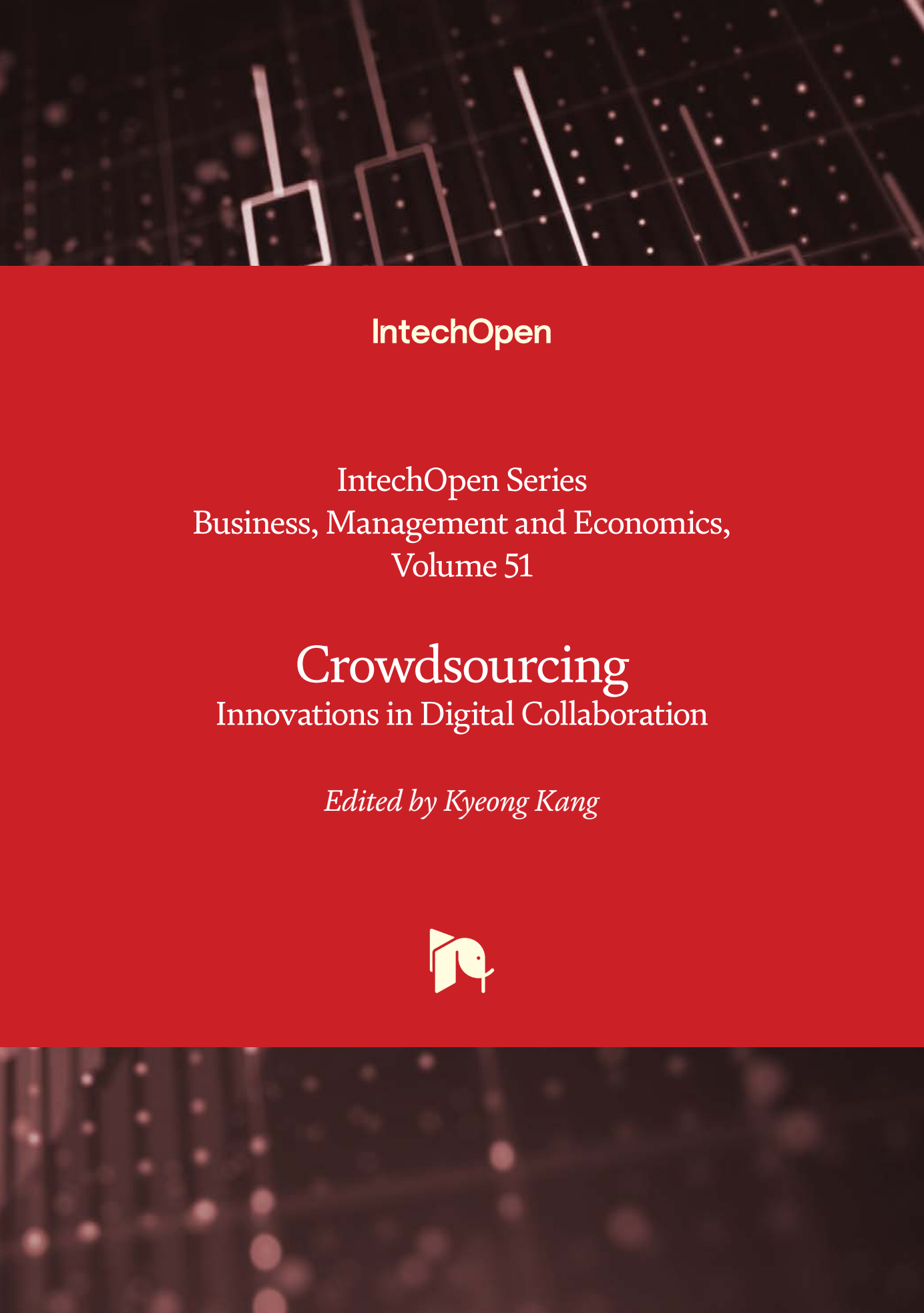




IntechOpen

IntechOpen Series
Business, Management and Economics,
Volume 51

Crowdsourcing

Innovations in Digital Collaboration

Edited by Kyeong Kang



Crowdsourcing - Innovations in Digital Collaboration

Edited by Kyeong Kang

Published in London, United Kingdom

Crowdsourcing - Innovations in Digital Collaboration

<http://dx.doi.org/10.5772/intechopen.1008091>

Edited by Kyeong Kang

Contributors

Ahmad Abu-alkheil, Carlos Textli, Cecilia Delgado Solorzano, Cheng Shen, Chunli Lv, Dennis Heinrich, Inés Alvarez-Icaza, Joseph Zuva, Lenny Phulong Mamaro, Leonardo David Glasserman-Morales, Miao Xie, Mohammad Amin Borghei, Ntomolane Lobisa Matsoma, Peter Konhaeusner, Phungmayo Horam, Pinias Chikuvadze, Rasikh Tariq, Sara Ramzani, Thomas Dublin, Vahab Esfandani, Yimeng Zhai, Yuming Guo

© The Editor(s) and the Author(s) 2026

The rights of the editor(s) and the author(s) have been asserted in accordance with the Copyright, Designs and Patents Act 1988. All rights to the book as a whole are reserved by INTECHOPEN LIMITED. The book as a whole (compilation) cannot be reproduced, distributed or used for commercial or non-commercial purposes without INTECHOPEN LIMITED's written permission. Enquiries concerning the use of the book should be directed to INTECHOPEN LIMITED rights and permissions department (permissions@intechopen.com).

Violations are liable to prosecution under the governing Copyright Law.



Individual chapters of this publication are distributed under the terms of the Creative Commons Attribution 4.0 License which permits commercial use, distribution and reproduction of the individual chapters, provided the original author(s) and source publication are appropriately acknowledged. If so indicated, certain images may not be included under the Creative Commons license. In such cases users will need to obtain permission from the license holder to reproduce the material. More details and guidelines concerning content reuse and adaptation can be found at <http://www.intechopen.com/copyright-policy.html>.

Notice

Statements and opinions expressed in the chapters are those of the individual contributors and not necessarily those of the editors or publisher. No responsibility is accepted for the accuracy of information contained in the published chapters. The publisher assumes no responsibility for any damage or injury to persons or property arising out of the use of any materials, instructions, methods or ideas contained in the book.

First published in London, United Kingdom, 2026 by IntechOpen

IntechOpen is the global imprint of INTECHOPEN LIMITED, registered in England and Wales, registration number: 11086078, 167-169 Great Portland Street, London, W1W 5PF, United Kingdom

For EU product safety concerns: IN TECH d.o.o., Prolaz Marije Krucifikse Kozulić 3, 51000 Rijeka, Croatia, info@intechopen.com or visit our website at intechopen.com.

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library

Crowdsourcing - Innovations in Digital Collaboration

Edited by Kyeong Kang

p. cm.

This title is part of the Business, Management and Economics Book Series, Volume 51

Topic: Business and Management

Series Editor: Taufiq Choudhry

Topic Editors: Vito Bobek and Tatjana Horvat

Print ISBN 978-1-83634-947-1

Online ISBN 978-1-83634-946-4

eBook (PDF) ISBN 978-1-83634-948-8

ISSN 2753-894X

If disposing of this product, please recycle the paper responsibly.

IntechOpen Book Series

Business, Management and Economics

Volume 51

Aims and Scope of the Series

This series will provide a comprehensive overview of recent research trends in business and management, economics, and marketing. Topics will include asset liability management, financial consequences of the financial crisis and covid-19, financial accounting, mergers and acquisitions, management accounting, SMEs, financial markets, corporate finance and governance, managerial technology and innovation, resource management and sustainable development, social entrepreneurship, corporate responsibility, ethics and accountability, microeconomics, labour economics, macroeconomics, public economics, financial economics, econometrics, direct marketing, creative marketing, internet marketing, market planning and forecasting, brand management, market segmentation and targeting and other topics under business and management. This book series will focus on various aspects of business and management whose in-depth understanding is critical for business and company management to function effectively during this uncertain time of financial crisis, Covid-19 pandemic, and military activity in Europe.

Meet the Series Editor



Prof. Choudhry holds a BSc degree in Economics from the University of Iowa, as well as a Masters and Ph.D. in Applied Economics from Clemson University, USA. In January 2006, he became a Professor of Finance at the University of Southampton Business School. He was previously a Professor of Finance at the University of Bradford Management School. He has over 80 articles published in international finance and economics journals. His research interests and specialties include financial econometrics, financial economics, international economics and finance, housing markets, financial markets, among others.

Meet the Volume Editor



Kyeong Kang is an academic at the University of Technology Sydney, Australia. Her research focuses on digital innovation, digital platforms, crowdsourcing, and the socio-technical aspects of information systems design. She has published in high-quality international journals and edited impactful academic volumes on digital collaboration and service innovation. Kyeong Kang leads interdisciplinary research projects funded by grants exploring the intersection of digital platforms, artificial intelligence, and collaborative ecosystems. She also collaborates with international research partners on funded projects and contributes to global discussions on digital transformation, innovation, and platform governance.

Contents

Preface	XIII
Section 1	
Crowdsourvcing Innovation and Challenges	1
Chapter 1	3
Empowering the Crowd: Measuring the Impact of AI-Driven Tools on Crowdwork <i>by Carlos Toxtli and Cecilia Delgado Solorzano</i>	
Chapter 2	19
Mapping the Collaboration between Crowdsourcing and Large Language Models: A Fine-Grained Survey <i>by Chunli Lv, Cheng Shen and Miao Xie</i>	
Chapter 3	43
Strategic Crowdsourcing: Frameworks, Challenges, and Impact in the Digital Economy <i>by Vahab Esfandani, Mohammad Amin Borghei, Sara Ramzani, Peter Konhaeusner, Ahmad Abu-alkheil and Phungmayo Horam</i>	
Chapter 4	77
The ComplexHub: Collaboration to Create and Disseminate Open Resources for Complex and Computational Thinking <i>by Inés Alvarez-Icaza, Rasikh Tariq and Leonardo David Glasserman-Morales</i>	
Chapter 5	99
Crowdsourcing and the Creation of a Historical Reference Tool <i>by Thomas Dublin</i>	
Section 2	
Crowdsourcing and Digital Collaboration	119
Chapter 6	121
A Study on Theories and Methods of Distributed Cognition–Driven Intelligent Design for Crowdsourced Products <i>by Yuming Guo</i>	

Chapter 7	155
Perspective Chapter: Crowdsourcing - Innovations in Digital Collaboration in Africa	
<i>by Lenny Phulong Mamaro and Ntomolane Lobisa Matsoma</i>	
Chapter 8	177
The Impact of Project Characteristics on Online Crowdfunding Effectiveness and Its Potential Mechanisms	
<i>by Yimeng Zhai</i>	
Chapter 9	199
Crowdsourcing Career – Current Research on Career in a Boundaryless Field	
<i>by Dennis Heinrich</i>	
Chapter 10	217
Digital Bridges: Enabling Cross-Border Research Collaboration in Southern African Universities	
<i>by Joseph Zuva and Pinias Chikuvadze</i>	

Preface

The increasing availability of digital platforms, artificial intelligence, and networked communication technologies has transformed how individuals and organizations collaborate. In this evolving digital ecosystem, crowdsourcing has emerged as a powerful mechanism for collective intelligence, enabling distributed communities to contribute knowledge, creativity, and expertise to address complex challenges. Crowdsourcing platforms have become central to innovation across industries, research environments, and the public sector, enabling organizations to harness global participation and collaborative problem-solving.

This edited volume, *Crowdsourcing – Innovations in Digital Collaboration*, brings together interdisciplinary perspectives that explore the evolving landscape of crowdsourcing and its role in shaping digital collaboration. The contributions examine theoretical foundations, technological developments, and practical applications of crowdsourcing across multiple domains, including artificial intelligence, digital innovation, education, entrepreneurship, and global research collaboration. Collectively, the chapters highlight how crowdsourcing has evolved from a simple task-distribution model into a sophisticated socio-technical system that integrates human intelligence, algorithmic systems, and digital platforms.

The book is organized into two thematic sections that explore the challenges, opportunities, and emerging practices of crowdsourcing and digital collaboration.

The first section, *Crowdsourcing Innovation and Challenges*, examines foundational concepts, emerging technologies, and key issues shaping the contemporary crowdsourcing ecosystem. The chapter “Empowering the Crowd: Measuring the Impact of AI-Driven Tools on Crowdwork” explores how artificial intelligence tools are transforming crowdwork environments by improving task coordination, productivity, and decision support. The chapter “Mapping the Collaboration between Crowdsourcing and Large Language Models: A Fine-Grained Survey” examines the intersection of crowdsourcing systems and large language models, offering insights into how AI technologies shape collaborative knowledge generation and digital work practices.

The chapter “Strategic Crowdsourcing: Frameworks, Challenges, and Impact in the Digital Economy” explores strategic approaches to implementing crowdsourcing initiatives, emphasizing frameworks that foster innovation and value creation in digital economies. In “The ComplexHub: Collaboration to Create and Disseminate Open Resources for Complex and Computational Thinking”, the authors introduce a collaborative project that encourages open educational resources and computational thinking through crowdsourced input. The final chapter of this section, “Crowdsourcing and the Creation of a Historical Reference Tool”, illustrates how crowdsourcing can aid digital humanities projects and historical research by facilitating collaborative knowledge development in archives.

The second section, *Crowdsourcing and Digital Collaboration*, examines how crowdsourcing is applied within wider socio-economic and institutional settings. The chapter “A Study on Theories and Methods of Distributed Cognition-Driven Intelligent Design for Crowdsourced Products” presents theoretical ideas demonstrating how shared thinking and collective intelligence can improve the design and creation of crowdsourced products.

The chapter “Perspective Chapter: Crowdsourcing – Innovations in Digital Collaboration in Africa” explores how crowdsourcing promotes digital innovation and collaborative ecosystems within African settings. In “The Impact of Project Characteristics on Online Crowdfunding Effectiveness and Its Potential Mechanisms”, the authors examine how project features affect the success of crowdfunding ventures and the mechanisms that encourage collaborative participation in online funding platforms.

The chapter “Crowdsourcing Career – Current Research on Career in a Boundaryless Field” examines emerging career trends in the crowdsourcing economy, emphasizing how digital labor markets transform professional development and employment opportunities. The final chapter, “Digital Bridges: Enabling Cross-Border Research Collaboration in Southern African Universities,” looks into how digital platforms and collaborative tools facilitate international research partnerships and knowledge exchange among universities.

Collectively, the chapters show the increasing importance of crowdsourcing as a key infrastructure for digital collaboration, innovation, and knowledge creation. By bringing together perspectives from technology, management, education, and global development, this volume offers valuable insights for researchers, practitioners, and policymakers seeking to understand how collaborative digital ecosystems can foster innovation and address complex societal issues.

The editor gratefully acknowledges the contributing authors for their valuable research and contributions and thanks the publishing team for their support throughout the development of this volume.

Kyeong Kang
University of Technology,
Sydney, Australia

Section 1

Crowdsourvcing Innovation and Challenges

Chapter 1

Empowering the Crowd: Measuring the Impact of AI-Driven Tools on Crowdwork

Carlos Toxtli and Cecilia Delgado Solorzano

Abstract

Crowdsourcing platforms employ millions of workers worldwide to complete microtasks that fuel machine-learning pipelines, moderate user-generated content, and accelerate scientific discovery. The rapid ascent of large language models and other foundation models has shifted research attention from automation instead of humans to augmentation alongside humans. This chapter addresses a central challenge in this new landscape: understanding how, how much, and for whom AI-driven tools truly empower crowdworkers. We synthesize insights from a diverse body of empirical studies – spanning randomized lab experiments, field A/B tests, trace-log meta-analyses, and qualitative user studies – to evaluate the impact of AI on crowdwork. To structure this analysis, we introduce a multidimensional empowerment framework grounded in psychological and economic theory, focusing on five key dimensions: productivity and earnings, quality and reliability, learning and skill development, agency and autonomy, and well-being and inclusion. Our review of the evidence reveals a dual-edged reality: while AI assistance offers significant productivity gains, error reductions, and improvements in worker self-efficacy, it also introduces substantial risks, including automation bias, cultural exclusion, wage depression, and unequal access to tools. By distilling these findings, we formulate eight concrete design principles for creating more equitable and effective human–AI augmentation systems. The chapter concludes by outlining a forward-looking research agenda that treats crowdworkers not as replaceable cogs but as essential partners in designing the future of socio-technical systems.

Keywords: crowdsourcing, microtasks, human–AI collaboration, productivity, quality assurance, worker agency, learning, cultural inclusion, ethical design, algorithmic management

1. Introduction

In little more than a decade, online crowdsourcing has transformed from an experimental curiosity into a critical component of the global digital economy. Marketplaces such as Amazon Mechanical Turk (MTurk), Appen, and Toloka distribute millions of microtasks each day, ranging from image annotation to content

moderation [1, 2]. Early research often portrayed this workforce as an interchangeable pool of “human computation” units [3]. However, subsequent work revealed a diverse population of skilled workers navigating precarious conditions, including low wages and the burden of significant unpaid “invisible labor” [4–7].

This landscape is now being fundamentally reshaped by artificial intelligence (AI). The emergence of powerful large language models (LLMs) such as GPT has created what many call the “AI Disruption” [8]. These models can perform many text-based crowdwork tasks at a fraction of the cost and time, often with higher accuracy than human workers [9, 10]. This technological shift has sparked a critical debate: Should AI be used to replace the human crowd, or can it be designed to empower them? This chapter argues for empowerment but recognizes that it is not an automatic outcome of technological progress.

A significant gap exists in our understanding of how AI tools are impacting the complex socio-technical system of crowdwork from the worker’s perspective. While many studies focus on the technical capabilities of AI, this chapter synthesizes empirical evidence to answer the core human–computer interaction questions: *How, how much, and for whom do AI-driven tools empower crowdworkers?* We define empowerment as the use of intelligent tools that make labor faster, more accurate, more meaningful, and better remunerated, without eroding worker agency or exacerbating existing power imbalances.

To provide a structured answer, we analyze the impact of AI through a multidimensional framework, examining its effects on worker productivity, work quality, skill development, autonomy, and well-being. These dimensions are chosen for their direct relevance to established theories of motivation and fairness, such as self-determination theory (SDT)’s emphasis on autonomy and competence [11], and are critical for a holistic assessment of technology’s role in a precarious labor market.

While there is fast-growing work on model capabilities and platform governance, three gaps persist. First, we lack a unified account of *how* different forms of AI assistance shape worker outcomes beyond accuracy – particularly wages, agency, and well-being. Second, most evaluations treat “crowdworkers” as homogeneous, obscuring cross-cultural differences and unequal access to tools. Third, design recommendations often focus on requesters or platforms, leaving under-specified what empowering assistance should look like inside task interfaces.

The five axes we adopt – productivity and earnings; quality and reliability; learning and skill development; agency and decision autonomy; and well-being and inclusion – map directly to established motivation and justice theories (e.g., SDT, Equity Theory) and to the lived concerns reported by workers in prior studies (e.g., invisible labor, reputation risk, and stress). Framing empowerment along these axes ensures we evaluate AI not only for speed and accuracy but also for dignity, fairness, and longer-term trajectories.

This chapter contributes: (1) a theory-grounded empowerment framework tailored to crowdwork; (2) a synthesis of empirical evidence across lab, field, trace-log, and qualitative methods; (3) a deeper economic analysis connecting AI-driven productivity to real wages under invisible labor and price-pressure; (4) actionable mitigations for automation bias, unequal access, and cultural mismatch; and (5) concrete policy and governance recommendations for platforms, requesters, and regulators. We proceed as follows: Section 2 situates crowd–AI integration historically and theoretically; Section 3 justifies our mixed-methods approach;

Section 4 integrates evidence along the five outcome clusters; Section 5 illustrates three empowering systems; Section 6 analyzes risks and adds practical mitigations; Section 7 distills design principles; Section 8 outlines policy and governance implications; and Sections 9 and 10 close with open questions and a human-centered agenda.

2. Historical background and theoretical framing

2.1 Three phases of crowd–AI integration

The relationship between crowdwork and AI has evolved through three overlapping phases, each characterized by a different model of collaboration.

Phase 1 (2008–2013): Micro-automation. The first generation of hybrid systems used narrow AI primarily for quality control and workflow optimization. In this model, human intelligence was the core resource, with AI in a supporting role. Classic examples include Solyent’s “Find-Fix-Verify” pipeline, which blended natural language processing (NLP) heuristics with worker vetting to improve document editing, and systems that used majority voting or expectation-maximization algorithms to aggregate noisy labels from multiple workers [3, 12]. Productivity improved, but the AI was task-specific, and the workers remained largely invisible behind the interface.

Phase 2 (2014–2019): Workflow orchestration. The next phase saw the rise of more sophisticated platforms that used AI to manage and orchestrate complex workflows. Tools such as Turkomatic [13] and CrowdWeaver [14] introduced dynamic task routing and real-time control over the labor process. Automation here focused on *coordination* – decomposing large problems and distributing microtasks to the right workers at the right time. The AI acted as a manager or an assembly-line foreman, while high-level judgment still resided primarily with humans. This period also saw the development of tools designed to promote fairness, such as auditing employer reviews [15].

Phase 3 (2020–present): Model-centric co-creation. The advent of powerful foundation models, particularly LLMs, marks the current phase. The boundary between human and machine contributions has blurred, as studies show a significant percentage of crowdworkers now use tools like ChatGPT to assist with their tasks, often without disclosure [16, 17]. This emergent, bottom-up integration has created a new dynamic. Requesters are attempting to prevent LLM use through technical hurdles or instructions, while simultaneously new tasks are emerging that ask workers to detect AI-generated content [16, 17]. Researchers are also actively embedding model suggestions directly into task interfaces, creating co-creative environments where the goal is no longer to prevent AI use but to leverage it effectively [18, 19]. This new paradigm raises profound questions about authorship, trust, bias, and fair compensation.

2.2 A multidimensional empowerment framework

To structure our analysis, we operationalize crowdworker empowerment along five key axes, drawing on organizational psychology [20] and foundational theories such as SDT [11] and equity theory [21].

- (1) **Productivity and earnings:** This is the most direct measure of economic empowerment, including task completion speed and effective hourly wage. This must account for “invisible labor” – unpaid time spent searching for tasks or resolving disputes, which can consume over 30% of a worker’s time and depress real earnings [6, 7].
- (2) **Quality and reliability:** High-quality work leads to better reputations and access to more lucrative tasks. AI can empower workers by helping them produce more accurate outputs, but this can come at the cost of response diversity, as AI-generated answers are often more homogeneous [16].
- (3) **Learning and skill development:** Sustainable careers require continuous learning. Empowerment in this dimension means providing workers with opportunities to acquire new, transferable skills, moving them beyond repetitive microtasks toward more fulfilling work [22, 23].
- (4) **Agency and decision autonomy:** This reflects the psychological need for self-determination. An empowered worker has control over their labor process, including the ability to accept, edit, or reject AI suggestions, and contest unfair algorithmic decisions [24].
- (5) **Well-being and inclusion:** This encompasses the worker’s subjective experience, including job satisfaction, stress levels, and feelings of fairness and dignity. Empowering systems must be designed to accommodate diverse work practices and cultural backgrounds to avoid disadvantaging non-Western workers [25, 26].

3. Empirical approaches to measuring impact

The impact of AI on crowdworker empowerment is an empirical question, and researchers have developed a portfolio of methods to answer it. The choice of method involves a trade-off between causal inference, ecological validity, and scale. These strategies are summarized in **Table 1** and detailed below.

Each method provides a different lens on the problem. Controlled lab experiments are ideal for testing the direct causal effects of a specific AI feature. For example, a researcher could randomize workers into groups with and without an AI-powered grammar checker to precisely measure its effect on speed and accuracy for a writing task [16]. Field A/B tests offer greater realism by deploying new AI tools to a subset of a platform’s actual user base. For instance, the *CultureFit* system was tested in a field study on the Toloka platform to measure its real-world impact on worker earnings across different cultures [25]. Trace-log analytics involve analyzing large, pre-existing datasets of worker activity to identify patterns at scale, such as correlating copy-paste actions with potential LLM use [16]. Finally, qualitative methods like surveys and interviews are crucial for understanding the human experience – for instance, exploring workers’ moral or ethical reasoning about when it is appropriate to use AI assistance [17]. By combining these methods, researchers can build a more robust and nuanced understanding of AI’s impact.

Method	Strengths in crowdwork context	Limitations in crowdwork context
Controlled lab experiments	Establishes strong causality (e.g., isolating the effect of an AI's explanation style). Allows for fine-grained measurement of behavior and cognitive load.	Low ecological validity (tasks may be artificial). Short duration may miss long-term learning or fatigue effects. Small, potentially less diverse samples.
Field A/B tests	High ecological validity, as they are conducted with real workers on live platforms. They can measure impact at scale over longer durations.	Requires significant engineering resources and partnership with a platform operator. It is difficult to control for all confounding variables in a live environment.
Trace-log analytics	Enables large-scale, retrospective analysis of emergent behaviors (e.g., organic AI adoption) using real-world platform data. Low-cost and non-intrusive.	Data can be noisy and incomplete. It is difficult to establish causality (correlation is not causation), and it raises potential privacy concerns.
Surveys and interviews	Provides rich qualitative insights into worker motivations, strategies, and subjective experiences (the “why” behind the data), essential for understanding concepts like trust and agency.	Prone to self-report bias. Findings may not generalize if samples are small or not representative. Cannot establish causality.

