAH, J. J., KULKARNI, S. V., & VARGAS-HERNANDEZ, N. (2000). Evaluation of idea generation methods for conceptual design: Effectiveness metrics and design of experiments. *Journal of Mechanical Design*, 122(4), 377-384. <https://doi.org/10.1115/1.1315592>
- SHAIK, A., REDDY, C. R. K., MANDA, B., PRAKASHINI, C., & DEEPTHI, K. (2010). An empirical validation of object-oriented design metrics in object-oriented systems. *Journal of Emerging Trends in Engineering and Applied Sciences*, 1(2).
- ŠPERKOVÁ, L., ŠKOLA, P., & BRUCKNER, T. (2015). Evaluation of e-Word-of-Mouth through Business Intelligence processes in banking domain. *Journal of Intelligence Studies in Business*, 5(2), 36-47. <https://doi.org/10.37380/jisib.v5i2.129>
- TAGUE-SUTCLIFFE, J. (1992). An introduction to informetrics. *Information Processing & Management*, 28(1), 1-3. [https://doi.org/10.1016/0306-4573\(92\)90087-G](https://doi.org/10.1016/0306-4573(92)90087-G)
- TRIALOPA, E. F. (2022). *Optimizing the customer service performance with using chatbot by utilizing bot accuracy, journey completion rate, and customer satisfaction score (CSAT)*. <https://dspace.uui.ac.id/handle/123456789/42045>
- XIA, F. (1996). Module coupling: A design metric. In *Proceedings 1996 Asia-Pacific software engineering conference* (pp. 44-54). <https://doi.org/10.1109/APSEC.1996.566739>
- ZAGE, W. M., & ZAGE, D. M. (1993). Evaluating design metrics on large-scale software. *IEEE Software*, 10(4), 75-81. <https://doi.org/10.1109/52.219620>