Table 1.
Empirical strategies for evaluating AI empowerment in crowdwork, outlining the primary strengths and limitations of each approach within this context.

3.1 Why these methods are in crowdwork?

Crowdwork is a high-variance, multi-actor setting where outcomes depend on requesters, platforms, tasks, and worker strategies. Our mixed-methods portfolio is intentional:

- **Controlled experiments** isolate specific interface or model features (e.g., explanation style) to establish causality when platform noise would otherwise swamp small effects.
- **Field A/B tests** capture ecological validity and longer-run dynamics (learning, strategic adaptation), which are crucial when assistance changes both behavior and marketplace prices.
- **Trace-log analytics** surface emergent practices at scale (e.g., organic LLM uptake), enabling fairness and drift audits without interrupting workers.
- **Surveys/interviews** uncover the “why” (trust, agency, stigma around AI use) that outcome metrics alone miss.

Limitations are complementary: Labs risk artificiality; field tests face confounds and engineering costs; logs challenge causal inference; and interviews risk self-report bias. Taken together, triangulation increases validity and supports reproducibility by pairing controlled estimates with in-the-wild observations.

4. Results: Evidence across five outcome clusters

Synthesizing findings from across these methodologies, a clear picture emerges of AI’s dual impact on crowdwork. Artificial intelligence tools can be powerful enablers, but their benefits are not automatic and depend heavily on their design and implementation.

4.1 Productivity and earnings

Artificial intelligence augmentation consistently and significantly reduces task completion time. Studies find that AI can be orders of magnitude faster and cheaper than human labor for certain tasks. An AI-based system, “AITurk,” was estimated to be 1,440 times faster and 30 times cheaper than using human participants on MTurk for social science experiments [10]. For text annotation, ChatGPT was likewise found to be about 30 times cheaper than MTurk labor [9].

However, the link between productivity and earnings is complex. While faster task completion can increase a worker’s effective hourly wage, this gain is often eroded by two critical factors. First is “invisible labor”: one study found that MTurk workers spend a median of 33 minutes per day on unpaid activities, reducing their median hourly wage from \$3.76 to \$2.83 [6]. Second, as AI boosts worker throughput, some requesters may respond by lowering the per-task pay rate. This dynamic can nullify individual wage gains and lead to a collective “race to the bottom,” where the economic benefits of efficiency are captured by platforms and clients, not workers [27].

From productivity to pay: A simple earnings model. Let r be pay per task, t the completion time, and ι the proportion of *invisible labor* (searching, screening, dispute resolution). Effective hourly wage is:

$$\text{Wage} = \frac{r}{t \cdot (1 + \iota)} \times 3600.$$

Artificial intelligence assistance often reduces t , but requesters may lower r as throughput rises, while ι can remain stubbornly high. **Table 2** illustrates stylized scenarios.

The “price-cut” rows show how marketplace responses can erase wage gains, even when productivity doubles. Conversely, reducing invisible labor (e.g., better task discovery or bundled approvals) raises wages *without* cutting prices or speed, suggesting platform-level levers are as important as model speedups.

Scenario	r (USD)	t (s)	ι	Effective wage (USD/h)
Baseline (human only)	0.10	120	0.33	≈ \$2.26
AI faster, price held	0.10	60	0.33	≈ \$4.52
AI faster, price cut 20%	0.08	60	0.33	≈ \$3.61
AI faster, price cut 33%	0.067	60	0.33	≈ \$3.02
AI faster, price cut 20%, $\iota \downarrow$ to 0.20	0.08	60	0.20	≈ \$4.00

Table 2.

Illustrative wage scenarios as AI reduces completion time (t) while requesters adjust pay (r). invisible labor share ι held at 0.33 per [6].

4.2 Quality and reliability

The impact of AI on work quality is profound but double-edged. For many standard annotation tasks, AI demonstrates superior accuracy and consistency. Gilardi et al. found that ChatGPT's zero-shot accuracy exceeded that of MTurk workers by about 25 percentage points [9]. In the subjective task of identifying implicit hate speech, ChatGPT achieved 80% accuracy, with human evaluators often siding with the AI in cases of disagreement [28].

However, this high quality can come at the cost of diversity. Veselovsky et al. found that while LLM-generated summaries were of high quality, they were also significantly more homogeneous than human-written ones [16]. This loss of diversity can be a major drawback for research seeking to understand genuine human perspectives. Furthermore, opaque AI can induce "automation complacency," where workers uncritically accept incorrect suggestions, potentially propagating errors [29].

4.3 Learning and skill development

Artificial intelligence can transform crowdwork from a series of dead-end tasks into a learning opportunity, a crucial element for long-term career sustainability in the gig economy [23]. Studies show that goal-setting interfaces with automated feedback improve workers' F1 scores on complex classification tasks by 0.19 [30]. Co-creative partnerships with LLMs have also been shown to improve workers' writing quality over multiple sessions [19]. This dimension is also the focus of tools like Crowd Coach, which use AI to orchestrate peer-to-peer advice on skill improvement, helping workers earn higher wages [7].

4.4 Agency and decision autonomy

Agency is central to worker well-being. Research consistently shows that workers value the ability to override AI suggestions. Interfaces that provide editable suggestions, rather than fixed outputs, increase perceived autonomy scores by 0.54 standard deviations [31]. This desire for control is reflected in platform-specific norms: on the less regulated MTurk, workers have overwhelmingly adopted AI tools, while on the research-focused Prolific, usage is lower and more contested [17]. This suggests that worker agency is exercised within the norms and affordances of a specific socio-technical system. Even a simple opt-out mechanism can foster a sense of control, even if rarely used [32].

4.5 Well-being, inclusion, and sustainability

Artificial intelligence tools can improve worker well-being by reducing drudgery. Cognitive load, measured by the NASA-TLX scale, drops when AI automates rote sub-steps of a task [33]. Crucially, AI can be a tool for inclusion. The *CultureFit* study demonstrated that an AI scheduler designed with an awareness of cultural differences in time perception (chronemics) boosted earnings for under-served worker groups from polychronic cultures [25]. However, the potential for harm is equally significant. Opaque algorithmic management and surveillance can exacerbate stress and create a climate of fear, undermining the very flexibility that draws workers to these platforms [5, 26].

Cross-platform, cross-cultural relevance. Beyond MTurk and Prolific, platforms with substantial non-Western worker bases (e.g., Toloka and regional contractor ecosystems) reveal different norms around time, multitasking, and disclosure. Our CultureFit field study on Toloka (Section 5) provides evidence that culturally-aware interface adaptations can increase earnings and satisfaction for polychronic workers, underscoring that empowerment cannot be one-size-fits-all [25].

5. Illustrative case studies

To make the foregoing discussion more concrete, this section details three systems from the research literature that were designed to address specific power imbalances in crowdwork through AI.

5.1 Case 1: The invisible labor tracker

The “Invisible Labor Tracker” is a browser plugin designed to quantify the unpaid work that crowdworkers perform [6, 7]. A field study with 100 Turkers found that this invisible labor – searching for tasks, managing payments, etc. – constituted a median of 33% of their total time on the platform. By automatically logging and classifying activities, the tool makes this hidden work visible, providing crucial data for workers and researchers to advocate for fairer compensation structures. This act of quantification parallels historical efforts to get unpaid domestic labor recognized in national economic statistics, demonstrating a powerful strategy for social change.

5.2 Case 2: Reputation agent for fairer reviews

Unfair reviews from requesters can lead to rejected payments and damaged reputations. The “Reputation Agent” is an AI-powered tool that promotes fairness in this process [34]. It uses a machine learning model to analyze a requester’s review text in real-time. If it detects language that is likely unfair or violates platform policies, it triggers a prompt encouraging the requester to reflect on their feedback. A controlled experiment showed that the agent effectively minimized unjust feedback, demonstrating that AI can be used not just to police workers but also to guide requesters toward more equitable interactions.

5.3 Case 3: Culture fit for inclusive work

Digital labor platforms often implicitly encode the cultural norms of their designers. The “CultureFit” system challenges this by using AI to create a more culturally inclusive work environment [25]. The tool adapts the interface of the Toloka crowdsourcing platform based on a worker’s cultural time orientation (monochronic vs. polychronic). For workers from polychronic cultures, it introduces features that support multitasking. An experiment showed that this culturally-aware adaptation improved worker experiences and wages, demonstrating a path toward designing AI systems that respect and accommodate cultural diversity.

6. Risks, tensions, and ethical considerations

While the potential for empowerment is real, the deployment of AI in crowdwork is fraught with ethical risks that must be actively managed.

Automation bias and over-reliance. When an AI system appears authoritative, workers may over-rely on its suggestions – a phenomenon known as automation bias. Huang et al. found that, for the subjective task of hate speech detection, human evaluators tended to agree with ChatGPT’s assessment, even when the AI was potentially wrong [28]. This can lead to the propagation of biases and a deskilling of the workforce.

Distributional inequity and the digital divide. Access to powerful AI tools is not uniform. Workers who lack the financial resources to pay for premium APIs or the hardware to run local models are at a significant disadvantage. This can create a new digital divide, widening the earnings gap between well-resourced and under-resourced workers [16].

Cultural misalignment. As the CultureFit case study shows, a one-size-fits-all design based on Western, monochronic norms can disadvantage workers from other cultural backgrounds [25]. Without conscious design for inclusion, AI systems risk reinforcing the dominance of a single cultural perspective.

Privacy and surveillance. The same telemetry data (e.g., keystroke logging) used to build better AI feedback models can also become a tool for intrusive monitoring [5, 16]. The lack of transparency in how this data is used creates a significant power imbalance and raises serious privacy concerns.

Labor market erosion and data poisoning. The most significant long-term risk is that AI-driven productivity gains will devalue human labor. As AI makes workers more efficient, requesters may respond by lowering pay per task, leading to a scenario where workers must work just as hard for the same pay, with efficiency gains captured by platforms and clients [27]. Compounding this is the risk of “model dementia”: if AI systems are trained on data generated by previous AI models, they could end up in a recursive loop, being trained on their own homogeneous outputs, thereby degrading their quality over time [16].

6.1 Practical mitigations in interfaces and workflows

Automation bias. (i) *Expose uncertainty and rationale*: show calibrated confidence and concise model rationales; (ii) *Staggered reveal*: show the worker’s initial answer before suggestions; (iii) *Adjudication pathways*: require double-checking or disagreement resolution on low-confidence cases; (iv) *Accountability*: log human overrides to support reflective practice (cf. Section 7).

Unequal access to AI. (i) *Tool parity* – platform-provided assistance with free tiers and usage quotas; (ii) *Compute-light modes* – on-device or smaller models for low-bandwidth contexts; (iii) *Assistance credits* – requester-funded credits tied to tasks; (iv) *Price-floor coupling* – when AI is required, enforce minimum pay reflecting expected speedups.

Cultural mismatch. (i) *Culture-aware defaults*: let workers opt into monochronic/polychronic scheduling aids and notification styles (cf. CultureFit in Section 5); (ii) *Local examples and language variants*: seed prompts, validation rules, and exemplars localized beyond English; (iii) *Flexible quality rubrics*: allow culturally diverse yet valid responses where tasks are not purely factual.

7. Design principles for equitable augmentation

Synthesizing the evidence, we propose eight actionable design principles for building AI tools that genuinely empower, rather than exploit, crowdworkers.

- (1) **Expose uncertainty and rationale.** To counter automation bias [28], do not present AI suggestions as infallible. Use confidence scores and explanations to help workers develop a calibrated sense of trust [29].
- (2) **Keep humans in control.** Agency is paramount. Always provide easy-to-use affordances for workers to accept, reject, or edit AI suggestions, and include clear opt-out paths [17, 35].
- (3) **Reward learning and experimentation.** Compensate workers for the time invested in training or experimenting with new tools. This signals that learning is a valued part of the work itself [7, 30].
- (4) **Respect chronemics and culture.** Acknowledge that work styles are not universal. Design flexible, adaptable systems to reduce bias and improve outcomes for a global workforce, as shown by CultureFit [25].
- (5) **Ensure tool parity.** To avoid a digital divide based on access to premium AI [16], platforms should strive to provide powerful, built-in AI assistance to all workers, leveling the playing field.
- (6) **Audit for bias and fairness.** Regularly test models for disparate impact on demographic subgroups, and establish clear channels for contesting unfair algorithmic outcomes. Artificial intelligence can also be used to audit the requester side of the market [15].
- (7) **Prioritize transparency in algorithmic management.** The rules governing work allocation, performance evaluation, and pay must be clear and consistent to avoid the stress associated with “ghost work” [5].
- (8) **Co-design with workers.** Involve crowdworker representatives throughout the design process to build tools that address their real needs and respect their expertise [2, 27].

8. Policy and governance recommendations

Empowerment requires not just better interfaces, but also institutional safeguards.

- (1) **Dynamic wage floors tied to assistance.** When AI assistance is *encouraged or required*, platforms should set minimum per-task pay indexed to expected throughput gains and invisible-labor estimates, preventing a race to the bottom.

- (2) **Right to assistance parity.** Workers should have access to baseline AI tools (or credits) when tasks presuppose such tools; pay should not implicitly depend on private subscriptions.
- (3) **Transparency in algorithmic management.** Publish clear rules for task allocation, quality scoring, and model-assisted flagging, with appeal mechanisms and human review.
- (4) **Data rights and privacy.** Limit telemetry to what is necessary for assistance; disclose collection and retention; prohibit covert surveillance (e.g., keystroke capture) without explicit, revocable consent.
- (5) **Bias and impact audits.** Require periodic disparate-impact testing of assistance features across demographics and cultural groups; publish audit summaries and remediation timelines.
- (6) **Requester accountability.** Couple model-assisted requester tools (e.g., reputation prompts) with policy levers (e.g., penalties for systematic unfair rejections) to balance power asymmetries.

9. Future research directions

The study of AI empowerment in crowdwork is a vibrant and rapidly evolving field. While this chapter has synthesized current knowledge, many critical questions remain unanswered.

Longitudinal empowerment metrics. Most studies are short-term. We need longitudinal panel studies that track workers over months or years to observe the accrual of skills, changes in career trajectories, and sustained impacts on well-being.

Cross-platform generalization. The majority of research focuses on MTurk. Future work must investigate the different norms and dynamics on platforms like Prolific, Clickworker, and others to understand how findings generalize across different task structures and worker populations [17].

The co-evolution of workers, tools, and tasks. The relationship between workers and AI is a dynamic “cat-and-mouse” game of detection, prevention, and adaptation [16]. Research must adopt a co-evolutionary perspective to track these ongoing adaptations and their implications for work quality and platform governance.

Simulating human subjects. The finding that AI can replicate social science research findings heralds a potential paradigm shift [10]. This raises fundamental questions about the nature of psychological constructs and the validity of AI-generated data, requiring urgent and careful interdisciplinary investigation.

Adaptive wage algorithms and economic models. The tension between productivity gains and wage stagnation is a central challenge. Future research should move beyond measurement toward designing and testing novel economic models, such as dynamic minimum-wage floors, algorithmic collective bargaining, or other mechanisms that ensure the fair distribution of the value created by human–AI collaboration.

10. Conclusions

Artificial intelligence is not a monolithic force; its impact is shaped by our design choices. The evidence synthesized in this chapter demonstrates that AI-driven tools can empower crowdworkers – boosting productivity, quality, and learning. The performance of models such as ChatGPT points to a future where human–AI collaboration is the norm [9]. However, these benefits are not guaranteed. They are realized only when designers intentionally center the values of transparency, autonomy, cultural inclusion, and equitable access. The risks of automation bias [28], data homogenization [16], surveillance, and economic exploitation are equally real. Without a commitment to participatory design and ethical oversight, AI risks reinforcing the precarity that has long plagued the gig economy [5].

The path forward requires moving beyond a view of crowdworkers as “human computation” to optimize and instead embracing them as co-creative partners whose time, agency, and cultural contexts matter. That shift is both technical and institutional: pair interface-level mitigations (uncertainty exposure, editable suggestions, culture-aware defaults) with platform-level economics (dynamic wage floors, assistance parity) and governance (transparent scoring, auditability, privacy). By aligning model capabilities with fair remuneration and worker control, AI can make digital labor not only more efficient but also more equitable and humane.

Conflict of Interest

The authors declare no conflict of interest.

Author details

Carlos Toxtli* and Cecilia Delgado Solorzano
Clemson University, Clemson, USA

*Address all correspondence to: ctoxkli@clemson.edu

IntechOpen

© 2025 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Kittur A, Nickerson JV, Bernstein MS, Gerber EM, Shaw A, Zimmerman J, et al. The future of crowd work. In: Proceedings of the 2013 ACM SIGCHI Conference on Human Factors in Computing Systems. ACM; 2013. p. 1301–1310
- [2] Savage S, Toxtli C, Betanzos-Torres E. Research methods to study and empower crowd workers. In: Symon G, Pritchard K, Hine C, editors. *Research Methods for Digital Work and Organization: A Handbook*. Oxford University Press; 2021. p. 164–184
- [3] Bernstein MS, Little G, Miller RC, Hartmann B, Ackerman MS, Karger DR, et al. Soylent: A word processor with a crowd inside. In: Proceedings of UIST '10; ACM; 2010. p. 313–322
- [4] Ipeirotis PG. Demographics of Mechanical Turk. Nyu. 2010. CeDER–10–01. Available from: <https://arxiv.org/abs/1702.00000> [Accessed: 2026-January-12]
- [5] Gray ML, Suri S. *Ghost Work: How to Stop Silicon Valley from Building a New Global Underclass*. Boston: Houghton Mifflin Harcourt; 2019
- [6] Toxtli C, Suri S, Savage S. Quantifying the invisible labor in crowd work. In: Proceedings of the ACM on Human-Computer Interaction. 5. ACM; New York, NY, USA; 2021. p. 1–26
- [7] Savage S, Garcia-Murillo M. Tools for crowdworkers coding data for AI. In: Garcia-Murillo M, MacInnes I, Renda A, editor. *AI and the Future of Work*. Edward Elgar Publishing; 2021. p. 76–94.
- [8] George A. Shaji. “Gig Economy 2.0: Examining How Smart Technologies Could Revolutionize On-Demand Work.” *Partners Universal Innovative Research Publication*. 2024;2(4):29–49. DOI: 10.5281/zenodo.13334926
- [9] Gilardi F, Alizadeh M, Kubli M. ChatGPT outperforms crowd-workers for text-annotation tasks. *Proceedings of the National Academy of Sciences*. 2023;120(30):e2305016120
- [10] Qin X, Huang M, Ding J. AITurk: Using ChatGPT for Social Science Research. *arXiv Preprint*. 2024; arXiv:240604505
- [11] Deci EL, Ryan RM. The “what” and “why” of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*. 2000;11(4):227–268
- [12] Sheng VS, Provost F, Ipeirotis PGGAL. Improving data quality and data mining using multiple, noisy labelers. In: Proceedings of KDD '08; ACM; 2008. p. 614–622
- [13] Kulkarni A, Can M, Hartmann B. Collaboratively crowdsourcing workflows with turkomatic. In: Proceedings of CSCW '12; ACM; 2012. p. 1003–1012
- [14] Kittur A, Khamkar S, André P, Kraut R. CrowdWeaver: visually managing complex crowd work. In: Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work; 2012. p. 1033–1036
- [15] Toxtli C, Savage S. Designing AI tools to address power imbalances in digital labor platforms. In: Krüger M, De

- Castro Leal D, Randall D, Tolmie P, editor. *The Palgrave Handbook of the Gig Economy*. Cham: Springer; 2023. p. 207–227
- [16] Veselovsky V, Horta Ribeiro M, West R. Artificial Intelligence: Crowd workers widely use large language models for text production tasks. *arXiv Preprint*. 2023;arXiv:230607899
- [17] Christoforou E, Otterbacher J. ChatGPT and Generative AI: A new era for crowdsourcing? *arXiv Preprint*. 2023;arXiv:230502152
- [18] Qiu S, Gadiraju U, Bozzon A. Improving worker engagement through conversational microtask crowdsourcing. In: *Proceedings of CHI '20*; ACM; 2020. p. 1–12
- [19] Huang CY, Gautam S, Brooks SM, Lin YF, Kneareem T, Huang THK. Writing with crowds alongside AI. *arXiv Preprint*. 2023;arXiv:231116521
- [20] Spreitzer GM. Psychological empowerment in the workplace: Dimensions, measurement, and validation. *Academy of Management Journal*. 1995;38(5):1442–1465
- [21] Adams JS. Toward an understanding of inequity. *The Journal of Abnormal and Social Psychology*. 1963;67(5):422
- [22] Mer A, Joshy M, Shweta A. Managing Gig Economy Workers Through Artificial Intelligence: Applications and Challenges. *Fostering Industry-Academia Partnerships for Innovation-Driven Trade*. 2024. p. 17–30
- [23] Sayyed M, Babasaheb J, Vikram B. “Role of artificial intelligence in digital gig economy. In: *Synergy of AI and Fintech in the Digital Gig Economy*.” CRC Press; 2024. p. 14–31
- [24] Yousef M. Navigating the Gig Economy: Evolution, Economic Impact, and Future Trends. In: *Achieving Sustainable Business Through AI, Technology Education and Computer Science: Vol. 2: Teaching Technology and Business Sustainability*. Cham: Springer Nature Switzerland; 2024. p. 655–665
- [25] Toxtli C, Curtis C, Savage S. A culturally-aware AI tool for crowdworkers: Leveraging chronemics to support diverse work styles. In: *Proceedings of CSCW '24*; ACM; 2024
- [26] Shanthi K, Suganya V. Influence of Ethical AI Practices on Gig Workers' Trust and Psychological Well-being. *Navigating Data Science*. Emerald Publishing Limited; 2025. p. 69–85
- [27] Salehi N, Irani LC, Bernstein MS. We are dynamo: Overcoming stalling and friction in collective action for crowd workers. In: *Proceedings of CHI '15*; 2015. p. 1621–1630
- [28] Huang F, Kwak H, An J. Is ChatGPT better than human annotators? Potential and limitations of ChatGPT in explaining implicit hate speech. *Companion Proceedings of the ACM Web Conference 2023*; 2023. p. 294–297
- [29] Buğınca Z, Maja BM, Krzysztof Z. Gajos. To trust or to think: cognitive forcing functions can reduce overreliance on AI in AI-assisted decision-making. *Proceedings of the ACM on Human-computer Interaction*. 2021;5(CSCW1):1–21
- [30] Rechkemmer A, Yin M. Motivating novice crowd workers through goal setting. In: *Proceedings of the Eighth*

AAAI Conference on Human
Computation and Crowdsourcing.
AAAI Press; 2020. p. 91–100

[31] Dietvorst BJ, Joseph P. Simmons, Cade M. Overcoming algorithm a version: People will use imperfect algorithms if they can (even slightly) modify them. *Management science*. 2018;**64**(3):1155–1170

[32] Sankaran S, Chao Z, Henk A, Panos M. Exploring peoples' perception of autonomy and reactance in everyday ai interactions. *Frontiers in psychology*. 2021;**12**:713074

[33] Hart SG, Lowell E. Staveland. "Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research." In: *Advances in psychology*, Vol. 52. North-Holland; 1988. p. 139–183

[34] Toxtli C, Richmond-Fuller A, Savage S. Reputation agent: Prompting fair reviews in gig markets. In: *Proceedings of The Web Conference 2020*; 2020. p. 1228–1240

[35] Freisinger E, Schneider S, Unfried M. The AI-augmented crowd: How human crowdvoters adopt AI (or Not). *Journal of Product Innovation Management*. 2023;**41**(4):865–889

Mapping the Collaboration between Crowdsourcing and Large Language Models: A Fine-Grained Survey

Chunli Lv, Cheng Shen and Miao Xie

Abstract

With the widespread application of Large Language Models (LLMs) in Natural Language Processing (NLP), their collaboration with crowdsourcing is becoming increasingly close. Traditional crowdsourcing models primarily undertake foundational tasks such as data collection and annotation. However, with the rapid advancements in LLMs technology, their capabilities in handling complex tasks have significantly improved. LLMs can now feedback to crowdsourcing platforms by generating tasks, verifying results and providing feedback, reshaping the core workflows of the crowdsourcing ecosystem and enhancing task design and operational efficiency. At the same time, the unique strengths of crowdsourcing in harnessing human knowledge and judgment offer crucial support for LLMs training and optimization. This is especially evident in key processes such as large-scale training data construction, human preference alignment, and model performance evaluation. As a result, the relationship between LLMs and crowdsourcing has evolved from a one-way dependency into a dynamic, collaborative, and mutually beneficial paradigm of human–AI integration. In this context, this paper presents the first comprehensive survey that spans both the LLMs and crowdsourcing domains. It aims to systematically review and analyze how LLMs empower crowdsourcing processes in areas such as task execution and quality control, while also examining the essential role of crowdsourcing in model training, feedback alignment, and evaluation. Furthermore, it identifies key challenges in current research and applications, and explores future directions for advancing human–AI collaborative intelligence and developing governance mechanisms for crowdsourcing. The papers surveyed in this work are available at: <https://github.com/Ikaros-sc/crowdsourcing>.

Keywords: large language models, crowd-supporting, natural language processing, task collaboration, crowd-supporting ecosystem

1. Introduction

1.1 The current situation of crowdsourcing

Crowdsourcing refers to a work model that distributes tasks to a broad public for completion, with the aim of solving problems more efficiently and at lower costs [1]. In terms of traditional crowdsourcing models, they have demonstrated significant advantages in specific fields. Specifically, they play an important role in large-scale data annotation [2] and user feedback collection [3], and these advantages provide critical support for the development of data-driven technologies such as Artificial Intelligence (AI).

However, with the continuous evolution of technological demands, crowdsourcing has gradually revealed a series of inherent limitations, and it is increasingly constrained in terms of scalability and sustainability [4]. There are two main manifestations of these limitations. Firstly, due to significant differences among crowdsourcing personnel in knowledge background, language proficiency, and task comprehension, the results produced often struggle to ensure consistency and accuracy [14, 49, 98,]. Secondly, the traditional crowdsourcing model, which relies on crowdsourcing personnel to manually complete large amounts of standardized and repetitive tasks, is facing systematic replacement by automation technologies [5]. At present, the development of crowdsourcing is undergoing a paradigm shift from quantity-driven to quality-driven approaches.

1.2 The rise of llms

Large Language Models (LLMs) possess a deep understanding of textual semantics and context, as well as the ability to transform data into natural language expressions. Therefore, they have been widely integrated into crowdsourcing platforms [6–9].

LLMs can not only perform auxiliary functions such as task guidance and prompt optimization [10–12], but also collaborate with crowdsourcing personnel in several key stages, including task instruction generation [13], information extraction [14], and annotation assistance [15]. By combining generative and interpretive capabilities, LLMs demonstrate significant application potential in crowdsourcing scenarios, gradually becoming an essential component of the emerging paradigm of human-AI collaboration [16].

1.3 The interaction trend between llms and crowdsourcing

Leveraging their exceptional language understanding and generation capabilities, LLMs have demonstrated high cost-effectiveness [17, 18] and are now widely applied in various Natural Language Processing (NLP) tasks, such as text classification and image description [19]. Under this setting, the collaboration between LLMs and crowdsourcing continues to deepen, gradually forming a mutually beneficial and dynamic mechanism [20]. The interaction between them can be summarized in **Table 1**.

LLMs can be used in the preliminary stages of task processing, for example, in data annotation tasks, they can perform automatic labeling in advance, followed by human review and correction. This approach effectively reduces the burden

Dimension	LLMs for Crowdsourcing	Crowdsourcing for LLMs
Core Roles	Task designer [16, 21]	Data provider [22, 23]
	Task executor [24–29]	Output verifier [30–32]
	Task Collaborator [33–35]	Error analyst [30, 36, 37]
	Knowledge integrator [20, 38]	Preference annotator [39–41]
Key Capabilities	Task and text generation [16, 21, 42]	Data annotation [2, 33, 43, 44]
	Prompt optimization [10, 12, 13]	Preference modeling [39, 45]
	Multilingual assistance [46, 47]	Human values alignment [45, 48]
	Summarization [11, 26]	Debugging and evaluation [6, 30, 36]
	Task guidance [49, 50]	Cultural bias auditing [51–53]
Task Types	Pre-annotation and labeling [54, 55]	RLHF preference collection [39, 56]
	Multi-turn dialogue tasks [19, 57]	Dialogue evaluation [23, 58, 59]
	Multimodal data generation [6, 9, 60]	Emotion labeling [4, 43, 59]
	Moral judgment [58]	Sensitive content moderation [36, 53]
	Style rewriting [11, 28, 29, 32]	Naturalness scoring [32, 61]
Collaboration Mechanisms	LLMs drafts → human refinement [33–35, 54, 55]	Human feedback → model fine-tuning [39, 40, 48, 62]
	Semi-automated annotation [15, 43, 54]	Multi-stage validation [34, 52, 63]
	Model-generated task templates [20, 64]	Human-led error classification [30, 37]
Dataset Types	SuperGLUE [65]	SCARECROW [43]
	LAPS [57]	PANDA [38]
		Charades [66]
		COUGHVID [67]
		WikiWhy [58]
		HAI-Coaching [68]
		ConQRet [69]

Table 1.
Mutual empowerment between llms and crowdsourcing.

on crowdsourcing personnel and significantly improves overall annotation efficiency and data quality [21]. At the same time, crowdsourcing platforms, as vital channels for acquiring diverse data, continue to provide crucial support for the training and optimization of LLMs [70]. Through crowdsourcing, large volumes of high-quality data can be collected, such as daily conversations [59], software testing [71, 72] and answers [73, 74], and subjective evaluations of model outputs [75]. These datasets not only supply abundant training samples for the model but also play a key role in supervised learning, particularly in scoring model responses and collecting preference feedback [40, 41], thereby offering strong signals for fine-tuning.

Crowdsourcing also plays the role of an anomaly detector in quality control of model-generated content, identifying and correcting logical errors, inappropriate

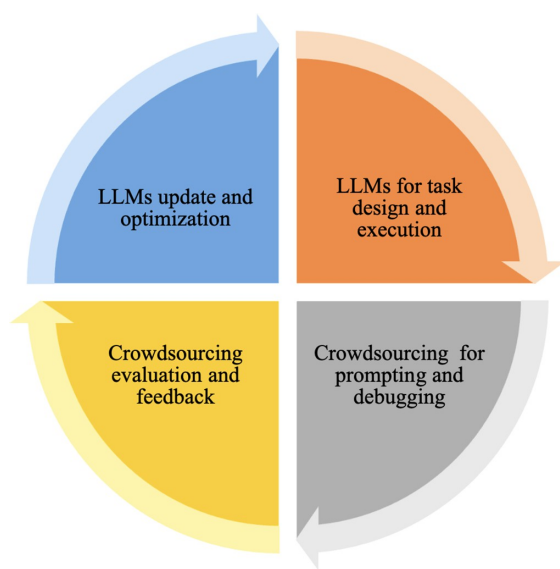


Figure 1.
The positive feedback loop between llms and crowdsourcing.

expressions, or outputs that deviate from task objectives [36, 51, 76]. This enhances system reliability and builds user trust.

In summary, crowdsourcing promotes model performance through the provision of training data and feedback mechanisms, while optimized LLMs, in turn, further empower the crowdsourcing process, significantly improving efficiency and output quality in task design, execution, and management. This positive feedback loop not only drives the continuous evolution of the models themselves but also accelerates the deeper transformation of collaboration between AI systems and humans [31], signaling a promising future for human-AI integration. This feedback loop can be depicted by **Figure 1**.

Unlike prior research that examines isolated applications of LLMs or focuses solely on performance metrics, this study systematically explores the bidirectional collaboration between LLMs and crowdsourcing. We introduce a structured classification framework based on their role in tasks. This framework defines how LLMs empower and are supported by crowdsourcing. Then we explore key challenges and future directions for LLMs-crowdsourcing collaborative system, which clearly distinguishes our work from existing surveys.

1.4 Systematic review method

To systematically present the collaborative relationship between LLMs and crowdsourcing, as well as the evolution of related research, we selected several representative high-quality databases, including ACL Anthology, IEEE Xplore, ACM Digital Library, and arXiv. During the retrieval process, we used the following Boolean operation statements: `[[All: crowdsourcing] OR [All: crowdsourcing] OR [All: crowdsourced]] AND [[All: llm] OR [All: llms] OR [All: llm-based]]`. In the content of the article, information such as research tasks, research methods, datasets,

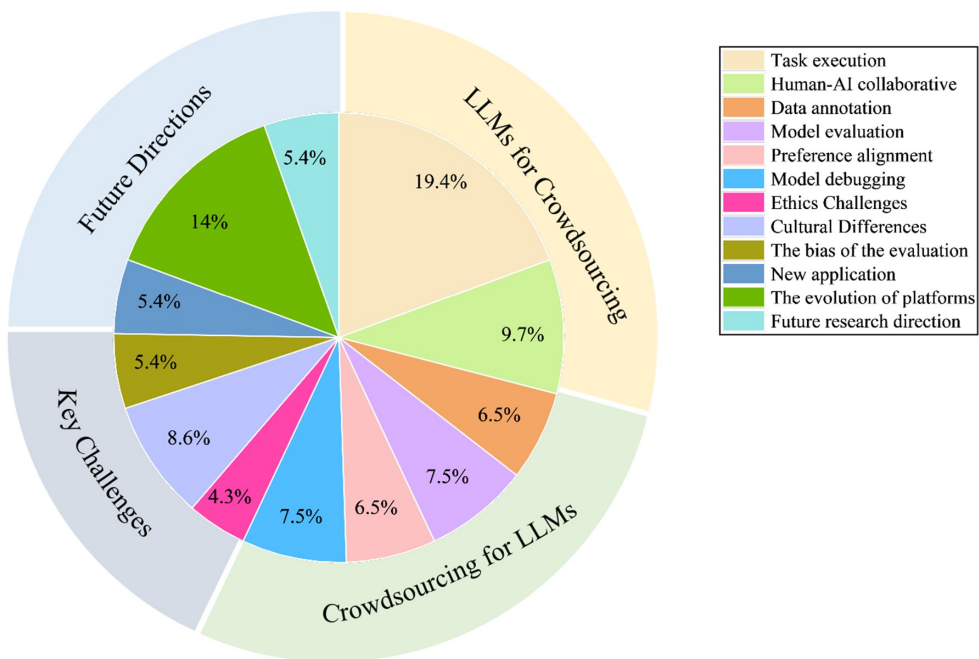


Figure 2.
The percentage of papers classified by topic.

evaluation metrics, and limitations was extracted to ensure the relevance and comprehensiveness of the results. We retrieved over 300 references in total. After manual review and exclusion of papers with publication year is too early, not written in English, exceeds the discipline scope, and is not focused on crowdsourcing, a final set of 109 papers was selected.

Figure 2 presents the overall structure and focus of this research in a thematic distribution format, which can be summarized into three interrelated directions: First, it focuses on leveraging large models to empower crowdsourcing tasks, emphasizing their potential value in task generation, execution, and collaboration; Second, explore the role of crowdsourcing in promoting model development and optimization, highlighting the complementary relationship between human feedback and the capabilities of large models; Thirdly, it focuses on key issues such as culture, prejudice, and research evolution to reveal the ethical challenges and future development directions in this field.

2. Llms for crowdsourcing

The introduction of LLMs offers new solutions to bottlenecks in traditional crowdsourcing, such as high costs and low efficiency. LLMs can not only assist crowdsourcing personnel at various stages but also take on key responsibilities in specific tasks, significantly enhancing automation and data output quality [77]. To fully reveal the transformative potential and practical impact of LLMs on crowdsourcing, this chapter systematically examines their roles in task design,

execution, collaboration, and optimization while reviewing related research progress.

2.1 Task generation and execution

As LLMs advance in natural language understanding and generation capabilities, their roles within crowdsourcing platforms have steadily expanded. They have evolved from simple auxiliary tools into core participants capable of both constructing and executing tasks. This shift enables LLMs not only to support automatic generation of task content, but also to directly engage in task execution, significantly improving processing efficiency and data quality [21, 42].

In traditional crowdsourcing workflows, task design typically relies on manually written instructions. This process is often time-consuming and labor-intensive, and may result in issues such as unclear or ambiguous wording, which can lead to misunderstandings and low execution efficiency. The integration of LLMs has brought fundamental changes to this stage. With only a brief task objective or a few keywords as input, LLMs can automatically generate well-structured and clearly articulated task descriptions that include essential elements such as background, step-by-step instructions, and important considerations [16, 38, 75, 78]. In addition, LLMs can adapt to the language backgrounds of crowdsourcing personnel by generating multilingual translations, ensuring consistent understanding across different languages [46]. This reduces execution errors caused by language barriers and enhances both the efficiency and quality of global crowdsourcing projects.

During the task execution phase, many standardized language tasks that were originally performed by crowdsourcing personnel, such as text classification [24], keyword extraction [25], and summarization [11, 26], are increasingly being efficiently replaced by LLMs. Although these tasks require a certain level of comprehension and judgment, they are typically well-structured and clearly defined, making them highly suitable for automated processing by models. LLMs have demonstrated performance on such tasks that rivals or even surpasses that of humans. For example, models can automatically perform sentiment [4], topic [24], or intent classification [27] based on just a few examples, significantly reducing the need for human intervention. In summarization tasks, LLMs produce higher-quality output while avoiding the redundancy often caused by multiple overlapping responses in traditional crowdsourcing [60]. Additionally, LLMs have shown outstanding capabilities in sentence rewriting [28], multilingual translation [47], and parallel corpus construction [79], effectively lowering the labor cost of crowd involvement in language annotation tasks.

2.2 Human-machine collaborative execution paradigm

Although LLMs have demonstrated strong execution capabilities in many simple and standardized tasks, single automated approaches often struggle to ensure accuracy and contextual coherence when handling complex tasks, open-ended text generation, and multimodal content [29, 33]. Therefore, human-AI collaboration is becoming a more promising paradigm for task processing.

This collaboration model typically follows a two-stage process. First, LLMs quickly generate a draft of the task, such as questionnaire responses, product

descriptions, or dialogue texts, providing a basic content framework. Then, crowdsourcing personnel review and refine the draft by performing fact-checking, language polishing, semantic corrections, or style adjustments to ensure the content's accuracy, readability, and suitability [34, 35, 64]. In this process, LLMs provide efficient content generation while humans contribute judgment, commonsense understanding, and language fine-tuning, achieving an effective balance between efficiency and quality [31].

In addition, human-AI collaboration is also well suited for semi-automated annotation processes. Models can perform preliminary labeling on raw texts [18], while crowdsourcing personnel are responsible for reviewing and correcting the results [54]. This approach is especially effective for tasks with complex labeling standards or strong contextual dependencies. It can significantly improve overall processing efficiency while ensuring annotation quality.

This collaborative mechanism fully demonstrates the complementary strengths of artificial intelligence and human intelligence: models handle efficient generation and processing, and humans take charge of accuracy control and value judgment [54]. Through this human-AI collaboration, the advantages of LLMs in speed and scalability are retained, while their limitations in factual accuracy, logical consistency, and contextual understanding are effectively compensated. This makes the approach particularly suitable for tasks with high requirements for output quality and semantic precision.

3. Crowdsourcing for llms

With the roles of LLMs in crowdsourcing continue to expand, the value of crowdsourcing in model development has become increasingly prominent. As efficient method for data acquisition and knowledge integration, crowdsourcing plays an irreplaceable role in training, evaluation and continuous optimization of LLMs. From early-stage data collection to later-stage model fine-tuning, crowdsourcing continuously injects valuable human intelligence into LLMs. This chapter systematically examines how crowdsourcing contributes human signals at multiple critical stages, including training corpus construction, prompt template design, model response evaluation and scoring, alignment with user preferences.

3.1 Data annotation

In traditional NLP tasks, crowdsourcing mainly involves assigning clear and standardized labels to existing data [44, 80]. These tasks typically have well-defined structures and explicit labeling requirements. However, as task complexity increases, especially in areas like training dialogue models, prompt engineering, or value alignment, crowdsourcing personnel not only need to possess certain background knowledge and semantic understanding but also face significantly greater challenges in task design and quality control [99–100].

In response to this situation, a hybrid annotation approach combining LLMs and crowdsourcing has emerged in recent years. LLMs or other automated tools first perform pre-annotation, followed by confirmation and modification by crowdsourcing personnel with expertise [55]. This human-AI collaboration strategy effectively covers large volumes of basic data, allowing crowdsourcing personnel to

focus more on identifying and correcting biases and errors in the model’s pre-annotations [43]. As a result, annotation efficiency and data quality improve, preventing propagation of model errors within the training set [31].

This collaborative mechanism strengthens the supervisory role of crowdsourcing personnel within automated processes, making them not just simple data providers but key participants in quality control. For example, in the training of OpenAI’s InstructGPT [56], a strategy was employed where the model generates initial drafts that are then rated and ranked by crowdsourcing personnel. This approach effectively collects high-quality human preference signals and drives the model’s optimization toward outcomes that better align with human expectations.

3.2 Model evaluation

With significant improvements in generation capabilities, LLMs have expanded applications to complex language tasks such as text summarization [21] and inference [58]. Their outputs are open-ended and diverse, far beyond closed classification or matching tasks handled by traditional NLP models. This expansion has brought increasing challenges for evaluation, as model performance can no longer be fully measured by traditional metrics.

Human evaluation has gradually become a key method for assessing LLMs output quality. A common practice involves crowdsourcing personnel ranking multiple model-generated results [81], identifying issues such as factual errors, logical inconsistencies, or inappropriate expressions, thereby providing subjective quality judgments better aligned with human standards [32].

At the same time, automated evaluation still plays an irreplaceable role in large-scale experiments, rapid model iteration, and fine-tuning processes. Metrics such as BLEU [82] remain efficient and valuable references in tasks like sentence matching and text similarity. However, these metrics often struggle to accurately capture more complex language dimensions such as semantic coherence, factual accuracy, linguistic fluency, and cultural sensitivity.

Therefore, building a scientific and robust model evaluation system is gradually moving toward a paradigm that combines human evaluation and automated evaluation [83]. On one hand, crowdsourcing personnel participate in constructing reference answers, scoring output quality, and collecting human preference feedback, providing high-quality annotations for model training and evaluation [84]. On the other hand, there is active exploration of using LLMs themselves for scoring (such as self-evaluation) or bias analysis, leveraging their semantic understanding to extend the boundaries of automated evaluation.

3.3 Human preference alignment

As LLMs application scenarios expand, their outputs need not only meet task-level accuracy and logical consistency but also reflect adaptability to human values, social norms, and communication styles. This means model behavior must align with human preferences as much as possible to achieve safe, trustworthy, and responsible intelligent systems [85].

In this alignment process, the crowdsourcing mechanism plays a crucial role. Serving as a bridge for large-scale human feedback collection and value expression, crowdsourcing provides essential support for training human-oriented LLMs [45].

Among these methods, Reinforcement Learning from Human Feedback (RLHF) is currently the most mainstream and effective alignment technique [39]. Its core idea is to introduce large-scale human rating data on top of pretrained models, guiding the model outputs toward answers that better meet user expectations through preference modeling.

In the RLHF process, crowdsourcing personnel play a key role. Following specific guidelines, they evaluate the quality of model outputs in open-ended questions, judging whether the responses are coherent, useful, and ethically appropriate [48]. This human value-based evaluation mechanism provides the model with quantifiable preference signals, enabling it to generate content that is not only correct but also appropriate [54].

3.4 Model debugging

LLMs are widely applied across various tasks, but errors and instability in their outputs have become increasingly apparent. Issues such as cultural biases [36], and pragmatic misunderstandings [86] not only affect the model's practical usability but also raise higher demands for its trustworthiness and controllability. Therefore, systematically identifying, analyzing, and explaining the erroneous outputs of LLMs has become an important research direction to enhance model safety and robustness.

In this context, crowdsourcing methods have been effectively introduced into the debugging and root cause analysis processes of LLMs. Through detailed identification and feedback on model outputs by crowdsourcing personnel, researchers can more comprehensively pinpoint the specific sources of model failures and develop more targeted optimization strategies accordingly [30]. Specifically, crowdsourcing platforms can be used to collect and annotate large-scale failure samples of LLMs, including filtering erroneous outputs, categorizing error types, and annotating reasons for misjudgments [37]. Such data are crucial for identifying systematic weaknesses of models in particular tasks or contexts and help build more targeted correction and training mechanisms.

In actual debugging processes, identifying model errors often requires balancing broad feedback with expert judgment. Therefore, a hybrid analysis mechanism that combines general crowdsourcing personnel with domain experts has gradually taken shape. Crowdsourcing personnel handle the initial identification and annotation of basic issues [7]. Then, researchers with professional backgrounds conduct in-depth analysis of complex, high-risk, or highly specialized samples to identify model deficiencies in specific knowledge structures or semantic levels [68]. This layered collaboration mechanism not only improves the quality of debugging data but also enhances the precision and efficiency of the model optimization process.

4. Key challenges

Although the deep integration of LLMs and crowdsourcing has significantly advanced task efficiency and intelligent system development, it still faces critical challenges and structural bottlenecks that demand systematic examination. This chapter addresses the core issues confronting current LLMs–crowdsourcing

collaborative systems, with particular attention to the uncertainties and risks surrounding ethical standards, evaluation criteria, feedback mechanisms, and quality control.

4.1 Ethics and employment challenges

In traditional crowdsourcing platforms, the manual work of crowdsourcing personnel has long been the core support for task completion [6]. However, with the continuous improvement of LLMs' generative capabilities, many low-complexity and rule-based tasks have gradually become automated. While this trend significantly improves task efficiency, it also raises widespread concerns among crowdsourcing personnel about job displacement [31].

In some practical applications, LLMs are used as preprocessing tools, where the model completes initial generation before passing the results to humans for verification and correction. Although such tasks often require a degree of complexity and judgment, platforms frequently downplay the value of human input by labeling them as collaborators, thereby suppressing payment standards and exacerbating inequalities faced by crowdsourcing personnel. For instance, in a labeling task, the LLMs completes 70% of the pre-labeling first, while the crowdsourcing personnel only perform the verification. The platform may calculate salary based on the revision volume, which could lead to a significant drop in the income of a large number of crowdsourcing personnel. This erosion of labor value caused by automation is not merely a matter of technical efficiency but reflects a redistribution of labor rights and human rights. According to the United Nations (UN) Guiding Principles on Business and Human Rights, companies have a responsibility to respect and protect human rights in their global operations, including workers' rights to fair income and protection from exploitation and discrimination. Such structural wage suppression resulting from technological substitution not only violates labor agreements but also undermines the fundamental economic and social rights of workers, particularly those located at the lower end of the global labor chain.

Therefore, as LLMs increasingly permeate the field of crowdsourcing, attention to the associated ethical issues must progress [87]. It is essential to establish more transparent and equitable mechanisms for task distribution and compensation, clearly acknowledging the actual contributions of human labor within automated workflows. This ensures that technological advancement does not come at the expense of labor rights, and it reflects a necessary commitment to responsibility in technological development [51]. It is critical for the long-term sustainability of crowdsourcing systems and the public's trust and acceptance. In some tasks where LLMs generates drafts and then crowdsourcing personnel rewrite some details, there will be a phenomenon where the final dataset is only labeled by AI, and the contributions of the crowdsourcing personnel are not recognized, which undermines the trust and sustainability of the crowdsourcing ecosystem.

4.2 Cultural differences

Crowdsourcing platforms heavily rely on the linguistic and cultural backgrounds of their personnel during data collection. Currently, many mainstream crowdsourcing personnel are concentrated in specific countries or cultural regions.

As a result, when performing tasks such as text annotation or model evaluation, their judgments are often influenced by their own linguistic habits and value systems, inevitably introducing cultural biases [52].

This issue becomes particularly pronounced in tasks involving subjective judgment. In evaluating the offensiveness, sensitivity, or moral orientation of texts, interpretations and tolerance levels can vary significantly across cultural contexts [51, 53]. For the sentence “You are really amazing”, it might be labeled as positive in the English context. However, in the Chinese context, it might be labeled as sarcastic. If a crowdsourcing system fails to recognize and mitigate such biases, these perspectives may be embedded into the training data, thereby affecting the model’s generalization capabilities and fairness.

The problem is further complicated as LLMs are widely used in multilingual, cross-cultural scenarios. Yet, most existing crowdsourcing validation mechanisms are dominated by reviewers from a single language or cultural background, hindering assessment of model performance across diverse contexts [88] and limiting accurate judgment of a model’s cross-cultural robustness.

To address this challenge, researchers and platforms must incorporate crowdsourcing personnel from multilingual and multicultural backgrounds to build more inclusive and diverse evaluation systems [41, 89]. At the data annotation stage, it is also important to emphasize the labeling of culturally diverse semantic elements to enhance the model’s sensitivity to cultural differences [90]. In the model output sentence: “Women should not work outside”, some of the crowdsourcing personnel rated it as gender discrimination. While other crowdsourcing personnel merely rated it as a kind gesture towards women. Furthermore, introducing cultural fairness metrics into model training and fine-tuning processes—and proactively identifying and correcting potential biases—will be crucial for improving both model performance and trustworthiness [69]. This approach aligns closely with the United Nations Educational Scientific and Cultural Organization (UNESCO) Recommendation on the Ethics of Artificial Intelligence, which emphasizes cultural diversity, inclusiveness, and non-discrimination as fundamental principles for responsible AI development. By embedding these principles into data collection, annotation, and model governance, platforms can move beyond technical bias mitigation toward establishing normative safeguards that ensure AI systems are sensitive to and respectful of different cultural contexts.

4.3 The bias of the evaluation

Most LLMs applications primarily use automated metrics like accuracy or BLEU to quantify performance. However, crowdsourcers apply richer, multidimensional criteria in manual evaluation: language naturalness, semantic coherence, logical consistency, and potential misleading content [38, 61]. Thus, outputs scoring well automatically may still be rated low-quality by humans due to ambiguity, logical leaps, or inaccuracies.

The gap between automatic and human judgment is stark in subjective tasks: open-ended generation, dialogue reasoning, sentiment understanding. Automatic systems rely on surface text matching, missing complex dimensions like contextual reasoning, commonsense inference, cultural references, or values—areas where human evaluation excels [3].

To address this issue, recent studies have explored hybrid evaluation mechanisms combining automated and human-based assessments. Typically, automatic metrics are used for initial screening, while human evaluators supplement the process [63] by assessing high-level quality dimensions, striking a balance between efficiency and accuracy. Crowdsourcing platforms can also adopt multi-round validation procedures [34], involving personnel from diverse linguistic and cultural backgrounds to perform cross-evaluation, thereby improving the robustness and objectivity of model assessments. For instance, when dealing with highly subjective issues such as “whether immigration is legal”, the interpretations of different crowdsourcing personnel from different countries will be cross-compared, thereby reducing the risk of a single cultural bias.

5. Emerging trends and future directions

Building on the critical challenges identified previously, the collaboration between LLMs and crowdsourcing is entering a new stage of development. Their integration is shifting from operational tasks toward more systematic and intelligent transformation. This chapter examines this evolving trajectory, exploring potential breakthroughs in collaborative intelligence, process automation, and feedback loops between LLMs and crowdsourcing.

5.1 New application scenarios

The widespread application of LLMs in the field of NLP is continuously driving the evolution of crowdsourcing systems and giving rise to a range of emerging use cases with practical potential.

With blockchain advancement, its integration with crowdsourcing and LLMs offers new perspectives for building trustworthy data collaboration frameworks. Traditional crowdsourcing often suffers from data opacity, lack of process transparency, and unfair compensation distribution. These challenges can be effectively addressed by leveraging blockchain’s decentralized, tamper-proof, and auditable characteristics [91]. Securely recording every step of the crowdsourcing workflow on-chain ensures data source reliability and task execution transparency [31, 92].

Currently, LLMs training widely adopts the RLHF paradigm. Most existing RLHF pipelines, developed independently by organizations or companies, lack generalizability and reusability. Fields like AI dialogue systems and intelligent agents often require extensive and diverse user participation, but single-organization datasets fail to cover all real-world scenarios, leading to inadequate testing, sample bias, and difficulty in identifying potential model issues. Thus, building a standardized RLHF platform is an effective solution. It can aggregate diverse participants to enhance feedback diversity and comprehensiveness, provide unified task templates, feedback interfaces, and evaluation metrics to improve training consistency and efficiency [93], and include modules for annotator selection, preference elicitation, feedback normalization, and anomaly detection to ensure human feedback diversity, fairness, and robustness [45].

5.2 The evolution of crowdsourcing platforms

Current crowdsourcing relying primarily on human labor for large-scale task distribution and execution. With the continuous advancement of LLMs, crowdsourcing platforms are undergoing a profound transformation. LLMs are being integrated into key stages such as task publishing, quality control, and result analysis, enabling smarter and partially automated workflows that significantly improve task efficiency and data quality [64].

A new generation of crowdsourcing platforms has emerged, positioning LLMs as task mediators or collaborators. On these platforms, LLMs not only play a supporting role but actively participate in workflows [94]. Human participants primarily oversee and review the process, forming an efficient collaboration model where the model takes the lead and humans ensure quality. Additionally, LLMs can act as interpreters or assistants, providing real-time operational guidance for crowdsourcing personnel, explaining complex task instructions, or translating multilingual terminology. This reduces cognitive barriers and improves the overall quality and efficiency of task execution [50].

This emerging crowdsourcing model, centered on human-AI collaboration, not only reshapes the structure of task allocation but also redefines the core functions and value logic of crowdsourcing platforms. It marks a shift from labor-driven operations to intelligent collaboration, opening new pathways for the development of future crowdsourcing ecosystems [9].

Moreover, with the expansion of crowdsourcing platform scales and the increasing complexity of tasks, static allocation strategies can hardly address core challenges such as worker capability heterogeneity, task demand dynamics, and environmental uncertainty [95]. In this context, Multi-armed bandit (MAB) algorithms [96, 97], relying on the “exploration-exploitation” mechanism, provide crucial support for online adaptive decision-making [98]. For example, contextual MAB and combinatorial MAB models have effectively optimized dynamic task allocation; algorithms like ME-UCB [101] have improved quality control accuracy; and MAB-based incentive strategies have significantly enhanced worker participation. Notably, when selecting workers for crowdsourcing tasks, considering their previous collaboration networks [102, 103] is also of great importance, as it can help identify workers with good cooperation records and strong teamwork abilities, thereby improving the overall efficiency and quality of task completion [104]. These applications promote the field of crowdsourcing from theoretical exploration to practical application.

5.3 Future research direction

One of the core challenges currently facing crowdsourcing systems is the issue of bias in both data and participant groups [105]. To ensure fairness and inclusiveness in the crowdsourcing process, researchers urgently need to develop multidimensional and diversified evaluation mechanisms, as well as design quantifiable metrics for participant diversity [106]. These efforts aim to effectively identify and prevent discrimination and the spread of bias that may emerge during the LLMs’ learning process through crowdsourcing data.

As crowdsourcing tasks grow in complexity and LLMs advance in capability, traditional evaluation methods relying solely on accuracy or single-dimensional

metrics no longer suffice to reflect system performance comprehensively. Therefore, establishing a more standardized and fine-grained evaluation framework, including consistency, robustness, bias assessment, and explainability, is a key step in advancing this field [107, 108]. Besides, exploring hybrid collaboration mechanisms combining expert crowdsourcing with LLMs could yield higher-quality data and more effective model training [109].

Moreover, Integrating LLMs, crowdsourcing, and MAB is a promising future research direction, given their strong characteristic complementarity. Crowdsourcing systems need to efficiently match massive dynamic tasks with heterogeneous workers. MAB excels in real-time decision optimization via balancing exploration and exploitation but struggles with unstructured information understanding and cross-scenario knowledge transfer. LLMs, with strengths in semantic parsing, logical reasoning, and data generation, can precisely address MAB's shortcomings, offering smarter decision support for complex crowdsourcing scenarios. Specifically, LLMs' semantic understanding can enhance MAB's modeling accuracy for unstructured contexts like task descriptions and worker feedback; LLMs-generated synthetic data can boost MAB's exploration efficiency in small-sample scenarios; LLMs' reasoning ability can optimize MAB's dynamic strategy adjustment logic, especially enabling knowledge transfer in cross-domain crowdsourcing tasks.

6. Conclusion

LLMs' rapid rise has deepened the ties between crowdsourcing and AI. This study provides the first comprehensive synthesis of cross-disciplinary research on LLMs–crowdsourcing integration. It identifies bidirectional interaction mechanisms across task design, collaboration, quality control, and model development. LLMs reshape crowdsourcing workflows through advanced language capabilities, while crowdsourcing enhances LLMs development through annotation, feedback, evaluation, and debugging. These dynamics highlight the need for standardized frameworks to strengthen human–AI complementarity. The findings have implications for future research directions, operational practices that enable efficient bidirectional feedback, and governance policy that ensure transparency, protect labor rights, and align technological development with human-centered values and the public benefit.

Acknowledgments

This work was supported by the Basic Operation Project of the Start-up Fund for Young Researchers of China Agricultural University, entitled “Research and Development of Key Technologies for Knowledge-Driven Retrieval and Generation” (Project Nos.: 2025RC040 and 2025TC008), as well as the Visiting Scholar Program of the China Scholarship Council (CSC) (Project No.: 202506350123).

Author details

Chunli Lv^{1,2}, Cheng Shen¹ and Miao Xie^{1,2*}

1 College of Information and Electrical Engineering, China Agricultural University, Beijing, China

2 Key Laboratory of Agricultural Machinery Monitoring and Big Data Application, Ministry of Agriculture and Rural Affairs, Beijing, China

*Address all correspondence to: xiemiao@cau.edu.cn

IntechOpen

© 2025 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Trippas JR, Lawati SFDA, Mackenzie J, Gallagher L. What do users really ask large language models? an initial log analysis of google bard interactions in the wild. SIGIR, 2024
- [2] Ibrahim S, Traganitis PA, Fu X, Giannakis GB. Learning from crowdsourced noisy labels: A signal processing perspective. arXiv preprint arXiv:2407.06902, 2024
- [3] Zeng X, La Barbera D, Roitero K, Zubiaga A, Mizzaro S. Combining large language models and crowdsourcing for hybrid human-ai misinformation detection. In Proceedings of the 47th International ACM SIGIR Conference on Research and Development in Information Retrieval, 2332–2336, 2024
- [4] Latif S, Usama M, Malik MI, Schuller BW. Can large language models aid in annotating speech emotional data? uncovering new frontiers. arXiv preprint arXiv:2307.06090, 2023
- [5] Huang S-H, et al. On replacing humans with large language models in voice-based human-in-the-loop systems. In Proceedings of the AAAI Symposium Series, volume 3, 45–49, 2024
- [6] He O, Jain A, Rodriguez-Leon AA, Taduvayi A, Mauriello ML. From crowdsourcing to large multimodal models: Toward enhancing image data annotation with gpt-4v. 2023
- [7] He Z, Huang C-Y, Ding C-KC, Rohatgi S, Huang T-HK. If in a crowdsourced data annotation pipeline, a gpt-4. In Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems, 1–25, 2024
- [8] Shrivastava I, Barkai N, Kharkar R. Harnessing large language models for cost-effective relevance labeling in job search systems. The AAAI Workshop on Computational Jobs Marketplace, 2025
- [9] Wu T, Zhu H, Albayrak M, et al. Llms as workers in human-computational algorithms? replicating crowdsourcing pipelines with llms. In Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems, 1–10, 2025
- [10] Ling Y, Yu S, Fang C, Pan G, Wang J, Liu J. Redefining crowdsourced test report prioritization: An innovative approach with large language model. Information and Software Technology. 2025;179:107629
- [11] Roitero K, Wright D, Soprano M, Augenstein I, Mizzaro S. Efficiency and effectiveness of llm-based summarization of evidence in crowdsourced fact-checking. In Proceedings of the 48th International ACM SIGIR Conference on Research and Development in Information Retrieval, SIGIR '25, 457–467, New York, NY, USA, 2025. Association for Computing Machinery
- [12] Wang C, Freire SK, Zhang M, Wei J, Goncalves J, Kostakos V, Sarsenbayeva Z, Schneegass C, Bozzon A, Niforatos E. Safeguarding crowdsourcing surveys from chatgpt with prompt injection. arXiv preprint arXiv:2306.08833, 2023

- [13] Xu J, Ma MD, Wang F, Xiao C, Chen M. Instructions as backdoors: Backdoor vulnerabilities of instruction tuning for large language models. arXiv preprint arXiv:2305.14710, 2023
- [14] Li J, Hui B, Qu G, Yang J, Li B, Li B, Wang B, Qin B, Geng R, Huo N, et al. Can llm already serve as a database interface? a big bench for large-scale database grounded text-to-sqls. *Advances in Neural Information Processing Systems*. 2023;**36**: 42330–42357
- [15] He X, Lin Z, Gong Y, Jin A, Zhang H, Lin C, Jiao J, Yiu SM, Duan N, Chen W, et al. Annollm: Making large language models to be better crowdsourced annotators. arXiv preprint arXiv:2303.16854, 2023
- [16] Ma K, Grandi D, McComb C, Goucher-Lambert K. Exploring the capabilities of large language models for generating diverse design solutions. arXiv preprint arXiv:2405.02345, 2024
- [17] Petukhova K, Kochmar E. A fully automated pipeline for conversational discourse annotation: Tree scheme generation and labeling with large language models. arXiv preprint arXiv:2504.08961, 2025
- [18] Zhang H, Yang J, Nie J, Liang P, Wu K, Lian D, Mao R, Song Y. Efficient data labeling by hierarchical crowdsourcing with large language models. In *Proceedings of the 31st International Conference on Computational Linguistics*, 11290–11303, 2025
- [19] Lee Y-J, Ko B, Kim H-G, Hyeon J, Choi H-J. Dialogcc: An automated pipeline for creating high-quality multi-modal dialogue dataset. arXiv preprint arXiv:2212.04119, 2022
- [20] Ide T, Murata E, Kawahara D, Yamazaki T, Li S, Shinzato K, Sato T. Phalm: Building a knowledge graph from scratch by prompting humans and a language model. arXiv preprint arXiv:2310.07170, 2023
- [21] Faggioli G, Dietz L, Clarke CL, Demartini G, Hagen M, Hauff C, Kando N, Kanoulas E, Potthast M, Stein B, et al. Perspectives on large language models for relevance judgment. In *Proceedings of the 2023 ACM SIGIR International Conference on Theory of Information Retrieval*, 39–50, 2023
- [22] Chai C, Fan J, Li G, Wang J, Zheng Y. Crowd-powered data mining. arXiv Preprint, 2018
- [23] Siro C, Aliannejadi M, de Rijke M. Context does matter: Implications for crowdsourced evaluation labels in task-oriented dialogue systems. arXiv preprint arXiv:2404.09980, 2024
- [24] Li Z, Zhu H, Lu Z, Yin M. Synthetic data generation with large language models for text classification: Potential and limitations. arXiv preprint arXiv:2310.07849, 2023
- [25] Wiegreffe S, Hessel J, Swayamdipta S, Riedl M, Choi Y. Reframing human-ai collaboration for generating free-text explanations. arXiv preprint arXiv:2112.08674, 2021
- [26] Hu Q, Moon G, Ng HT. From moments to milestones: Incremental timeline summarization leveraging large language models. In *Proceedings of the 62nd Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, 7232–7246, 2024
- [27] Cegin J, Simko J, Brusilovsky P. Chatgpt to replace crowdsourcing of

- paraphrases for intent classification: Higher diversity and comparable model robustness. arXiv preprint arXiv:2305.12947, 2023
- [28] Honovich O, Scialom T, Levy O, Schick T. Unnatural instructions: Tuning language models with (almost) no human labor. arXiv preprint arXiv:2212.09689, 2022
- [29] Liu S, Sabour S, Wang X, Mihalcea R. Free lunch for user experience: Crowdsourcing agents for scalable user studies. arXiv preprint arXiv:2505.22981, 2025
- [30] Wang X, Dao F, Ji Y, Qiu S, Zhu X, Dong W, Wang H, Zhang W, Zheng X. Crowdsourcing intelligence for improving disaster forecasts. *The Innovation*. 2024;5(4):100647
- [31] Chan A, Di C, Rupertus J, Smith GD, Nagaraj Rao V, Horta Ribeiro M, Monroy-Hernández A. Redefining research crowdsourcing: Incorporating human feedback with llm-powered digital twins: Incorporating human feedback with llm-powered digital twins. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems*, 1–10, 2025
- [32] Gao L, Zhang DY, Bahar P, Schwenk H, Kordjamshidi P, Cohen WW, Neubig G. Human evaluation of text style transfer: A user study. In *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*, 1131–1146, 2020
- [33] Kazari K, Chen Y, Shakeri Z. Scaling public health text annotation: Zero-shot learning vs. crowdsourcing for improved efficiency and labeling accuracy. arXiv preprint arXiv:2502.06150, 2025
- [34] Zhang Y, Dong D, Hung C-T, Heyerdahl L, Giles-Vernick T, Yeoh E-K. Human-llm collaborative construction of a cantonese emotion lexicon. arXiv preprint arXiv:2410.11526, 2024
- [35] Christoforou E, Demartini G, Otterbacher J. Crowdsourcing or ai sourcing? *Communications of the ACM*. 2025;68(4):24–27
- [36] Ding Z, Srinivasan A, MacNeil S, Chan J. Fluid transformers and creative analogies: Exploring large language models’ capacity for augmenting cross-domain analogical creativity. In *Proceedings of the 15th Conference on Creativity and Cognition*, 489–505, 2023
- [37] Lakkaraju H, Kamar E, Caruana R, Horvitz E. Interpretable and interactive learning with human-in-the-loop. arXiv preprint arXiv:1606.05685, 2016
- [38] Qian R, Ross C, Fernandes J, Smith E, Kiela D, Williams A. Perturbation augmentation for fairer nlp. arXiv preprint arXiv:2205.12586, 2022
- [39] Kaufmann T, Weng P, Bengs V, Hüllermeier E. A survey of reinforcement learning from human feedback. arXiv Preprint, 2024
- [40] Zheng L, Chiang W-L, Sheng Y, Zhuang S, Wu Z, Zhuang Y, Lin Z, Li Z, Li D, Xing E, et al. Judging llm-as-a-judge with mt-bench and chatbot arena. *Advances in Neural Information Processing Systems*. 2023;36:46595–46623
- [41] Cheng M, Zhang H, Yang J, Liu Q, Li L, Huang X, Song L, Li Z, Huang Z,

- Chen E. Towards personalized evaluation of large language models with an anonymous crowd-sourcing platform. In Companion Proceedings of the ACM Web Conference 2024, 1035–1038, 2024
- [42] Feng K, Ding K, Ma K, Wang Z, Zhang Q, Chen H. Sample-efficient human evaluation of large language models via maximum discrepancy competition. arXiv preprint arXiv:2404.08008, 2024
- [43] Dou Y, Forbes M, Koncel-Kedziorski R, Smith NA, Choi Y. Is gpt-3 text indistinguishable from human text? scarecrow: A framework for scrutinizing machine text. arXiv preprint arXiv:2107.01294, 2021
- [44] Snow R, O'Connor B, Jurafsky D, Ng AY. Cheap and fast—but is it good?: Evaluating non-expert annotations for natural language tasks. In Proceedings of the 2008 Conference on Empirical Methods in Natural Language Processing, 254–263. Association for Computational Linguistics, 2008
- [45] Wong MF, Tan CW. Aligning crowd-sourced human feedback for reinforcement learning on code generation by large language models. IEEE Transactions on Big Data, 2024
- [46] Choi J, Lee E, Jin K, Kim Y. Gpts are multilingual annotators for sequence generation tasks. arXiv preprint arXiv:2402.05512, 2024
- [47] Wang C, Engler D, Li X, Hou J, Wald DJ, Jaiswal K, Xu S. Near-real-time earthquake-induced fatality estimation using crowdsourced data and large-language models. International Journal of Disaster Risk Reduction. 2024; 37: 04680
- [48] Bai Y, Kadavath S, Kundu S, et al. Training a helpful and harmless assistant with reinforcement learning from human feedback. arXiv preprint arXiv:2204.05862, 2022
- [49] Zhang L. Reasoning about procedures with natural language processing: A tutorial. arXiv Preprint. 2022
- [50] Gimpel H, Laubacher R, Meindl O, Wöhl M, Dombetzki L. Advancing content synthesis in macro-task crowdsourcing facilitation leveraging natural language processing. Group Decision and Negotiation. 2024;33: 1301–1322
- [51] Lau M. Artificial intelligence language models and the false fantasy of participatory language policies. Working Papers in Applied Linguistics and Linguistics at York. 2021;1:4–15
- [52] Deng WH, Yurrita M, Daz M, Suh J, Judd N, Groves L, Shen H, Eslami M, Holstein K. Responsible crowdsourcing for responsible generative ai: Engaging crowds in ai auditing and evaluation. In Proceedings of the AAAI Conference on Human Computation and Crowdsourcing, volume 12, 148–150, 2024
- [53] Masud S, Singh S, Hangya V, Fraser A, Chakraborty T. Hate personified: Investigating the role of llms in content moderation. arXiv preprint arXiv:2410.02657, 2024
- [54] Wang Y, Stevens D, Shah P, Jiang W, et al. Model-in-the-loop (milo): Accelerating multimodal ai data annotation with llms. arXiv preprint arXiv:2409.10702, 2024
- [55] Sultan O, Bitton Y, Yosef R, Shahaf D. Parallelparc: A scalable

pipeline for generating natural-language analogies. arXiv preprint arXiv:2403.01139, 2024

[56] Ouyang L, Wu J, Jiang X, Almeida D, Wainwright CL, Mishkin P, Zhang C, Agarwal S, Slama K, Ray A, Schulman J, Hilton J, Kelton F, Miller L, Simens M, Askell A, Welinder P, Christiano P, Leike J, Lowe R. Training language models to follow instructions with human feedback. arXiv Preprint, 2022

[57] Joko H, Chatterjee S, Ramsay A, De Vries AP, Dalton J, Hasibi F. Doing personal laps: Llm-augmented dialogue construction for personalized multi-session conversational search. In Proceedings of the 47th International ACM SIGIR Conference on Research and Development in Information Retrieval, 796–806, 2024

[58] Ho M, Sharma A, Chang J, Saxon M, Levy S, Lu Y, Wang WY. Wikiwhy: Answering and explaining cause-and-effect questions. arXiv preprint arXiv:2210.12152, 2022

[59] Zheng C, Sabour S, Wen J, Zhang Z, Huang M. Augesc: Dialogue augmentation with large language models for emotional support conversation. arXiv preprint arXiv:2202.13047, 2022

[60] Moskovskiy D, Pletenev S, Panchenko A. LLMs to Replace Crowdsourcing For Parallel Data Creation? The Case of Text Detoxification In Findings of the Association for Computational Linguistics: EMNLP 2024. Miami, Florida, USA: Association for Computational Linguistics; 2024. p. 14361–14373

[61] Tsaneva S, Vasic S, Sabou M. Llm-driven ontology evaluation: Verifying ontology restrictions with chatgpt. The Semantic Web: ESWC Satellite Events. 2024;2024:15

[62] Chen Z, Ma Y, Kveton B, Deoras A. Active learning with crowd sourcing improves information retrieval. In Workshop on Interactive Learning with Implicit Human Feedback, 2023

[63] Semnani SJ, Yao VZ, Zhang HC, Lam MS. Wikichat: Stopping the hallucination of large language model chatbots by few-shot grounding on wikipedia. arXiv preprint arXiv:2305.14292, 2023

[64] Allen G, He G, Gadiraju U. Power-up! what can generative models do for human computation workflows? arXiv preprint arXiv:2307.02243, 2023

[65] Gupta H, Scaria K, Anantheswaran U, Verma S, Parmar M, Sawant SA, Baral C, Mishra S. Targen: Targeted data generation with large language models. arXiv preprint arXiv:2310.17876. 2024

[66] Sigurdsson GA, Varol G, Wang X, Farhadi A, Laptev I, Gupta A. Hollywood in homes: Crowdsourcing data collection for activity understanding. arXiv Preprint, 2016

[67] Orlandic L, Teijeiro T, Atienza D. The coughvid crowdsourcing dataset, a corpus for the study of large-scale cough analysis algorithms. Scientific Data. 2021;8(1):156

[68] Balloccu S, Reiter E, Li K, Sargsyan R, Kumar V, Reforgiato D, Riboni D, Dušek O. Ask the experts: Sourcing a high-quality nutrition counseling dataset through human-ai collaboration. In Findings of the

- Association for Computational Linguistics: EMNLP 2024. Miami, Florida, USA: Association for Computational Linguistics. 2024. p. 11519–11545
- [69] Dhole KD, Shu K, Agichtein E. Conqret: Benchmarking fine-grained evaluation of retrieval augmented argumentation with llm judges. arXiv preprint arXiv:2412.05206, 2024
- [70] Sun Z, Feng K, Yang J, Fang H, Qu X, Ong Y-S, Liu W. Revisiting bundle recommendation for intent-aware product bundling. ACM Transactions on Recommender Systems. 2024;2(3):1–34
- [71] Cui Q, Wang J, Yang G, Xie M, Wang Q, Li M. Who should be selected to perform a task in crowdsourced testing? In 2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC), volume 1, 75–84, 2017
- [72] Wang J, Wang S, Chen J, Menzies T, Cui Q, Xie M, Wang Q. Characterizing crowds to better optimize worker recommendation in crowdsourced testing. IEEE Transactions on Software Engineering. 2021;47(6):1259–1276
- [73] Cambazoglu BB, Sanderson M, Scholer F, Croft B. A review of public datasets in question answering research. In ACM SIGIR Forum, volume 54, 1–23. ACM New York, NY, USA, 2021
- [74] Mishra S, Nouri E. Help me think: A simple prompting strategy for non-experts to create customized content with models. arXiv preprint arXiv:2208.08232, 2022
- [75] Gao M, Varshney A, Chen S, Goddla V, Gallifant J, Doyle P, Novack C, Dillon-Martin M, Perkins T, Correia X, et al. The use of large language models to enhance cancer clinical trial educational materials. JNCI Cancer Spectrum. 2025;9:pkaf021
- [76] Xu J, Han L, Sadiq S, Demartini G. On the role of large language models in crowdsourcing misinformation assessment. In Proceedings of the International AAAI Conference on Web and Social Media, volume 18, 1674–1686, 2024
- [77] Moore S, Bier N, Stamper J. Assessing educational quality: Comparative analysis of crowdsourced, expert, and ai-driven rubric applications. In Proceedings of the AAAI Conference on Human Computation and Crowdsourcing, volume 12, 115–125, 2024
- [78] Li J. A comparative study on annotation quality of crowdsourcing and llm via label aggregation. In ICASSP 2024-2024 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 6525–6529. IEEE, 2024
- [79] Jansen BJ, Jung S-G, Salminen J. Employing large language models in survey research. Natural Language Processing Journal. 2023;4:100020
- [80] Bragg J, Choi E, Weld DS. Flexcrowd: Modeling the reliability of flexible annotations. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 1–13. ACM, 2021
- [81] Kostic I, Balog K, Radlinski F. Generating usage-related questions for preference elicitation in conversational recommender systems. ACM Transactions on Recommender Systems. 2024;2(2):1–24

- [82] Papineni K, Roukos S, Ward T, Zhu W-J. Bleu: A method for automatic evaluation of machine translation. In Isabelle P, Charniak E, Lin D, editors, Proceedings of the 40th Annual Meeting of the Association for Computational Linguistics, 311–318, Philadelphia, Pennsylvania, USA, July 2002. Association for Computational Linguistics
- [83] Yang S, Kasneci G. Is crowdsourcing breaking your bank? cost-effective fine-tuning of pre-trained language models with proximal policy optimization. arXiv preprint arXiv:2402.18284, 2024
- [84] Gehrmann S, et al. The gem benchmark: Natural language generation, its evaluation and metrics. In ACL, 4496–4513, 2021
- [85] Wang Y, Yu Z, Zeng Z, Yang L, Wang C, Chen H, Jiang C, Xie R, Wang J, Xie X, et al. Pandalm: An automatic evaluation benchmark for llm instruction tuning optimization. arXiv preprint arXiv:2306.05087, 2023
- [86] Hong M-H, Crisan A. Conversational ai threads for visualizing multidimensional datasets. arXiv preprint arXiv:2311.05590, 2023
- [87] Mishra A, Rahman S, Kim H, Mitra K, Hruschka E. Characterizing large language models as rationalizers of knowledge-intensive tasks. arXiv preprint arXiv:2311.05085, 2023
- [88] Lu Y, Feng W, Zhu W, Xu W, Wang XE, Eckstein M, Wang WY. Neuro-symbolic procedural planning with commonsense prompting. arXiv preprint arXiv:2206.02928, 2022
- [89] Marjeh R, Van Rijn P, Sucholutsky I, Sumers TR, Lee H, Griffiths TL, Jacoby N. Words are all you need? language as an approximation for human similarity judgments. arXiv preprint arXiv:2206.04105, 2022
- [90] Liu Y, Yao Y, Ton J-F, Zhang X, Guo R, Cheng H, Klovchov Y, Taufiq MF, Li H. Trustworthy llms: A survey and guideline for evaluating large language models’ alignment. arXiv preprint arXiv:2308.05374, 2023
- [91] Xie M, Wang Q, Cui Q, Yang G, Li M. Cqm: Coverage-constrained quality maximization in crowdsourcing test. In 2017 IEEE/ACM 39th International Conference on Software Engineering Companion (ICSE-C), 192–194, 2017
- [92] Liang Y, Li Y, Shin B-S. Faircs–blockchain-based fair crowdsensing scheme using trusted execution environment. Sensors. 2020;20(11):3172
- [93] Yuan Y, Hao J, Ma Y, Dong Z, Liang H, Liu J, Feng Z, Zhao K, Zheng Y. Uni-rlhf: Universal platform and benchmark suite for reinforcement learning with diverse human feedback. arXiv Preprint, 2024
- [94] Wang S, Li Q, Cui L, Yan Z, Xu Y, Shi Z, Min X, Shen Z, Yu H. Towards ai-empowered crowdsourcing. arXiv preprint arXiv:2212.14676, 2023
- [95] Wang Q, Cong G, Melo G, Xie M, Yang Q. Dynadiffuse: A dynamic diffusion model for continuous time constrained influence maximization. AAAI Press, 2015
- [96] Chen Y, Xie M, Liu J, Zhao K. Interconnected neural linear contextual bandits with ucb exploration. In Pacific-Asia Conference on Knowledge Discovery and Data Mining, 2022

- [97] Peng Y, Xie M, Liu J, Meng X, Jin R. A practical semi-parametric contextual bandit. In Twenty-Eighth International Joint Conference on Artificial Intelligence IJCAI-19, 2019
- [98] Xie M, Yin W, Xu H. Autobandit: A meta bandit online learning system. International Joint Conferences on Artificial Intelligence Organization, 2021
- [99] Xie M, Wang Q, Yang G, Li M. Cocoon: Crowdsourced testing quality maximization under context coverage constraint. In IEEE International Symposium on Software Reliability Engineering (ISSRE), 316–327, 2017.
- [100] Cui Q, Wang J, Xie M, Wang Q. Towards crowd worker selection for crowdsourced testing task. *Journal of Software*. 2018;29:3648–3664
- [101] Song Y, Jin H. Minimizing entropy for crowdsourcing with combinatorial multi-armed bandit. *IEEE INFOCOM*, 2021
- [102] Xie M, Bhowmick SS, Cong G, Wang Q. Panda: Toward partial topology-based search on large networks in a single machine. *The VLDB Journal*. 2017;26(2):1–26
- [103] Xie M, Bhowmick SS, Su H, Cong G, Han WS. Panda: A system for partial topology-based search on large networks. In *Proceedings of the VLDB Endowment*, volume 11, 1966–1969, 2018
- [104] Wang C, Xie M, Bhowmick SS, Choi B, Xiao X, Zhou S. Ferrari: An efficient framework for visual exploratory subgraph search in graph databases. *The VLDB Journal*. 2020;29:1–26
- [105] Xie H, Maddalena E, Qarout R, Checco A. The dark side of recruitment in crowdsourcing: Ethics and transparency in micro-task marketplaces. *Computer Supported Cooperative Work (CSCW)*. 2023;32(3):439–474
- [106] Ghai B, Liao QV, Zhang Y, Mueller K. Measuring social biases of crowd workers using counterfactual queries. *arXiv Preprint*, 2020
- [107] Figueras BC, Sagarzazu E, Etxaniz J, Barnes J, Gamallo P, Flores IDD, Agerri R. Truth knows no language: Evaluating truthfulness beyond English. *arXiv Preprint*, 2025
- [108] Ren R, Agarwal A, Mazeika M, Menghini C, Vacareanu R, Kenstler B, Yang M, Barrass I, Gatti A, Yin X, Trevino E, Geralnik M, Khoja A, Lee D, Yue S, Hendrycks D. The mask benchmark: Disentangling honesty from accuracy in ai systems. *arXiv Preprint*, 2025
- [109] Gupte A, Wang R, Venkatesh VLN, Kim T, Zhao D, Yuan Z, Min B-C. Rebel: Rule-based and experience-enhanced learning with llms for initial task allocation in multi-human multi-robot teaming. *arXiv preprint arXiv:2409.16266*. 2025

Strategic Crowdsourcing: Frameworks, Challenges, and Impact in the Digital Economy

*Vahab Esfandani, Mohammad Amin Borghei, Sara Ramzani,
Peter Konhaeusner, Ahmad Abu-alkheil and
Phungmayo Horam*

Abstract

The digital economy has expanded organizations' ability to source ideas, labor and capital through online participation, making crowdsourcing a strategic mechanism for innovation and problem solving. This chapter conceptualizes strategic crowdsourcing as a socio-technical system rather than ad hoc task outsourcing and synthesizes dispersed theory and evidence into a coherent framework for design and governance. It defines major typologies—micro-tasks, open innovation contests, co-creation, crowdfunding, internal crowdsourcing and citizen science—and situates them relative to outsourcing and open-source collaboration to clarify when each approach fits task uncertainty, required expertise and desired ownership of outputs. Building on open innovation, socio-technical systems and participatory governance perspectives, the chapter proposes an integrated model with five linked layers: contextual drivers; input configuration (task specification, crowd definition and call design); enabling infrastructure (platforms and technologies, including AI and blockchain-based mechanisms); process mechanisms (incentive design, validation and quality assurance, data governance and ethical/legal safeguards); and outputs/outcomes (innovation, organizational learning, governance effects and social value with feedback loops). Cross-sector illustrations from technology, healthcare, education, civic tech and sustainability highlight recurring trade-offs around motivation, quality control, fair compensation, privacy and confidentiality and intellectual property rights. The chapter also evaluates emerging hybrid human–AI crowdsourcing and decentralized autonomous organizations (DAOs), emphasizing that their benefits depend on transparent rules, accountable allocation of rewards and decision rights and human-in-the-loop oversight to mitigate bias, concentration of control and trust failures. Overall, strategic crowdsourcing is positioned as potentially democratizing when aligned with organizational goals and governed responsibly. It concludes by outlining research directions for comparative studies, cross-cultural analysis and regulation-aware design.

Keywords: strategic crowdsourcing, collective intelligence, digital economy, innovation management, crowdsourcing typologies, open innovation

1. Introduction

National boundaries have shifted with the digital economy because it has introduced the ability to access a large and flexible labor force through the internet. Crowdsourcing has been a strategic course of action as a mode of utilizing collective intelligence in terms of innovation and problem-solving and was initially used at a grassroots level, but later became systematically employed as a business resource [1, 2]. Companies embrace it as a source of an international reservoir of innovative skills, important resources, and implementation in the sense of creativity and problem-solving [3, 4]. It enables access to the so-called excess capacities and produces high-quality ideas, particularly in cases where internal R&D is scant [3, 5, 6].

New literature highlights the fact that the study of crowdsourcing is still divided across various fields in the context of the digital evolution of the economy. Through an in-depth literature review of the topic of crowdsourcing and digital information, it was identified that initial studies focused on conceptual development and the construction of typologies, but they have since shifted to studying how they operates on digital platforms and crowdfunding, as well as the improvement of machine learning and social media [7]. The emerging organizational and individual value propositions of crowdsourcing, due to its unique capability of harnessing dispersed knowledge and collective intelligence, have not been studied enough, and ethical concerns associated with crowdsourcing, e.g., privacy, compensation, and fairness have not been extensively explored. [7] points out that crowdsourcing, combined with digital information, has not been studied nearly enough, with under-studied and unexplored research areas, a lack of interdisciplinary collaboration, and an absence of overarching frameworks. To broaden the research agenda involves examining the ways in which digital platforms can specifically influence incentives to participate, social recognition, skills development, and algorithmic control, in tandem with digital inequalities and regulation issues. This chapter expands on those observations in the sense that it presents crowdsourcing not as a transactional process but as a socio-technical system redefining both organizational borders and labor relations.

Crowdsourcing is another example of the erosion of consumer/producer distinctions in the digital economy, where consumers become working consumers and producers become consuming producers, resulting in community creation around things that people share [2, 3]. Most strategic analytical planning, with an emphasis on stakeholder empowerment, the democratization of innovation, and governance, is preferred in digital cities planning and in the practical implementation of policies [8]. Motivations will be based on both economic and social grounds to enhance engagement, identify talent, and foster continued learning. Crowdsourcing is perfectly applicable to wicked problems; it harnesses distributed knowledge, encourages creativity, and provides quick solution iteration [1, 2, 8]. In spite of its increasing use, knowledge of its influence on strategic experience, the combination, and the elimination of uncertainty is still lacking [1, 5].

In spite of the proliferating research, the conceptual boundaries and strategic implications of crowdsourcing are fragmented. A new academic review has highlighted the fact that existing definitions are extremely varied and that many practitioners use the term to describe virtually any form of online collaboration. That review synthesized disparate definitions and put forward eight core elements that any definition of crowdsourcing should include – who constitutes the crowd, the nature of the task, the mechanism for remuneration, the initiator, the resulting product, the process, the

type of call, and the medium through which it is issued [9]. Such definitional inconsistencies make it hard to combine findings from across disciplines and understand how crowdsourcing compares to other mechanisms of open innovation.

The chapter addresses the conceptual deficiency by systematically and integratively synthesizing scattered insights on crowdsourcing. Its objective is to move beyond descriptive inventories toward a strategic notion of crowdsourcing in its various typologies and its potential to be purposefully designed and governed to generate innovation and societal value. Drawing on theories of open innovation, socio-technical systems, and participatory governance, the text develops an integrated framework relating typology choices to methodological decisions, incentive design, quality control, and ethical considerations. By theorizing this framework and mapping it onto contemporary empirical cases across diverse sectors, the chapter elucidates the conditions under which crowdsourcing enables innovations that reshape organizational boundaries, democratize innovation, and influence policy. This orientation establishes a platform for subsequent sections that investigate conceptual foundations (Section 2), methodological approaches (Section 9), computational and AI integration (Sections 10, 11), application domains (Sections 12–18), emerging trends (Section 19), and strategic implications culminating in a synthesized discussion and conclusion.

1.1 Defining crowdsourcing in the digital age

Digital-age crowdsourcing uses web connectivity to crowdsource solutions to problems, brainstorm ideas, and carry out tasks by way of an open invitation to a wide and usually ill-defined audience. The term was coined in 2006 by Jeff Howe, and it entails assigning functions to a large online community through the use of Web 2.0 technologies, thereby facilitating real-time communications and collaboration [10–12]. Businesses, governments, and non-profits make use of it based on open challenges, contests, and distributed tasks [8, 10, 13]. The framework is founded on shared intelligence to perform various tasks, including product development or urban development design [8, 14, 15]. The essential elements are an open call format, a widely distributed workforce, task decomposition, an incentive structure, and a quality control mechanism [8, 10, 11, 16–18]. It finds its reflection in the spatial crowdsourcing of urban services and in the functions of digital marketing and open innovation [14, 15, 17].

2. Conceptual foundations and theoretical perspectives

2.1 Historical evolution of crowdsourcing

Although it appears formally as a relatively recent term in the digital age, crowdsourcing has connections to the long-established customs of joint efforts associated with fundraising and subscription-based publications. These analog systems were the predecessors of the present distributed participation [19]. General Crowdsourcing Evolution, the introduction of the internet, and Web 2.0 in particular, completely changed crowdsourcing as it allowed users to contribute content and collaborate online, which paved the way for what is happening today on a mass scale through the use of social media and review sites [20]. This transformation has incorporated crowdsourcing into open innovation, co-creation, and organizational theory [21]. It has attracted millions of users, which has become key to the digital

economy, determined by activities on the platform and platform design [22]. In spite of the increase, the difficulties linked to its definition, scale, morals, and the design of participation – such as Byte link – are generating continuous research on the subject of incentive design and quality assurance [9, 11, 19].

2.2 Typologies of crowdsourcing

Crowdsourcing includes a variety of patterns that fit specific objectives and activities. Micro-task crowdsourcing divides projects into easy-to-work tasks among many dispersed workers and utilizes scalability and cost-effectiveness, with a financial reward often being used [23, 24]. Complex, though likely creative, problem-solving engages external people in open innovation crowdsourcing that rewards any successful input made, particularly when in-house expertise is limited [25–27]. Crowdfunding is defined by the concept of collective funding of financial projects, unlike the concept of crowdsourcing, which involves labor [28].

Other typologies involve crowd ideation to make creative suggestions, co-creation, in which multiple people are used to develop a product, and crowd voting, where a group of individuals is used to make judgments [23, 27, 28]. Crowd networking and crowd sharing support community relationships and the sharing of resources [28]. Citizen science is the inclusion of non-professionals as volunteers in scientific research, such as data collection and analysis [28, 29]. These typologies vary based on the nature of tasks, process (integrative vs. selective), type of reward, and openness/expertise [23, 26, 27, 30]. Internal crowdsourcing uses the intelligence of employees in internal problem-solving and innovation [31]. Academic crowdsourcing combines amateurs and professionals in research activities [29, 32].

Table 1 summarizes the key typologies of crowdsourcing described above, outlining the task nature, participation models, typical applications and defining features of each typology.

Table 2 maps each crowdsourcing type to its innovation and governance impact and highlights associated ethical and legal considerations.

Typology	Task nature	Participation model	Typical applications	Key features/Details
<i>Micro-tasks</i>	Simple, repetitive	Open, large crowd	Data entry, tagging, moderation	High scalability, minimal expertise required [27, 33]
<i>Open innovation</i>	Complex, creative	Open, diverse crowd	Product design, problem-solving	Integrative/selective, external expertise [10, 27]
<i>Crowd funding</i>	Financial support	Open, large crowd	Startups, creative projects	Small contributions, democratized funding [10, 33]
<i>Creative/Complex tasks</i>	Creative, skilled	Open, competitive	Design, music, scientific research	Competitions, specialized skills [27, 29]
<i>Internal crowdsourcing</i>	Varied	Closed, internal crowd	Idea generation, internal problems	Employee-driven, organizational focus [31]
<i>Academic/Scientific</i>	Research tasks	Open, mixed crowd	Data analysis, citizen science	Professional/amateur collaboration [29, 32]

Table 1.
Summary table of key typologies of crowdsourcing.

Typology	Innovation and governance impact (Keywords)	Ethical and legal considerations (Keywords)
<i>Micro-tasks</i>	Operational efficiency; large-scale data processing; cost reduction; rapid iteration [9]	Risk of low compensation; exploitation of workers; quality validation; privacy issues [9]
<i>Open innovation/complex tasks</i>	Breakthrough product and process innovation; access to diverse expertise; cross-sector problem solving [34]	Intellectual-property ownership; idea appropriation; fairness in reward allocation [34]
<i>Crowd funding</i>	Democratized financing; community building; support for start-ups and social innovation [9]	Risk of fraud; regulatory compliance; transparency of fund use and accountability [9]
<i>Co-creation/creative tasks</i>	Enhanced user engagement; product/service co-design; improved adoption and loyalty [9]	Unclear ownership of co-created assets; managing participant expectations; fair representation [9]
<i>Internal crowdsourcing</i>	Harnesses employee knowledge; fosters intrapreneurship and organizational learning [9]	Privacy and confidentiality; balancing openness with hierarchy; recognition and compensation [9]
<i>Citizen science/academic crowdsourcing</i>	Advances scientific research; democratizes knowledge; strengthens public trust; informs policy [9]	Data accuracy and validation; informed consent; equitable recognition; access to results [9]

Table 2.
Mapping crowdsourcing typologies to innovation/governance impact and ethical considerations.

3. Crowdsourcing, outsourcing, and open collaboration: A comparative analysis

Crowdsourcing works when the solutions are uncertain, and a diverse crowd with anonymity is employed [25–27]. Outsourcing presupposes that the supplier has been formally contracted with the providers for clearly defined and predictable tasks [25, 26, 35, 36]. Open sourcing is collaborative, voluntary, and involves open sharing, in which outputs are generated through community-driven, rapid innovation, and is predominantly used in software development [27, 37]. All the models have particular benefits and weaknesses, conditioning their implementation in the stratagem [25–27, 35–37].

Crowdsourcing can be more economical for decomposable tasks where mass participation is an advantage because transaction costs, labor costs, and pay-by-reward models are lower [25, 38–41]. Nevertheless, the cost-effectiveness depends on the complexity of the tasks, their duration, and the demands on their quality; therefore, the outsourcing option is most appropriate when the project is complex and requires a long-term commitment [38, 41, 42]. Pay-per-task models in crowdsourcing are short-term and connected with the continued ownership of output by the client, whereas open-source applications depend on voluntary contributions with outputs provided freely to the community for iteration [25, 38–41].

Table 3 provides a comparative summary of crowdsourcing, outsourcing and open-source collaboration across dimensions such as participants, motivations, control, task type, ownership, quality control and innovation potential.

Aspect	Crowdsourcing	Outsourcing	Open sourcing (Open Source)
<i>Participants</i>	Large, undefined crowd	Selected external provider(s)	Global community of volunteers
<i>Motivation</i>	Financial, intrinsic, reputation	Financial (contractual)	Intrinsic, reputation, community
<i>Control</i>	Client sets task, crowd submits solutions	Client defines scope, provider executes	Decentralized, community-driven
<i>Task type</i>	Routine, complex, creative	Well-defined, repeatable, or specialized	Software, documentation, creative works
<i>Output ownership</i>	Typically retained by client	Defined by contract	Openly shared, governed by licenses
<i>Quality control</i>	Varies, may require filtering	Managed by provider/client	Peer review, community standards
<i>Innovation potential</i>	High, due to diversity	Moderate, depends on provider	High, collaborative innovation
<i>References</i>	[25, 26, 35, 37]		

Table 3.
Comparative summary.

4. How crowdsourcing typologies improve innovation outcome

The use of crowdsourcing typologies and different external know-how promotes innovation, gaining more ground through expanded idea generation and user-driven development [14, 25, 43, 44]. Innovation and idea crowdsourcing bring a variety of participants, which broadens novel solutions to difficult issues, whereas internal processes broaden the outlook [14, 25, 43, 44]. The motivation of participants (intrinsic and extrinsic) affects the quality of solutions, and adequate task framing contributes to the increase in creativity [45–47]. The user-driven innovation is related to the alignment of products with market needs, and successful crowdsourcing should be integrated into the organizational innovation framework with effective alignment of purpose, task design, and participant mix [14, 44, 46, 48].

Advanced typologies of crowdsourcing, mainly involving generative artificial intelligence (AI), no longer rely on ideation through rather rote crowdsourcing services limited to humans, but instead involve the concept previously stated – the co-creation of human and AI [49]. Researchers pitted solutions from human-only teams against those from human world + large language model teams in a longitudinal crowdsourcing challenge. They discovered that multi-team (human + AI) solutions exhibited a greater level of strategic viability, financial and environmental worth, as well as overall quality; however, human-only teams demonstrated better novelty and creativity. Such findings indicate that hybrid search processes have the potential to harness the breadth of crowd creativity while leveraging AI's capability to synthesize information and assess feasibility. It is worth noting that prompt engineering, which involves human guidance in repeatedly revising AI queries, became a key aspect in enhancing the quality of solutions [49].

Use of AI does not, therefore, substitute crowd creativity but amplifies early innovation because it offers a cost and scale-efficient way of searching solution

space and filtering ideas. In addition to the positive performance implications, researchers suggest that generative AI can affect the boundaries of organizations and exacerbate the Not Invented Here syndrome: Organizations that use personal data can overlook external crowdsourced data and, by doing so, become less likely to absorb external information. Organizations need to build what is called an appropriation capacity: the capacity to get external ideas to fit into their own contexts and develop cultures that have an appreciation of external cooperation [50]. NIH bias can be offset with hybrid typologies that mix crowd ideation, algorithmic curation, and internal review at a faster rate of discovery.

5. Crowdsourcing in practice: Models and applications

5.1 Strategic crowdsourcing applications in the technology sector

Software engineering takes advantage of crowdsourcing to code, test, identify bugs, and find solutions to problems due to its fast implementation and variety of solutions [42, 51]. Under Industry 4.0, it enables product development, innovation, data supply to manufacturing, crowdsensing, and troubleshooting, incorporating external knowledge and real-time information to become flexible [52]. Smart cities rely on mobile crowdsourcing (MCS), which can support decentralized services and real-time data acquisition related to urban operation management and disaster response, applied to IoT, and wireless technologies [17, 53]. It is a tactical IS-sourcing trend and is able to leverage trained expertise for brainstorming and systems problem-solving, enabling rapid responses to technology requirements [1]. Internal crowdsourcing democratizes strategy, introduces innovation, and penetrates employees of all ranks [54, 55]. Ride-sharing and other sharing economy services rely on spatial crowdsourcing, addressing issues with the assignment and quality control of tasks as well as privacy [17, 53].

5.2 Strategic crowdsourcing applications in health, finance, and education

Crowdsourcing in the health sector has been applied in medical diagnosis and disease surveillance, where crowd assessments equate to expert assessments under surgical abilities and raise the rate of CPR intervention [56–58]. It facilitates the delivery of population health messages by creating culturally appropriate communication products in an economical manner [57, 59–61]. It has the capacity to perform AI tasks and health-related experiments on a massive scale and is used to support open collaborations in clinical research [58, 62]. In finance, strategic crowdsourcing uses collective intelligence to analyze investments, evaluate risk, and predict markets, providing agile feedback and innovation. It also saves operational expenses because it can outsource its non-ethical activities, such as data validation and compliance checks [1]. Crowdsourcing in the education sector raises assessment through the contribution of vast groups in the evaluation of student work as well as peer grading. It helps to encourage shared content and curriculum development, making it relevant and fast-changing. It encourages the interaction and involvement of students and raises the level of critical thinking and communication, particularly online [63].

6. Relationship between community involvement and crowdfunding

The engagement of the community plays a very important role in the success of crowdfunding, and higher levels of cultural, local, and online community engagement result in higher levels of funding [64–67]. Interested sharing and community updates, comments, etc., could establish trust and stimulate contributions [65, 68]. Developing the internal social capital of the platform contributes to attracting initial support to build on a self-reinforcing momentum [69, 70], strategic referrals done as early as possible through social proof [71], and encouraging word-of-mouth [72]. Long-term participation is essential for trust, clarity of fund management, and inclusivity [73]. Rewards systems, where individual efforts are rewarded and achievable rewards are potential, continue to do so [74, 75].

The involvement of the community will always be a key aspect of a crowdfunding campaign, but more than the raw quantity of participants, the rhythm of participation over time is determinant. Based on signal theory and information overload theory, a study by Solodoha, which analyzed 2,852 reward-based crowdfunding campaigns, found an inverted U-shaped correlation between update frequency and campaign outcomes, with moderate amounts of updates signaling commitment and progress, thereby reducing uncertainty and attracting more backers, while excessive updates caused cognitive overload and loss of impact [76].

The notion of updates provides a position of credibility that can reassure those who have taken a bet on the abilities and resource commitment of the entrepreneur, but a surfeit of updates makes it seem that there is a high probable risk and eliminates potential followers. This statement supplements the earlier data about early referrals and the practice of immediate and clear updates, implying that the organizers of campaigns should develop a strategy for updates that avoids over-relating transparency and saturation. In the two crowdfunding models noted above (donation-based and equity-based), the same signaling dynamics might be relevant, i.e., regular but minimal updates will encourage trust without incurring fatigue.

Table 4 illustrates how different community-involvement factors—such as local or cultural engagement, online community membership and the frequency of project updates—affect the success of crowdfunding campaigns.

7. Green and social innovation projects in practical crowdsourcing practices

Green and social innovation is growing through crowdsourcing, which relies on collective intelligence and local participation to address green and sustainability

Factor	Effect on crowdfunding success	
Local/cultural community engagement	Higher funding outcomes	[64, 65]
Online community membership	Increased exposure and backer participation	[66, 67]
Social interaction (comments, updates)	Greater trust, more contributions	[65, 68]
Internal social capital	Early support, self-reinforcing momentum	[69, 70]

Table 4.
Community involvement factor effect on crowdfunding success.

challenges [24, 77]. Sustainable Development Goals (SDGs) depend on crowdsourcing, enhanced by social media and trust in platforms [78]. Integrated platforms, combining social networking and crowdsourcing, are utilized to collaborate and share resources in relation to social and green innovation [79]. It is essential to adopt responsible innovation practices, such as inclusion and strategic alliances, along with design features and media portrayals, to encourage involvement [80–82]. Sustainable platforms are focused on long-term value creation and co-creation [83].

Crowdsourcing is a critical component of green and social innovation because, in both contexts, there are large numbers of stakeholders who need to be geared up to tackle environmental and social issues. Do Prado et al. (2025) conducted a systematic review adhering to the Methodi Ordinatio methodology and analyzed the literature on sustainable open innovation. They found that an overwhelming majority of the literature's interest in the topic was focused on environmental matters, the circular economy, and social aspects. Collaboration, crowdsourcing, knowledge management, and stakeholder engagement were identified as the main mechanisms by which open innovation can strengthen sustainability practices, although reviewers noted that most research still remains within a limited number of regions and sectors. The authors call for increased interdisciplinary and international collaborations, as well as economic development and environmental responsibility [84]. Such findings highlight the need to use the power of crowds to come up with solutions for green product design, waste reduction, and social entrepreneurship, and to establish mechanisms for assessing environmental and social effects. In the context of the work of technology platforms, the integration of the principles of sustainability values is also reflected in the creation of incentives to participate in the community in the long term and ensure environmental awareness.

8. Crowdsourcing in policy making and civic tech

Crowdsourcing is gaining traction in policymaking and the practice of civic technology to increase participation in political decision-making. Its most widespread application is in agenda-setting and policy evaluation, while its least widespread application is in other phases [85, 86]. ICT allows full transparency and deliberation over policymaking processes through what is known as crowd policymaking, and although large inputs can pose a problem, a solution is provided [86]. The process of good governance needs to be convenient, accessible, and efficient in processing data, and two-way communication increases citizens' participation [87, 88]. Crowdsourcing in urban planning is used as an addition to conventional participation, effectively utilizing the action of collective intelligence to improve solutions [89, 90]. Social media can also be used to conduct passive crowdsourcing, which provides important information on the needs of the population in terms of policy creation [88, 91].

Demonstrations in civic technology and public health suggest that the crowdsourcing process may be used to bridge research-practice gaps through community creativity. According to [92], the LIGHT global crowdsourcing competitions, which asked communities to collaborate in creating dissemination materials for health interventions, were described. These competitions were organized by the National Institute of Health Research. As per the World Health Organization/TDR open call methodological framework, the contests were organized in five steps: organizing a steering committee, popularizing the call,

accepting and judging entries, appreciating finalists, and broadcasting winning solutions. This strategy ensured that dissemination materials responded to audience requirements, helping to improve the receipt of evidence-based interventions [92]. Open calls to participate in policymaking have also been used in participatory budgeting, constitution drafting, and urban planning, as examples of how crowdsourced proposals may further enhance both transparency and legitimacy. The inclusion of coherent open-call mechanisms in the design of civic tech platforms may, therefore, enhance the adoption of policies and the popular perception of individual contributions to the process. This may be strengthened by a feedback loop designed to inform the crowd about the effect of its input on the process.

9. Methodological approaches in crowdsourcing research

Based on the evolution of the paradigm of the swift growth of crowdsourcing, a systematic and integrative literature review of insights related to crowdsourcing research from the early 2000s through mid-2025 was developed to form the strategic framework for this chapter. Whereas previous studies have mainly been used to summarize typologies or map bibliometric trends [9], the current study attempted to integrate conceptual, methodological, and empirical knowledge across several disciplines so that design principles could be generated. The review protocol followed the recommended guidelines for systematic and scoping reviews, combining database search, snowballing, and expert consultation.

Database searches were carried out in Web of Science, Scopus, Google Scholar, and PubMed using combinations of keywords such as “crowdsourcing,” “open innovation,” “digital economy,” “citizen science,” “ethics,” “quality control,” and “AI.” Searches were limited to book chapters, high-impact conferences, and peer-reviewed journal articles from English-language publications. The initial search returned approximately 1500 records. After duplicate screening and title and abstract screening, 420 articles were included. Inclusion criteria ensured that the studies explicitly discussed crowdsourcing as an organized socio-technical process rather than general user-generated content, while reporting conceptual frameworks, empirical results, or methodological knowledge as it relates to innovation, governance, ethics, or technology integration. Exclusion criteria included papers without an empirical or conceptual contribution, un-peer-reviewed commentary, and papers focused solely on crowdfunding.

Full-text articles were coded using hybrid inductive – deductive coding. Categories emanating from the literature and further refined stepwise comprised typology (micro task, open innovation, co-creation, internal, citizen science, crowdfunding), application field (technology, healthcare, education, civic governance, sustainability), methodological design (qualitative, quantitative, mixed method, econometric modeling, computational modeling), incentive system, quality control mechanisms, ethics and legal aspects, and reported result outcomes. Two of the researchers were trained to code the material independently and resolved differences among themselves after discussion. The coded analysis took place through thematic synthesis, and patterns, contradictions, and gaps were identified. To help understand relationships between typologies, methods, incentives, and outcomes, concept maps and matrices were created to illustrate this information and are presented as supplemental materials. Integrative definitions were referred to match the classification [9].

In addition to the qualitative synthesis, complementarity to the econometric and computational modeling studies that are used to estimate worker effort and pricing strategies, as well as to surveys on quality control techniques that derive models for assessing and improving crowdsourced outputs, were reviewed [34]. These studies were used to inform the conversation on incentive design, task allocation, data quality assurance, and combining human and artificial intelligence. A bibliographic dataset and a graphical flow chart of the peer review are provided in an online appendix for the purposes of replication and extension. The inclusion and exclusion criteria, along with the full coding frame, including search queries, have also been uploaded in the supplementary materials.

9.1 Integrated strategic crowdsourcing model

The main contribution of this chapter is the development of a unified strategic crowdsourcing framework that brings together typologies, methodological choices, enabling technologies, and contextual elements to create a logically consistent socio-technical framework. Investigation to date has been fragmented, with typologies alone or weaknesses put forward for discussion or enumeration, often accompanied by ambiguity in definitions [9]. The framework conceptualizes crowdsourcing as an iterative process, using upstream design-related decisions as a mechanism to link with downstream outcomes. Focus is placed on the fact that the chosen typology (micro-task, open invention, co-creation, crowdfunding, internal, or citizen science) determines the decomposition of the task, the selection of participants, the incentive mechanisms, and the quality control mechanisms.

The framework consists of five interconnected layers: (1) Contextual drivers – digital economy, socio-economic goals, and regulatory framework that drive crowdsourcing efforts; (2) Input configuration – task specification, crowd definition, and designing the call based on the key characteristics from the literature [9]; (3) Enabling infrastructure – platforms and technologies mediating interactions, such as web-based platforms, mobile apps, and blockchain/decentralized autonomous organizations; (4) Process mechanisms – incentives, quality assurance, data governance, and ethical safeguarding; and (5) Outputs and outcomes – innovation, governance, organizational learning, social value, and feedback loops. Each layer interacts differently with others; e.g., contextual drivers will affect suitable typology, platform capabilities will set limits on incentive design, and quality assurance will set limits on output reliability. Legal and ethical issues are present throughout the layers and need to be considered during the design process [9].

The complexity is increased by the combination of artificial intelligence and big-data analytics. AI can help in performing the distribution of workloads, predicting performance, and identifying anomalies, but it requires proper quality training data and transparent algorithms. Surveys of quality control approaches focus on the challenges introduced by human workers working with computation due to the diversity of their capabilities and motivation; the studies capture quality models of crowdsourcing tasks and suggest evaluation techniques and quality assurance actions to address quality issues [34].

Similarly, the emergence of blockchain and DAOs introduces new forms of governance that could lead to the democratization or consolidation of power in light of the distribution of voting rights and reward tokens. Furthermore, the framework attaches constitutive characteristics to technological enablers, which are not just

seen as neutral tools but significantly influence questions of participation, distribution of incentives, and accountability.

The typology, organizational aims, and process mechanisms in the design of process mechanisms need to be in congruence to carry out crowdsourcing strategies effectively. For simple classification problems, micro-tasking with static payments and automated quality control might be sufficient; for complex innovation-related problems, open calls, competitive prizes, and peer review should be used [34]. Internal crowdsourcing taps into employee knowledge but needs effective communication channels and recognition. Citizen science projects must include the management of participant consent, openness of data products, and recognition [9]. By situating crowd sourcing initiatives within this frame, practitioners can systematically evaluate a set of trade-off decisions, preempt potential ethical and legal challenges, and design interventions to maximize innovation impact while TNF contributors are safeguarded. The framework also identifies some areas for research at intersections between layers – including the effects of AI-mediated incentive design on participant motivation or the effects of regulatory change on platform governance.

10. Econometric and computational modeling in crowdsourcing research

The research on crowdsourcing also focuses on econometric and computational modeling, which allows for reflecting, predicting, and optimizing individual and crowd behavior and task outcomes [42, 93–96]. The econometric modeling requires additional studies in the estimation of costs and effort, strategic pricing with adjustments to the universal nature of worker abilities, and incentive schemes [42]. As a form of computational model, Bayesian and probabilistic methods combine noisy crowd-labeled data, guess the correct identifications, and discover cliques of annotators [93, 94]. Unified methodologies are used to mesh together the various inputs and predict results and worker trustworthiness [93, 94]. Solutions such as crowdsourcing on websites like Kaggle allow for equal experiments involving thousands of modeling methods to be used to analyze the information [95]. Developments in AI, then, extend into hybrid intelligence, where a person and a machine work together [96].

11. Integration of AI and crowdsourcing in big data environments

The analysis of crowdsourcing with AI and Big Data is revolutionizing research and enabling successful data management and knowledge extraction, as AI handles and processes large amounts of data provided by human participants [96–101]. Together, AI and crowdsourcing combine to maintain data lakes and determine quality, with crowdsourcing applying human cleverness to tasks beyond machine capacity, and AI rendering the workflow automatic [95, 97, 98]. The knowledge is obtained in AI applications based on crowdsourced big data, and data mining process frameworks are used to address cost, quality, and latency [98–100]. Crowdsourcing plays an important role in the production of labeled data, the assessment of ML models, the building of hybrid intelligence systems, and the insights of ML and mobile crowdsourcing delve

Challenge description	Key issues	
Data quality	Ensuring accuracy and reliability of crowdsourced data	[98]
Cost and latency control	Managing expenses and response times in large-scale analytics	[98, 100]
Privacy and security	Protecting user data in cloud-assisted and mobile crowdsourcing	[102]
Data governance	Establishing standards for integrating and managing big data	[97]

Table 5.
Challenges.

into federated learning and large language models [96, 101, 102]. Data quality, cost control, privacy, and data governance are issues to overcome.

The adaptation of the big data setup by combining AI and crowdsourcing is not limited to the process of data processing but extends to collaborative intelligence as well. Generative AI systems can depend on large proprietary data, and companies often find themselves in situations where they exacerbate NIH syndrome by focusing on their narrow internal expertise instead of leveraging crowdsourced knowledge. To overcome this hurdle, Sood et al. suggest the addition of absorptive capacity through appropriation capacity, which allows organizations to integrate external ideas into their internal environments [50]. On a methodological level, the perspective on precision health put forth by Washington promotes human-in-the-loop workflows, in which data labeled by a crowd and reviewed by experts is used to train machine learning models. Public labeling can identify complex aspects of behavior observed by human beings that computer algorithms cannot, thereby enhancing precision in diagnosis in areas such as psychiatry, behavioral science, and disease monitoring [92]. Enhanced algorithmic fairness is also achieved by including diverse opinions and detecting bias, which is associated with the combination of AI and crowd inputs. These lessons indicate that future AI-crowdsourcing systems should focus on transparent decision-making, inclusive design, and democratic problem-setting to fully utilize the benefits of human and mechanical intelligence.

Table 5 synthesizes the principal challenges associated with integrating AI and crowdsourcing in big-data environments, including data quality, cost and latency control, privacy, data governance and algorithmic bias.

12. Decision-making frameworks leveraging crowd inputs

Collective intelligence is exploited by decision-making systems through several methods and in different realms, including overcoming weaknesses in the ability to process unstructured information and guaranteeing decision quality [103–109]. Techniques include, on the one hand, a deep-learning sentiment analysis of fine-grained opinions and graph-based models (MH-GCN) to incorporate textual reviews into decisions [103, 104]. Model-based methods use cognitive models of individuals and provide better forecasting of choices than majority-rule approaches, whereas simulation schemes examine voting rules as smart within a fundamental framework of group intelligence [105, 106]. The application of other aspects of practical management, such as the MacroWiz systems, grants the ability to filter and optimize responses, diminish latency, and extend reliability [107].

Element	Description
<i>Data processing</i>	Sentiment analysis, graph models, probabilistic representations
<i>Quality control</i>	Filtering, optimization, simulation, and behavioral modeling
<i>Incentive and participation</i>	Motivation, engagement, and management of crowd contributions
<i>Application contexts</i>	Business, public policy, product design, regulatory decisions

Table 6.
Key elements in effective frameworks.

Crowdsourcing is used in regulatory as well as business models to ensure open innovation and eliminate risks [108, 109]. As an overview of effective design, **Table 6** lists the key elements of decision-making frameworks that leverage crowd inputs, covering data processing techniques, quality-control mechanisms and incentive/participation strategies.

13. Crowdsourcing in business strategy and innovation management

Crowdsourcing is a tool that boosts knowledge management, product development, and open innovation, among others [6, 14, 25, 43, 110–112]. Mechanisms used in the organization and technical means affect communities of innovation and enhance the acquisition of information and performance [110]. Being one of the central open innovation elements, crowdsourcing draws on ideas and solutions, in contrast to outsourcing, and it deals with uncertainty and rewards [6, 25]. Customized innovation strategies are made possible by different models (internal, community-founded, open, broker-mediated) [43]. Crowdsourcing helps in product strategy with ideation, customer-focused design, and development between businesses and customers in product development [14, 111, 112]. Its emergence has highlighted its transformation of organizational forms and its assistance to all phases of innovation management [112, 113]. Looking ahead, **Table 7** outlines emerging trends in strategic crowdsourcing, spanning changes in organizational forms, phases of innovation management and patterns of networked innovation.

14. Internal vs. External crowdsourcing structures

There is internal and external crowd sourcing as approaches to the use of collective intelligence. Internal crowdsourcing is used to leverage underutilized

Theme	Key insights
<i>Organizational forms</i>	Crowdsourcing is reshaping organizational structures and institutional logic [113]
<i>Innovation management phases</i>	Crowdsourcing supports all phases: search, select, implement, capture [112]
<i>Networked innovation</i>	Different crowdsourcing configurations enable flexible collaboration [43]

Table 7.
Emerging trends.

Aspect	Internal crowdsourcing	External crowdsourcing
<i>Participants</i>	Employees within the organization	Individuals outside the organization (public, customers)
<i>Innovation focus</i>	Taps into underutilized internal knowledge and skills	Accesses diverse, novel perspectives and expertise
<i>Incentives</i>	Often non-monetary (recognition, collaboration)	Can include monetary rewards, recognition, or PR
<i>IP and confidentiality</i>	Easier to manage, less risk of IP leakage	Greater risk, requires clear IP and confidentiality terms
<i>Culture and collaboration</i>	Enhances internal transparency, breaks silos	Builds external engagement, can improve brand intimacy
<i>Drawbacks</i>	Fewer “wildcard” ideas, risk of resistance, less PR	Uncertainty in quality, integration challenges

Source: Refs. [36, 54, 114, 115]

Table 8.
Key differences between internal and external crowdsourcing.

knowledge, address employees' more easily manageable intellectual property (IP), and increase internal transparency. External crowdsourcing introduces a diverse and new knowledge base, develops external relationships, yet assumes greater risk regarding IP and quality [36, 54, 114, 115]. The implementation difficulties are associated with managing functions and abrasion, sharing knowledge relationships, and choosing a platform [116–118]. From a strategic perspective, internal crowdsourcing promotes a flexible innovation and cooperation approach, whereas external crowdsourcing induces disruptive concepts, outer commitment, and motivations that support design efficacy [54, 119].

Table 8 compares internal and external crowdsourcing by contrasting participants, innovation focus, intellectual-property risks and other key aspects that influence the choice between these configurations.

15. Human capital, motivation, and community building in strategic integration

The focal point of the strategic integration and organizational effect of crowdsourcing is human capital, motivation, and community building, which impacts participation, creativity, and sustainability [120–127]. Proper crowdsourcing requires understanding both the profiles of workers and the design of work [124, 127]. In some cases, intrinsic motivation can be more critical for creative inputs, although both intrinsic and extrinsic motivations correlate with community commitment and task design [120, 121, 125, 126]. The reward mechanisms are expected to align with the motivations of the participants [125]. Participation and creativity are enhanced by active community managers, platform trust, and the possibility of social interaction and knowledge sharing [121, 122, 124, 126–128].

Table 9 summarizes how strategic elements—such as aligning participant motivation, managing communities and designing platforms—translate into different organizational outcomes in crowdsourcing initiatives.

Strategic element	Organizational implication
<i>Motivation alignment</i>	Increases sustained participation and quality of contributions
<i>Community management</i>	Enhances engagement, creativity, and knowledge-sharing
<i>Human capital utilization</i>	Enables skill development, innovation, and organizational learning
<i>Reward system design</i>	Optimizes participation and performance based on task and context

Table 9.
Strategic integration and organizational outcomes.

16. Managing intellectual property and ownership in strategic integration

Because of the involvement of multiple contributors and varied tasks, ownership and management of intellectual property (IP) are crucial as a key to the successful implementation of the strategic integration of crowdsourcing [104, 129–135]. Organizations need to actively obtain IP rights and minimize legal risks and are free to employ a passive stance, belong stance, bend stance, or sage stance depending on the context [129]. The platforms adopt different models of IP transactions based on the challenge and contributions [130]. Given that contradictions related to ownership and rights of using IP often trigger conflicts, clearly stating terms and conditions is a necessary measure [131, 132]. The rise of new structures takes into consideration the use of blockchain to achieve traceability and trust, whereby they need strong legal support [104]. The success of IP protection indirectly increases the effort among the participants by elevating their extrinsic motivation [133]. The ethical behaviors and the success of the projects are associated with the treatment of IP rights, whereas security guarantees play a crucial role in trust and competitive advantage [134, 135]. For practitioners, **Table 10** sets out key considerations for implementing strategic crowdsourcing, including clear intellectual-property policies, tailored ownership models, appropriate participant incentives and the need for legal and technical support.

17. Ethical, legal, and policy dimensions in strategic crowdsourcing

Strategic crowdsourcing focuses on ethical, legal, and policy-related aspects that chart the design, implementation, and governance issues [9, 134, 136–142]. Data privacy must be safeguarded, and transparency and autonomy are especially needed

Consideration	Organizational implication
<i>Clear IP policies</i>	Reduces legal risk, clarifies ownership, builds trust
<i>Tailored IP models</i>	Aligns with project goals and stakeholders' expectations
<i>Legal and technical support</i>	Ensures enforceability and operational efficiency
<i>Motivation and fairness</i>	Enhances participation and project success

Table 10.
Key considerations for implementation.

when working with sensitive data [134, 137–141]. Legal considerations concern what IP rights can be applied, how different regulations are exercised (e.g., HIPAA), and whether an entity is liable [134, 141, 142]. The process of policy development must be stridently regulated and universally acceptable so as to respond to arising concerns and universal injustices [9, 136, 137, 142].

Crowdsourcing also requires aspects such as data privacy [143, 144], proper compensation [136, 145, 146], regulation [135, 136], and sustainability [147]. The privacy issue of sensitive data dissemination requires privacy-preserving algorithms and strong security measures [135, 143, 144, 147]. The differences in pay and labor exploitation are dilemmas that should be addressed with different policies in the future [137, 145, 146]. Adherence to various regulations present around the world is an intricate issue, but it is associated with improved results [135, 136]. To be integrated over an extended period, platforms must emphasize openness and flexibility, which contribute to ecological objectives [147].

18. Challenges, limitations, and critiques in strategic crowdsourcing

Strategic crowdsourcing would encounter large-scale technical, organizational, ethical, and operational repercussions [11, 17, 18, 24, 34, 148–151]. The varying skills of the participants make quality control challenging, necessitating strongly built validation and reputation control systems [11–18, 34]. Ineffective task design and instructions also result in low-quality work and loss of enthusiasm. Both data privacy and data security questions remain open, particularly in mobile-based crowdsourcing [17, 148, 149]. Compensation design is complicated; lack of adequate pay can be demotivating to contributors [11, 17, 24]. The inexistence of common workflows makes it inconsistent [18].

Complaints include worker exploitation, power imbalances, and unclear ownership. Several services go bust as a result of weak strategy or poor involvement, evidencing unforeseen adverse effects [150]. However, the integration and scaling of crowdsourced solutions are still an issue, especially in specific areas [17, 148, 151].

Table 11 compiles the major challenges confronting strategic crowdsourcing, highlighting issues such as quality control, effective task design, privacy and security, fair compensation, workflow consistency and equity.

Challenge area	Key issues highlighted	Citations
Quality control	Diverse abilities, validation, reputation management	[11, 18, 34]
Task design	Clarity, decomposition, assignment, incentives	[24, 11, 17, 148]
Data privacy	Sensitive data, security, regulatory compliance	[152, 148]
Ethical concerns	Exploitation, power imbalance, unclear ownership	[150]
Standardization	Lack of workflows, inconsistent quality management.	[18]
Scalability	Integration, domain-specific challenges	[151, 148]

Table 11.
Summary table: Major challenges in strategic crowdsourcing.

Crowdsourcing Demographic Relationship Crowdsourcing is likely to encounter quality control difficulties as different skills are involved, and potentially, one party may act adversarially [18, 34, 93, 98, 153, 154]. Biases may be attributable to the heterogeneity of participants, individual situations, and suspicion toward the governance of the platform [155, 156]. The hazard of monopolization and limited flexibility that platform dependency implies poses a threat of being monopolistic [18]. Global participation is impeded by cultural and geopolitical barriers, which in turn affect the quality and legitimacy of contributions [155, 156].

19. Emerging trends and the future of crowdsourcing

Crowdsourcing, in general, is a living trend, advancing with the spread of applications, the development of technology, and the intensification of theoretical knowledge [13, 24, 87, 113, 151, 154, 157–159]. Studies are dedicated to the theoretical underpinnings, social capital, and value creation [12, 87, 113].

Crowdsourcing is being altered by the convergence of AI, blockchain, and decentralized autonomous organizations (DAOs) [149, 160–167]. The reorganization by DAOs using peer-to-peer interactions introduces risks to their security and legal status [164–167]. Global challenges, such as smart mobility, are being addressed with the increasingly frequent application of crowdsourcing (often implemented through DAOs), which uses federated intelligence and consensus mechanisms to make decisions at scale [168]. The benefits of hybrid human-AI collaboration models, which mix human creativity and the computational capabilities of AI, apply to complex and exploratory tasks and may produce new and creative solutions [149].

To the future, strategic crowdsourcing will evolve the impact of future technologies and socio-political forces. How these systems and governance inherent to DAOs and blockchain-based reward systems will govern and/or ethically impact VAT is still debated, but it is clear that trustless collaboration and the possibility of granular attribution are possible [84]. Generative AI has led to the further disruption of innovation pipelines, providing access to fast prototyping and scenario testing but evoking fears regarding intellectual property, algorithmic bias, and job displacement [50]. The risks can be reduced by using hybrid human-in-the-loop human eye/artificial intelligence crowdsourcing systems that provide human-in-the-loop validation and ethical supervision, and open additional collective intelligence. Simultaneously, a transition to inclusivity, sustainability, and foreseeable policy commonalities is needed in societal issues like global pandemics, shifts in climate change, and socio-economic disparity where crowdsourcing initiatives are needed. Future crowdsourcing frameworks should thus be required to accommodate interdisciplinary expertise, commit to participatory governance, and consistently evolve with changes in technological and cultural environments in order to be effective.

This synthesis indicates that the phenomenon of crowdsourcing in the digital economy should not be seen as a monolithic phenomenon, but rather as a spectrum of socio-technical arrangements. Microtask platforms like Mechanical Turk are adept at enlisting large numbers of contributors for the performance of small tasks at a large-scale level; still, they at the same time provoke issues regarding fairness and knowledge quality [9]. While open innovation contests leverage the

multidisciplinary knowledge required for solving difficult problems, they have to be carefully managed in terms of intellectual property and reputational motivations [34]. Crowdfunding and co-creation activities democratize the financial and construction processes but rely on trust, transparency, and unambiguous governance processes to prevent opportunism [9]. Citizen science and internal crowdsourcing have the potential to include volunteers and employees, respectively, in novel ways of scientific progress and organizational learning.

Strategically, crowdsourcing refreshes the setup of innovation and governance by breaking the boundaries between producers, consumers, and citizens. When designed well, crowdsourcing offers benefits such as speeding up product development, identifying latent needs, involving stakeholders in policy co-creation, and producing novel data streams for public services. On the other hand, misaligned incentives, poor quality control, and unclear decision-making can destroy trust and consolidate existing imbalances [9].

The combination of AI and blockchain increases these dynamics by enabling complex operations of task allocation processing, reputation features, and distributed administration. Yet, these technologies also raise potential problems concerning algorithmic prejudice, privacy issues, as well as the concentration of control [34]. Our unified framework highlights the fact that the efficacy of strategic crowdsourcing is maximal only when organizations ensure that the typology is appropriate to the kind of problem being addressed, that there are equitable and transparent incentives, quality assurance mechanisms are deployed as appropriate, and that the ethical and legal ramifications are considered at every point along the way.

In the future, crowdsourcing research and practice need to pivot away from descriptive case studies and toward comparative and theorizing activities. Future studies should explore the mediation of the relationship between the typology of crowdsourcing and the innovation outcomes by different governance models (i.e., hierarchical, participatory, or decentralized) [9]. More work needs to be done looking at how hybrid human-AI systems might utilize creativity and decision-making without marginalizing human participants [34]. Additionally, there seems to be a need for cross-cultural analyses to highlight the way digital inequalities, regulations, and cultural norms influence participation and value creation. By adopting a set of methodologies that are integrative and by placing crowdsourcing in wider socio-technical frameworks, researchers and practitioners can realize all the transformative potentials of crowdsourcing while decreasing associated dangers. Finally, **Table 12** lists open issues and future challenges for strategic crowdsourcing, covering task design and incentives, privacy and ethics, large-scale deployment, human-AI collaboration, cross-cultural differences and future research directions.

Area	Key future directions and challenges
Task design and incentives	More effective, adaptive, and fair mechanisms needed
Privacy and ethics	Enhanced privacy-preserving and ethical frameworks
Large-scale deployment	Addressing scalability and real-world integration
Theoretical development	Deeper inquiry into organizational and social impacts

Table 12.
Open issues and future challenges.

20. Conclusion

Strategic crowdsourcing is one of the key players in the realm of the digital economy, as it is regularly transformed through the adaptation of collective intelligence into various applications and innovation results. While it has the potential to make great positive contributions in terms of efficiency and problem-solving, its successful application needs to overcome complex issues related to quality control, ethical labor practices, intellectual property, and the integration of technology. The future of crowdsourcing points to even more advanced hybrid models that utilize AI and blockchain, offering unparalleled potential for decentralized cooperation and tackling global challenges, provided these inherent complexities are effectively addressed.

Based on the synthesized framework and evidence, it could be concluded that strategic crowdsourcing is best conceived as a socio-technical system, which needs to be governed and designed thoughtfully rather than as the ad-hoc outsourcing of tasks. The success of a crowdsourcing scheme is related to a proper alignment between typology, incentive mechanisms, technological infrastructure, and the larger institutional setting. Micro-tasks bring efficiency, open-innovation contests stimulate creativity, crowd funding resources, and citizen science democratize knowledge; and each model comes with trade-offs in relation to quality, fairness, and intellectual property.

For practitioners, this analysis highlights the need to invest in platform governance, transparency, design of incentives, quality control, and ethical safeguards. For researchers, that suggests the usefulness of integrative and comparative approaches, hybrid human-AI models, and a more careful study of the interaction of crowdsourcing with emergent technologies such as blockchains and large language models. Ultimately, it will be the use of crowdsourcing for purposes of innovation and policymaking that most contributes to good governance when encouraged as an inclusive process respectful of the rights of potential (or existing) contributors and embedded in reflexive governance structuring that can adapt to changing digital ecosystems.

Author details

Vahab Esfandani*, Mohammad Amin Borghei, Sara Ramzani, Peter Konhaeusner, Ahmad Abu-alkheil and Phungmayo Horam
Gisma University of Applied Sciences, Potsdam, Germany

*Address all correspondence to: vahab.esfandani@gisma.com

IntechOpen

© 2026 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Nevo D, Kotlarsky J. Crowdsourcing as a strategic IS sourcing phenomenon: Critical review and insights for future research. *The Journal of Strategic Information Systems*. 2020;**29** (4):101593. DOI: 10.2139/ssrn.3663509
- [2] Safiullin MR, Burganov RT, Burganova AR. Crowdsourcing as a new driver of the digital economy and a tool for harmonizing the interests of participants. *Bulletin of Saint Petersburg University Economy*. 2022. DOI: 10.21638/spbu05.2022.104
- [3] Bauer RM, Gegenhuber T. Crowdsourcing: Global search and the twisted roles of consumers and producers. *Organization*. 2015;**22** (5):661–681. DOI: 10.1177/1350508415585030
- [4] Jiao Y, Wu Y, Lu S. The role of crowdsourcing in product design: The moderating effect of user expertise and network connectivity. *Technology in Society*. 2021;**64**:101496. DOI: 10.1016/J.TECHSOC.2020.101496
- [5] Cappa F, Oriani R, Pinelli M, De Massis A. When does crowdsourcing benefit firm stock market performance? *Research Policy*. 2019;**48**(9):103825. DOI: 10.1016/J.RESPOL.2019.103825
- [6] Cricelli L, Grimaldi M, Vermicelli S. Crowdsourcing and open innovation: A systematic literature review, an integrated framework and a research agenda. *Review of Managerial Science*. 2022;**16**(5):1269–1310. DOI: 10.1007/s11846-021-00482-9
- [7] Garrigos-Simon FJ, Narangajavana-Kaosiri Y. Crowdsourcing and Digital Information: Looking for a Future Research Agenda. *Information*. 2025;**16** (7):536
- [8] Flores CC, Rezende DA. Crowdsourcing framework applied to strategic digital city projects. *Journal of Urban Management*. 2022;**11**(4):467–478. DOI: 10.1016/j.jum.2022.08.004
- [9] Wazny K. “Crowdsourcing” ten years in: A review. *Journal of Global Health*. 2017;**7**(2):020602. DOI: 10.7189/jogh.07.020601
- [10] Brabham DC. Using Crowdsourcing in Government. Washington, DC: IBM Center for the Business of Government; 2013. 1–42 p. DOI: 10.7551/mitpress/9693.001.0001
- [11] Chittilappilly AI, Chen L, Amer-Yahia S. A survey of general-purpose crowdsourcing techniques. *IEEE Transactions on Knowledge and Data Engineering*. 2016;**28**(9):2246–2266. DOI: 10.1109/TKDE.2016.2555805
- [12] Zhao Y, Zhu Q. Evaluation on crowdsourcing research: Current status and future direction. *Information Systems Frontiers*. 2014;**16**:417–434. DOI: 10.1007/s10796-012-9350-4
- [13] Brabham DC. Crowdsourcing as a model for problem solving: An introduction and cases. *Convergence*. 2008;**14**(1):75–90. DOI: 10.1177/1354856507084420
- [14] Hammon L, Hippner H. Crowdsourcing. *Business and Information Systems Engineering*. 2012;**4**:163–166. DOI: 10.1007/s12599-012-0215-7

- [15] Al-Nafisa AS, Alnafessah A, 2021, November. Crowdsourcing in digital marketing. In: The 23rd International Conference on Information Integration and Web Intelligence. p. 640–644. DOI: 10.1145/3487664.3487753
- [16] Garcia-Molina H, Joglekar M, Marcus A, Parameswaran A, Verroios V. Challenges in data crowdsourcing. *IEEE Transactions on Knowledge and Data Engineering*. 2016;**28**(4):901–911. DOI: 10.1109/TKDE.2016.2518669
- [17] Tong Y, Zhou Z, Zeng Y, Chen L, Shahabi C. Spatial crowdsourcing: A survey. *The VLDB Journal*. 2020;**29**:217–250. DOI: 10.1007/s00778-019-00568-7
- [18] Neto FRA, Santos CA. Understanding crowdsourcing projects: A systematic review of tendencies, workflow, and quality management. *Information Processing and Management*. 2018;**54**(4):490–506. DOI: 10.1016/J.IPM.2018.03.006
- [19] Rouzé V. Crowdsourcing and crowdfunding: The origins of a new system? In *Cultural Crowdfunding: Platform Capitalism, Labour and Globalization*. London: University of Westminster Press; 2019. p. 15–33. DOI: 10.16997/book38.b
- [20] Younis E. An overview of crowdsourcing. *Advanced Methodologies and Technologies in Network Architecture, Mobile Computing, and Data Analytics*. 2019;1763–1776. DOI: 10.4018/978-1-5225-2255-3.CH698
- [21] Ghezzi A, Gabelloni D, Martini A, Natalicchio A. Crowdsourcing: A review and suggestions for future research. *International Journal of Management Reviews*. 2018;**20**(2):343–363. DOI: 10.1111/ijmr.12135
- [22] Mourelatos E, Frarakis N, Tzagarakis M. A study on the evolution of crowdsourcing websites. *European Journal of Social Science Education and Research*. 2018;**5**(3):01–18. DOI: 10.26417/EJSER.V11I1.P29-40
- [23] Estellés-Arolas E, Hansson IK, Ajtamurto T, Ludwig T, Muller M. A Task-based Crowdsourcing Typology. *International Reports on Socio-Informatics (IRSI), Proceedings of the CSCW 2016, – Workshop: Toward a Typology of Participation in Crowdwork*. Catholic University of Valencia; 2016. 57–64 p
- [24] Bhatti SS, Gao X, Chen G. General framework, opportunities and challenges for crowdsourcing techniques: A Comprehensive survey. *Journal of Systems and Software*. 2020;**167**:110611. DOI: 10.1016/j.jss.2020.110611
- [25] Marjanovic S, Fry C, Chataway J. Crowdsourcing based business models: In search of evidence for innovation 2.0. *Science and Public Policy*. 2012;**39**(3):318–332. DOI: 10.1093/SCIPOL/SCS009
- [26] Schenk E, Guittard C. Crowdsourcing: What can be outsourced to the crowd, and Why. *Workshop on Open Source Innovation*, Strasbourg, France. 2009;**72**(3)
- [27] Schenk E, Guittard C. Towards a characterization of crowdsourcing practices. *Journal of Innovation Economics and Management*. 2011;**7**(1):93–107. DOI: 10.3917/JIE.007.0093
- [28] Ali-Hassan H, Allam H. Comparing crowdsourcing initiatives: Toward a typology development. *Canadian Journal of Administrative Sciences/Revue Canadienne Des Sciences de*

- l'Administration. 2016;**33**(4):318–331.
DOI: 10.1002/CJAS.1395
- [29] Lenart-Gansiniec R. Towards a typology development of crowdsourcing in science. *Journal of Information Science*. 2024;**50**(5):1345–1367. DOI: 10.1177/01655515221118045
- [30] Estellés-Arolas E, González-Ladrón-De-Guevara F. Clasificación de iniciativas de crowdsourcing basada en tareas. *Profesional de la Información*. 2012;**21**(3):283–291. DOI: 10.3145/EPI.2012.MAY.09
- [31] Pohlisch J. An introduction to internal crowdsourcing. *Internal Crowdsourcing in Companies*. 2021;**15**. DOI: 10.1007/978-3-030-52881-2_2
- [32] Hedges M, Dunn S. Academic crowdsourcing in the humanities: Crowds, communities and co-production. Chandos Publishing. 2017;**3**:27–49. DOI: 10.1016/B978-0-08-100941-3.00003-6
- [33] Estellés-Arolas E, Navarro-Giner R, González-Ladrón-de-Guevara F. Crowdsourcing fundamentals: Definition and typology. In *Advances in Crowdsourcing*. Cham: Springer International Publishing; 2015. p. 33–48. DOI: 10.1007/978-3-319-18341-1_3
- [34] Daniel F, Kucherbaev P, Cappiello C, Benatallah B, Allahbakhsh M. Quality control in crowdsourcing: A survey of quality attributes, assessment techniques, and assurance actions. *ACM Computing Surveys*. 2018;**51**(1):1–40. DOI: 10.1145/3148148
- [35] Stol KJ, Caglayan B, Fitzgerald B. Competition-based crowdsourcing software development: A multi-method study from a customer perspective. *IEEE Transactions on Software Engineering*. 2017;**45**(3):237–260. DOI: 10.1109/TSE.2017.2774297
- [36] Ford RC, Richard B, Ciuchta MP. Crowdsourcing: A new way of employing non-employees? *Business Horizons*. 2015;**58**(4):377–388. DOI: 10.1016/J.BUSHOR.2015.03.003
- [37] Olson DL, Rosacker K. Crowdsourcing and open source software participation. *Service Business*. 2013;**7**:499–511. DOI: 10.1007/S11628-012-0176-4
- [38] Grimaldi M, Vermicelli S, Cricelli L. Investigating the role of crowdsourcing in improving the quality of production processes: A systematic literature review. *The TQM Journal*. 2022. DOI: 10.1108/tqm-07-2021-0206
- [39] Mridha SK, Bhattacharyya M. Introducing collaboration in competitive crowdsourcing markets. *IEEE Intelligent Systems*. 2019;**34**(1):23–31. DOI: 10.1109/MIS.2019.2898184
- [40] Bloodgood J. Crowdsourcing: Useful for problem solving, but what about value capture? *Academy of Management Review*. 2013;**38**(3):455–457. DOI: 10.5465/AMR.2012.0318
- [41] Naik N, 2016, March. Crowdsourcing, open-sourcing, outsourcing and insourcing software development: A comparative analysis. In: 2016 IEEE Symposium on Service-Oriented System Engineering (SOSE). IEEE; p. 380–385. DOI: 10.1109/SOSE.2016.68
- [42] Sarı A, Tosun A, Alptekin GI. A systematic literature review on crowdsourcing in software engineering. *Journal of Systems and Software*.

2019;**153**:200–219. DOI: 10.1016/J.JSS.2019.04.027

[43] Simula H, Ahola T. A network perspective on idea and innovation crowdsourcing in industrial firms. *Industrial Marketing Management*. 2014;**43**(3):400–408. DOI: 10.1016/J.INDMARMAN.2013.12.008

[44] Lin L, Shen H, Liu S, Xu L, Cheng X. On the cybernetics of crowdsourcing innovation: A process model. *IEEE Access*. 2022;**10**:27255–27269. DOI: 10.1109/ACCESS.2022.3154101

[45] Acar OA. Motivations and solution appropriateness in crowdsourcing challenges for innovation. *Research Policy*. 2019;**48**(8):103716. DOI: 10.1016/J.RESPOL.2018.11.010

[46] Jespersen KR. Crowdsourcing design decisions for optimal integration into the company innovation system. *Decision Support Systems*. 2018;**115**:52–63. DOI: 10.1016/j.dss.2018.09.005

[47] Cheng X, Fu S, de Vreede T, De Vreede GJ, Seeber I, Maier R, Weber B. Idea convergence quality in open innovation crowdsourcing: A cognitive load perspective. *Journal of Management Information Systems*. 2020;**37**(2):349–376. DOI: 10.1080/07421222.2020.1759344

[48] Szopik-Depczyńska K, Dembińska I, Barczak A, Kędzierska-Szczepaniak A, Fazio M, Ioppolo G. The impact of crowdsourcing and user-driven innovation on R&D departments' innovation activity: Application of multivariate correspondence analysis. *Equilibrium: Quarterly Journal of Economics and Economic Policy*. 2024;**19**(1):171–206. DOI: 10.24136/eq.2732

[49] Boussioux L, Lane JN, Zhang M, Jacimovic V, Lakhani KR. The crowdless future? Generative AI and creative problem-solving. *Organization Science*. 2024;**35**(5):1589–1607

[50] Burger-Helmchen T. Crowdsourcing of inventive activities, AI, and the NIH syndrome. *Administrative Sciences*. 2024;**14**(11):300

[51] Mao K, Capra L, Harman M, Jia Y. A survey of the use of crowdsourcing in software engineering. *Journal of Systems and Software*. 2017;**126**:57–84. DOI: 10.1016/J.JSS.2016.09.015

[52] Vianna FRPM, Graeml AR, Peinado J. The role of crowdsourcing in industry 4.0: A systematic literature review. *International Journal of Computer Integrated Manufacturing*. 2020;**33**(4):411–427. DOI: 10.1080/0951192x.2020.1736714

[53] Kong X, Liu X, Jedari B, Li M, Wan L, Xia F. Mobile crowdsourcing in smart cities: Technologies, applications, and future challenges. *IEEE Internet of Things Journal*. 2019;**6**(5):8095–8113. DOI: 10.1109/JIOT.2019.2921879

[54] Stieger D, Matzler K, Chatterjee S, Ladstaetter-Fussenegger F. Democratizing strategy: How crowdsourcing can be used for strategy dialogues. *California Management Review*. 2012;**54**(4):44–68. DOI: 10.1525/cmr.2012.54.4.44

[55] Aten K, Thomas GF. Crowdsourcing strategizing: Communication technology affordances and the communicative constitution of organizational strategy. *International Journal of Business Communication*. 2016;**53**(2):148–180. DOI: 10.1177/2329488415627269

- [56] Wazny K. Applications of crowdsourcing in health: An overview. *Journal of Global Health*. 2018;**8** (1):010502. DOI: 10.7189/jogh.08.010502
- [57] Wang C, Han L, Stein G, Day S, Bien-Gund C, Mathews A, Ong JJ, Zhao PZ, Wei SF, Walker J, Chou R. Crowdsourcing in health and medical research: A systematic review. *Infectious Diseases of Poverty*. 2020;**9**:1–9. DOI: 10.1186/s40249-020-0622-9
- [58] Créquit P, Mansouri G, Benchoufi M, Vivot A, Ravaut P. Mapping of crowdsourcing in health: Systematic review. *Journal of Medical Internet Research*. 2018;**20**(5):e187. DOI: 10.2196/jmir.9330
- [59] Brabham DC, Ribisl KM, Kirchner TR, Bernhardt JM. Crowdsourcing applications for public health. *American Journal of Preventive Medicine*. 2014;**46**(2):179–187. DOI: 10.1016/j.amepre.2013.10.016
- [60] Parvanta C, Roth Y, Keller H. Crowdsourcing 101: A few basics to make you the leader of the pack. *Health Promotion Practice*. 2013;**14** (2):163–167. DOI: 10.1177/1524839912470654
- [61] Conrad EJ, Becker M, Powell B, Hall KC. Improving health promotion through the integration of technology, crowdsourcing, and social media. *Health Promotion Practice*. 2020;**21** (2):228–237. DOI: 10.1177/1524839918811152
- [62] Tucker JD, Day S, Tang W, Bayus B. Crowdsourcing in medical research: Concepts and applications. *PeerJournal*. 2019;**7**:e6762. DOI: 10.7717/peerj.6762
- [63] Alenezi HS, Faisal MH. Utilizing crowdsourcing and machine learning in education: Literature review. *Education and Information Technologies*. 2020;**25** (4):2971–2986. DOI: 10.1007/s10639-020-10102-w
- [64] Josefy M, Dean TJ, Albert LS, Fitza MA. The role of community in crowdfunding success: Evidence on cultural attributes in funding campaigns to “save the local theater”. *Entrepreneurship Theory and Practice*. 2017;**41**(2):161–182. DOI: 10.1111/etap.12263
- [65] De Larrea GL, Altin M, Singh D. Determinants of success of restaurant crowdfunding. *International Journal of Hospitality Management*. 2019;**78**:150–158. DOI: 10.1016/J.IJHM.2018.10.003
- [66] Hassna G. Crowdfund smart, not hard—Understanding the role of online funding communities in crowdfunding success. *Journal of Business Venturing Insights*. 2022;**18**:e00353. DOI: 10.1016/j.jbvi.2022.e00353
- [67] Hassna G, Zhao JL, 2018, May. The Impact of Online Consumption Community on Crowdfunding Success. In: *Americas Conference on Information Systems (AMCIS 2018)* New Orleans August. p. 16–18
- [68] Clauss T, Breitenacker RJ, Kraus S, Brem A, Richter C. Directing the wisdom of the crowd: The importance of social interaction among founders and the crowd during crowdfunding campaigns. *Economics of Innovation and New Technology*. 2018;**27**(8):709–729. DOI: 10.1080/10438599.2018.1396660
- [69] Colombo MG, Franzoni C, Rossi-Lamastra C. Internal social capital and the attraction of early contributions in

- crowdfunding. *Entrepreneurship Theory and Practice*. 2015;**39**(1):75–100. DOI: 10.1111/etap.12118
- [70] Buttice V, Colombo MG, Wright M. Serial crowdfunding, social capital, and project success. *Entrepreneurship Theory and Practice*. 2017;**41**(2):183–207. DOI: 10.1111/etap.12271
- [71] Burtch G, Gupta D, Martin P. Referral timing and fundraising success in crowdfunding. *Manufacturing and Service Operations Management*. 2021;**23**(3):676–694. DOI: 10.1287/MSOM.2020.0876
- [72] Lagazio C, Querci F. Exploring the multi-sided nature of crowdfunding campaign success. *Journal of Business Research*. 2018;**90**:318–324. DOI: 10.1016/J.JBUSRES.2018.05.031
- [73] Lubis RL, Gayo S. Evaluation of the performance of crowdfunding sharinghappiness. org in mobilizing the active role of the community to achieve sdgs 1. In: 9th Virtual International Conference on Education, Innovation and ICT. 2024-November. p. 654. DOI: 10.35912/jomaps.v2i4.2453
- [74] Zvilichovsky D, Danziger S, Steinhart Y. Making-the-product-happen: A driver of crowdfunding participation. *Journal of Interactive Marketing*. 2018;**41**(1):81–93. DOI: 10.1016/j.intmar.2017.10.002
- [75] Chakraborty S, Ma A, Swinney R. Designing rewards-based crowdfunding campaigns for strategic (but distracted) contributors. *Naval Research Logistics*. 2023;**70**(1):3–20. DOI: 10.1002/nav.22081
- [76] Solodoha E. How Much Is Too Much? The Impact of Update Frequency on Crowdfunding Success. *Administrative Sciences*. 2024;**14**(12):324
- [77] Füller J, Hutter K, Kröger N. Crowdsourcing as a service—from pilot projects to sustainable innovation routines. *International Journal of Project Management*. 2021;**39**(2):183–195. DOI: 10.1016/J.IJPROMAN.2021.01.005
- [78] Alvarez-Risco A, Del-Aguila-Arcentales S. Crowdsourcing for sustainability: Case of sustainable development goals. In *Crowdfunding in the Public Sector: Theory and Best Practices*. Cham: Springer International Publishing; 2021. p. 187–196. DOI: 10.1007/978-3-030-77841-5_12
- [79] Tung WF, Jordann G. Crowdsourcing social network service for social enterprise innovation. *Information Systems Frontiers*. 2017;**19**(6):1311–1327. DOI: 10.1007/s10796-017-9770-2
- [80] Molla FS, Line B, Harald TH. Practicing responsible research and innovation in a crowdsourcing project in Norway. *The ORBIT Journal*. 2018;**2**(1):1–28. DOI: 10.29297/ORBIT.V2I1.82
- [81] Karachiwalla R, Pinkow F. Understanding crowdsourcing projects: A review on the key design elements of a crowdsourcing initiative. *Creativity and Innovation Management*. 2021;**30**(3):563–584. DOI: 10.1111/CAIM.12454
- [82] Wang R, Chen B. A configurational approach to attracting participation in crowdsourcing social innovation: The case of Openideo. *Management Communication Quarterly*. 2023;**37**(2):340–367. DOI: 10.1177/08933189221108360
- [83] He HR, Liu Y, Gao J, Jing D. Investigating business sustainability of

crowdsourcing platforms. IEEE Access. 2022;**10**:74291–74303. DOI: 10.1109/access.2022.3190970

[84] Do Prado GF, de Souza JT, Piekarski CM. Sustainable and innovative: How can open innovation enhance sustainability practices? Sustainability. 2025;**17**(2):454

[85] Taeihagh A. Crowdsourcing: A new tool for policy-making? Policy Sciences. 2017;**50**(4):629–647. DOI: 10.1007/s11077-017-9303-3

[86] Vargas-Murillo AR, De La Asuncion INM, Delgado-Chávez CA, Taípe EM, Cuba CKR, Chavarri LCP. The Role of ICT in Collaborative Creation of Public Policies: Crowdsourcing Policymaking. In: 2024 International Conference on Inventive Computation Technologies (ICICT). IEEE; 2024-April. p. 1704–1708. DOI: 10.1109/ICICT60155.2024.10544427

[87] Mishra D, Maheshwari N. The past, present, and future of crowdsourcing and innovation: A bibliometric analysis and future research agenda. Information Development. 2024;02666669241238430. DOI: 10.1177/02666669241238430

[88] Wadekar S, Thapar K, Barge K, Singh R, Mishra D, Mohammed S. Developing Better Civic Services through Crowdsourcing: The Twitter Case Study. Authorea Preprints; 2023. DOI: 10.36227/techrxiv.12061392.v1

[89] Brabham DC. Crowdsourcing the public participation process for planning projects. Planning Theory. 2009;**8**(3):242–262. DOI: 10.1177/1473095209104824

[90] Haltofova B. Using crowdsourcing to support civic engagement in strategic

urban development planning: A case study of Ostrava, Czech Republic. Journal of Competitiveness. 2018. DOI: 10.7441/JOC.2018.02.06

[91] Charalabidis Y, N Loukis E, Androutsopoulou A, Karkaletsis V, Triantafyllou A. Passive crowdsourcing in government using social media. Transforming Government: People, Process and Policy. 2014;**8**(2):283–308. DOI: 10.1108/TG-09-2013-0035

[92] Washington P. A perspective on crowdsourcing and human-in-the-loop workflows in precision health. Journal of Medical Internet Research. 2024;**26**:e51138

[93] Li K, Wang S, Cheng X, Hu Q. A misreport-and collusion-proof crowdsourcing mechanism without quality verification. IEEE Transactions on Mobile Computing. 2021;**21**(9):3084–3095. DOI: 10.1109/TMC.2021.3052873

[94] Moreno PG, Artés-Rodríguez A, Teh YW, Perez-Cruz F. Bayesian nonparametric crowdsourcing. The Journal of Machine Learning Research. 2015;**16**(1):1607–1627. DOI: 10.5555/2789272.2886801

[95] Martinez MG, Walton B. The wisdom of crowds: The potential of online communities as a tool for data analysis. Technovation. 2014;**34**(4):203–214. DOI: 10.1016/J.TECHNOVATION.2014.01.011

[96] Vaughan JW. Making better use of the crowd: How crowdsourcing can advance machine learning research. Journal of Machine Learning Research. 2018;**18**(193):1–46

[97] O’Leary DE. Embedding AI and crowdsourcing in the big data lake. IEEE

Intelligent Systems. 2014;**29**(5):70–73. DOI: 10.1109/MIS.2014.82

[98] Li G, Wang J, Zheng Y, Franklin MJ. Crowdsourced data management: A survey. *IEEE Transactions on Knowledge and Data Engineering*. 2016;**28**(9):2296–2319. DOI: 10.1109/TKDE.2016.2535242

[99] Zhang J. Knowledge learning with crowdsourcing: A brief review and systematic perspective. *IEEE/CAA Journal of Automatica Sinica*. 2022;**9**(5):749–762. DOI: 10.1109/JAS.2022.105434

[100] Dhinakaran K, Nedunchelian R, Balasundaram A. Crowdsourcing: Descriptive study on algorithms and frameworks for prediction. *Archives of Computational Methods in Engineering*. 2022;**29**(1):357–374. DOI: 10.1007/s11831-021-09577-8

[101] Chen W, Hussain W, Al-Qudah I, Al-Naymat G, Zhang X. Intersection of machine learning and mobile crowdsourcing: A systematic topic-driven review. *Personal and Ubiquitous Computing*. 2025;**29**(1):77–101. DOI: 10.1007/s00779-024-01820-w

[102] Zhuo G, Jia Q, Guo L, Li M, Li P. Privacy-preserving verifiable set operation in big data for cloud-assisted mobile crowdsourcing. *IEEE Internet of Things Journal*. 2016;**4**(2):572–582. DOI: 10.1109/JIOT.2016.2585592

[103] Zuheros C, Martínez-Cámara E, Herrera-Viedma E, Herrera F. Crowd decision making: Sparse representation guided by sentiment analysis for leveraging the wisdom of the crowd. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*. 2022;**53**(1):369–379. DOI: 10.1109/TSMC.2022.3180938

[104] Liu CY, Chen C. Intellectual property management and legal protection Mechanism of Blockchain-based crowdsourced testing. *Journal of Internet Technology*. 2024;**25**(5):743–751. DOI: 10.70003/160792642024092505009

[105] Thomas B, Coon J, Westfall HA, Lee MD. Model-based wisdom of the crowd for sequential decision-making tasks. *Cognitive Science*. 2021;**45**(7):e13011. DOI: 10.1111/cogs.13011

[106] Yao X, Sun H, Fan B. A novel simulation framework for crowd co-decisions. *International Journal of Crowd Science*. 2020;**4**(1):2–16. DOI: 10.1108/ijcs-09-2019-0021

[107] Zhang X, Shangguan L, Yuan Y. A crowd wisdom management framework for crowdsourcing systems. *IEEE Access*. 2016;**4**:9764–9774. DOI: 10.1109/ACCESS.2016.2581298

[108] Täuscher K. Leveraging collective intelligence: How to design and manage crowd-based business models. *Business Horizons*. 2017;**60**(2):237–245. DOI: 10.1016/J.BUSHOR.2016.11.008

[109] Li J. Innovative Model of Regulatory Decision in Digital Era from Crowd Sourcing Perspective. *Hanspub.org*; 2020. p. 147–154. DOI: 10.12677/mm.2020.102018

[110] Daradkeh M, Atalla S. Innovation crowdsourcing mechanisms and innovation performance: An empirical study of a business intelligence community. *World Journal of Entrepreneurship, Management and Sustainable Development*. 2022;**18**(5):633–651. DOI: 10.47556/wjemsd.18.5.2022.5

- [111] Zhong L, Wang G. Product innovativeness strategy with crowdsourcing. *IEEE Access*. 2022;**10**:13243–13258. DOI: 10.1109/ACCESS.2022.3143703
- [112] Sivula A, Kantola J. Adapting crowdsourcing in innovation management. *International Journal of Innovation and Learning*. 2016;**19**(3):314–334. DOI: 10.1504/IJIL.2016.075657
- [113] Palacios M, Martinez-Corral A, Nisar A, Grijalvo M. Crowdsourcing and organizational forms: Emerging trends and research implications. *Journal of Business Research*. 2016;**69**(5): 1834–1839. DOI: 10.1016/J.JBUSRES.2015.10.065
- [114] Byrén E, 2013. Internal crowdsourcing for innovation development. How multi-national companies can obtain the advantages of crowdsourcing utilising internal resources.
- [115] Zuchowski O, Posegga O, Schlagwein D, Fischbach K. Internal crowdsourcing: Conceptual framework, structured review, and research agenda. *Journal of Information Technology*. 2016;**31**(2):166–184. DOI: 10.1057/jit.2016.14
- [116] Ruiz É, Beretta M. Managing internal and external crowdsourcing: An investigation of emerging challenges in the context of a less experienced firm. *Technovation*. 2021;**106**:102290. DOI: 10.1016/J.TECHNOVATION.2021.102290
- [117] Chen Q, Magnusson M, Björk J. Selection bias of ideas for sustainability-oriented innovation in internal crowdsourcing. *Technovation*. 2023;**124**:102761. DOI: 10.1016/j.technovation.2023.102761
- [118] Schenk E, Guittard C, Pénin J. Open or proprietary? Choosing the right crowdsourcing platform for innovation. *Technological Forecasting and Social Change*. 2019;**144**:303–310. DOI: 10.1016/J.TECHFORE.2017.11.021
- [119] Beretta M, Frederiksen L, Wallin M, Kulikovskaja V. Why and how firms implement internal crowdsourcing platforms. *IEEE Transactions on Engineering Management*. 2021;**70**(9):3036–3049. DOI: 10.1109/TEM.2020.3045118
- [120] Wu W, Gong X. Motivation and sustained participation in the online crowdsourcing community: The moderating role of community commitment. *Internet Research*. 2021;**31**(1):287–314. DOI: 10.1108/INTR-01-2020-0008
- [121] Zheng H, Li D, Hou W. Task design, motivation, and participation in crowdsourcing contests. *International Journal of Electronic Commerce*. 2011;**15**(4):57–88. DOI: 10.2753/JEC1086-4415150402
- [122] Pee LG, Koh E, Goh M. Trait motivations of crowdsourcing and task choice: A distal-proximal perspective. *International Journal of Information Management*. 2018;**40**:28–41. DOI: 10.1016/J.IJINFOMGT.2018.01.008
- [123] Piazza M, Mazzola E, Perrone G. Solvers' participation in crowdsourcing initiatives for social innovation: Exploring interactions among motivational forces. *Creativity and Innovation Management*. 2024;**33**(4):701–717. DOI: 10.1111/caim.12610

- [124] Khan HU, Ali F, Ghadi YY, Nazir S, Ullah I, Mohamed HG. Human–computer interaction and participation in software crowdsourcing. *Electronics*. 2023;**12**(4):934. DOI: 10.3390/electronics12040934
- [125] Borst I, 2010. Understanding Crowdsourcing: Effects of motivation and rewards on participation and performance in voluntary online activities (No. EPS-2010-221-LIS).
- [126] Martinez MG. Inspiring crowdsourcing communities to create novel solutions: Competition design and the mediating role of trust. *Technological Forecasting and Social Change*. 2017;**117**:296–304. DOI: 10.1016/J.TECHFORE.2016.11.015
- [127] Amer-Yahia S, Roy SB. Human factors in crowdsourcing. *Proceedings of the VLDB Endowment*. 2016;**9**(13):1615–1618. DOI: 10.14778/3007263.3007323
- [128] Hornuf L, Jeworrek S. The effect of community managers on online idea crowdsourcing activities. *Journal of the Association for Information Systems*. 2023;**24**(1):222–248. DOI: 10.17705/1jais.00777
- [129] De Beer J, McCarthy IP, Soliman A, Treen E. Click here to agree: Managing intellectual property when crowdsourcing solutions. *Business Horizons*. 2017;**60**(2):207–217. DOI: 10.2139/ssrn.2947096
- [130] Krech CA, 2019. Value creation approaches used in Open Innovation: An intellectual property view.
- [131] Al-bloush H, Solemon B. Intellectual property challenges in the crowdsourced software engineering: An analysis of crowdsourcing platforms. In: *International Conference of Reliable Information and Communication Technology* Cham: Springer International Publishing; p. 875–884. 2017. DOI: 10.1007/978-3-319-59427-9_90
- [132] Al-Bloush H, Solemon B. An analysis of intellectual property challenges in crowdsourcing platforms for software engineering. *International Journal of Engineering & Technology*. 2018;**7**(4):354–360. DOI: 10.14419/IJET.V7I4.35.22761
- [133] Ullah A, Zhang Q, Ahmed M. The influence of intellectual property rights protection on contribution efforts of participants in online crowdsourcing contests. *Computers in Human Behavior*. 2021;**123**:106869
- [134] Liu Z, Shestak V. Issues of crowdsourcing and mobile app development through the intellectual property protection of third parties. *Peer-to-Peer Networking and Applications*. 2020. DOI: 10.1007/s12083-020-00976-5
- [135] Liu Z, Sakulyeva T, Mikheev A, Stepanova D. Management problems in global crowdsourcing. *Journal of Global Information Management*. 2021;**30**(3):1–15. DOI: 10.4018/jgim.20220701.oa3
- [136] Du S, Babalola MT, D’cruz P, Dóci E, Garcia-Lorenzo L, Hassan L, Islam G, Newman A, Noronha E, Van Gils S. The ethical, societal, and global implications of crowdsourcing research. *Journal of Business Ethics*. 2024;**193**(1):1–16. DOI: 10.1007/s10551-023-05604-9
- [137] Schlagwein D, Cecez-Kecmanovic D, Hanckel B. Ethical norms and issues in crowdsourcing practices: A Habermasian analysis.

- Information Systems Journal. 2019;**29**(4):811–837. DOI: 10.1111/isj.12227
- [138] Dolmaysa JM. The ethics of crowdsourcing. *Linguistica Antverpiensia, New Series–Themes in Translation Studies*. 2011;**10**. DOI: 10.52034/LANSTTS.V10I.279
- [139] Cukur L. Towards an ethical framework for evaluating paid translation crowdsourcing and its consequences. *The Translator*. 2024;**30**(1):47–62. DOI: 10.1080/13556509.2023.2278226
- [140] Durward D, Blohm I, Leimeister JM, 2016, July. Is there papa in crowd work?: A literature review on ethical dimensions in crowdsourcing. In: 2016 Intl IEEE Conferences on Ubiquitous Intelligence & Computing, Advanced and Trusted Computing, Scalable Computing and Communications, Cloud and Big Data Computing, Internet of People, and Smart World Congress (UIC/ATC/ScalCom/CBDCCom/IoP/SmartWorld) (pp. 823–832). IEEE. DOI: 10.1109/UIC-ATC-ScalCom-CBDCCom-IoP-SmartWorld.2016.0131
- [141] Sims MH, Hodges Shaw M, Gilbertson S, Storch J, Halterman MW. Legal and ethical issues surrounding the use of crowdsourcing among healthcare providers. *Health Informatics Journal*. 2019;**25**(4):1618–1630. DOI: 10.1177/1460458218796599
- [142] Alqahtani AB, EI-Shubaki TR, Noorwali AF, Allouh D, Hemalatha M. Legal and ethical issues of crowdsourcing. *International Journal of Computer Applications*. 2017;**167**(10):1–3. DOI: 10.5120/IJCA2017914324
- [143] Zhao Y, Gong X, Chen X. Privacy-preserving incentive mechanisms for truthful data quality in data crowdsourcing. *IEEE Transactions on Mobile Computing*. 2020;**21**(7):2518–2532. DOI: 10.1109/tmc.2020.3040138
- [144] To H, Ghinita G, Fan L, Shahabi C. Differentially private location protection for worker datasets in spatial crowdsourcing. *IEEE Transactions on Mobile Computing*. 2016;**16**(4):934–949. DOI: 10.1109/TMC.2016.2586058
- [145] Rea SC, Kleeman H, Zhu Q, Gilbert B, Yue C. Crowdsourcing as a tool for research: Methodological, fair, and political considerations. *Bulletin of Science, Technology & Society*. 2020;**40**(3-4):40–53. DOI: 10.1177/02704676211003808
- [146] Gleibs IH. Are all “research fields” equal? Rethinking practice for the use of data from crowdsourcing market places. *Behavior Research Methods*. 2017;**49**(4):1333–1342. DOI: 10.3758/s13428-016-0789-y
- [147] Certoma C, Corsini F, Rizzi F. Crowdsourcing urban sustainability. Data, people and technologies in participatory governance. *Futures*. 2015;**74**:93–106. DOI: 10.1016/J.FUTURES.2014.11.006
- [148] Tong Y, Chen L, Shahabi C. Spatial crowdsourcing: Challenges, techniques, and applications. *Proceedings of the VLDB Endowment*. 2017;**10**(12):1988–1991. DOI: 10.14778/3137765.3137827
- [149] Raisch S, Fomina K. Combining human and artificial intelligence: Hybrid problem-solving in organizations. *Academy of Management Review*. 2025;**50**(2):441–464. DOI: 10.5465/amr.2021.0421

- [150] Manthe E, Mencarelli R, Pallud J. The dark side of crowdsourcing of complex tasks: A systematic literature review. *Information & Management*. 2025;104108. DOI: 10.1016/j.im.2025.104108
- [151] Khare R, Good BM, Leaman R, Su AI, Lu Z. Crowdsourcing in biomedicine: Challenges and opportunities. *Briefings in Bioinformatics*. 2016;17(1):23–32. DOI: 10.1093/bib/bbv021
- [152] Phuttharak J, Loke SW. A review of mobile crowdsourcing architectures and challenges: Toward crowd-empowered internet-of-things. *Ieee Access*. 2018;7:304–324. DOI: 10.1109/ACCESS.2018.2885353
- [153] Allahbakhsh M, Benatallah B, Ignjatovic A, Motahari-Nezhad HR, Bertino E, Dustdar S. Quality control in crowdsourcing systems: Issues and directions. *IEEE Internet Computing*. 2013;17(2):76–81. DOI: 10.1109/MIC.2013.20
- [154] Checco A, Bates J, Demartini G. Adversarial attacks on crowdsourcing quality control. *Journal of Artificial Intelligence Research*. 2020;67:375–408. DOI: 10.1613/jair.1.11332
- [155] Baruch A, May A, Yu D. The motivations, enablers and barriers for voluntary participation in an online crowdsourcing platform. *Computers in Human Behavior*. 2016;64:923–931. DOI: 10.1016/j.chb.2016.07.039
- [156] Djelassi S, Cambier F. Creative crowdsourcing: Understanding participation barriers and levers from a heterogeneous crowd perspective. *Journal of Marketing Management*. 2023;39(7-8):585–614. DOI: 10.1080/0267257X.2022.2131884
- [157] Anoop S, Salim A, Dhanya SP, 2023, April. Crowdsourcing of Internet of Things: Applications, Trends in technology and the Future. In 2023 International Conference on Power, Instrumentation, Control and Computing (PICCC) (pp. 1–6). IEEE. DOI: 10.1109/PICCC57976.2023.10142617
- [158] Guo B, Liu Y, Wang L, Li VO, Lam JC, Yu Z. Task allocation in spatial crowdsourcing: Current state and future directions. *IEEE Internet of Things Journal*. 2018;5(3):1749–1764. DOI: 10.1109/JIOT.2018.2815982
- [159] Chatzimilioudis G, Konstantinidis A, Laoudias C, Zeinalipour-Yazti D. Crowdsourcing with smartphones. *IEEE Internet Computing*. 2012;16(5):36–44. DOI: 10.1109/MIC.2012.70
- [160] Shi J. The evolution and future of DAOs: Embracing AI and new technologies. *Technium*. 2023;13(1):117–123. DOI: 10.47577/technium.v13i.9637
- [161] Li M, Weng J, Yang A, Lu W, Zhang Y, Hou L, Liu JN, Xiang Y, Deng RH. CrowdBC: A blockchain-based decentralized framework for crowdsourcing. *IEEE Transactions on Parallel and Distributed Systems*. 2018;30(6):1251–1266. DOI: 10.1109/TPDS.2018.2881735
- [162] Zhu S, Cai Z, Hu H, Li Y, Li W. zkCrowd: A hybrid blockchain-based crowdsourcing platform. *IEEE Transactions on Industrial Informatics*. 2019;16(6):4196–4205. DOI: 10.1109/TII.2019.2941735
- [163] Patel O. Blockchain - Integrated AI for Decentralized Autonomous

Organizations (DAOs). International Journal of Science and Research. 2019;8(4):2010–2019. DOI: 10.21275/sr24806045716

[164] Wang S, Ding W, Li J, Yuan Y, Ouyang L, Wang FY. Decentralized autonomous organizations: Concept, model, and applications. IEEE Transactions on Computational Social Systems. 2019;6(5):870–878. DOI: 10.1109/TCSS.2019.2938190

[165] Spychiger F, Lustenberger M, Martignoni J, Schädler L, Lehner P. Organizing projects with blockchain through a decentralized autonomous organization. Project Leadership and Society. 2023;4:100102. DOI: 10.1016/j.plas.2023.100102

[166] Qin R, Ding W, Li J, Guan S, Wang G, Ren Y, Qu Z. Web3-based decentralized autonomous organizations and operations: Architectures, models, and mechanisms. IEEE Transactions on Systems, Man, and Cybernetics: Systems. 2022;53(4):2073–2082. DOI: 10.1109/TSMC.2022.3228530

[167] Santana C, Albareda L. Blockchain and the emergence of Decentralized Autonomous Organizations (DAOs): An integrative model and research agenda. Technological Forecasting and Social Change. 2022;182:121806. DOI: 10.1016/j.techfore.2022.121806

[168] Zhao C, Dai X, Lv Y, Niu J, Lin Y. Decentralized autonomous operations and organizations in transverse: Federated intelligence for smart mobility. IEEE Transactions on Systems, Man, and Cybernetics: Systems. 2022;53(4):2062–2072. DOI: 10.1109/TSMC.2022.3228914

Chapter 4

The ComplexHub: Collaboration to Create and Disseminate Open Resources for Complex and Computational Thinking

*Inés Alvarez-Icaza, Rasikh Tariq and
Leonardo David Glasserman-Morales*

Abstract

This chapter presents the collaborative strategy developed for the creation of ComplexHub, a digital space for the construction, evaluation, and dissemination of open educational resources (OER) on complex thinking and computational thinking. This project originated to meet the demand of the Spanish-speaking population for resources available to lifelong learners, especially for the development of these two meta-competencies. The document presents the background of the project, the stages of development and conception, the collaboration strategies with different actors and institutions involved, and the functionalities enhanced by artificial intelligence to make this project a sustainable resource over time without requiring human resources for the evaluation and classification of the resources. Additionally, the effectiveness of collaboration strategies is analyzed, considering UNESCO recommendations and trends in this area. The results and conclusions are presented as a valuable resource for projects that require collaborative initiatives, where the contexts allow the development of OER with generative tools and in development contexts.

Keywords: open education, open resources, digital hub, educational innovation, lifelong learning

1. Introduction

The Complex Thinking Education for All (CTE4A) is a project developed by an interdisciplinary research group from the Institute for the Future of Education of Tecnológico de Monterrey, a Mexican university. It aims to build a digital collaborative medium that facilitates offering training in complex thinking (CxT) [1] and computational thinking (CT) [2] for lifelong learners. This project is a response to the upskilling needs [3] of professional adults and the demands of the working market. It also acknowledges the necessity for the development of specific

competencies that allow professionals to interconnect elements of reality with high-level solutions [4]. This platform, conceived as a digital learning hub (DLH) [5], is designed to host and promote the creation of open educational resources (OER) aimed at fostering the development of CT subcompetencies across both disciplinary and cross-cutting themes. The processes of creating, evaluating, and disseminating these resources will be supported by a range of capabilities and services, including artificial intelligence (AI), generative tools, multimedia content, and interactive, gamified user interfaces. All of this is framed within an Education 5.0 paradigm [6], where human-centered design and equitable access are fundamental principles.

The CTE4A project is designed to meet the lifelong learning needs of companies, public institutions, and individuals by providing educational experiences ranging from introductory to advanced levels. Its core value lies in creating an open and collaborative space for the development, assessment, and training of CT competencies. By integrating academic, industrial, and governmental perspectives, the project aligns with the sustainable development goals (SDGs) [7], with a strong commitment to ensuring inclusive and accessible content – particularly for vulnerable populations and with a focus on gender equity.

The CTE4A research group has been developing the ComplexHub as a platform-as-a-service [8] since 2024. The platform is built as a DLH, holding diverse functionalities and features to provide the following: (i) a hub for experts in CT research to assemble a network; (ii) methodologies and generative tools to create multichannel content; (iii) learning experiences and programs offered as micro-credentials and to train for certifications; and (iv) OER evaluation and validation tools. The OER and access are offered for individuals, academia, industry, civil society, or government, in open-source or on-demand tailor-made modalities.

This chapter is organized to provide, first, a theoretical grounding in the competences of complex and computational thinking as guiding paths for education in sustainability. The following section presents the project's relevance and the methodology followed to involve relevant stakeholders who have been engaged in the ComplexHub platform's design and development. The final section is a presentation of the platform and the preliminary results of the project.

2. Complex and computational thinking for sustainable development

Contemporary challenges related to sustainable development require developing better capacities to understand our reality and its complexity. In the search for potential solutions to global issues such as hunger, drought, quality education, equity, and wildlife protection, among others, humanity has discovered that we need to change our educational approach [9]. Becoming aware of our still limited capabilities as a society has made institutions turn their attention to new approaches in education [10]. Complex and computational thinking for sustainable development is one of them. Introducing these competencies to lifelong learning programs and higher educational curricula allows us to facilitate our understanding of interconnections between elements of reality while increasing our problem-solving capabilities. It also fosters a systemic perspective, allowing an improved scenario analysis to set the conditions for potential anticipation. Incorporating data-driven decision-making facilitates automating some mechanical tasks, increasing companies' and institutions' efficiency, and bringing innovative strategies for collaboration across disciplines.

2.1 Complex thinking

The open educational model for CxT promotes the development of four key cognitive abilities: critical, systemic, scientific, and innovative thinking [4]. This model organizes learning around four components: philosophical, theoretical, educational, and political. Each component plays a specific role in helping students solve problems, make informed decisions, and understand complex situations. The model supports accessible and inclusive education, designed to work across various learning environments. It focuses on real-world learning scenarios and includes tools, resources, and actors from education, government, industry, and society. The conceptual foundation of [4] aligns with the work of Edgar Morin, who emphasized that CxT involves recognizing interdependence, uncertainty, and contextuality in addressing real-world problems [11]. Morin argues that education must move beyond fragmented knowledge to improve integrative and reflexive reasoning capable of linking diverse domains of understanding [12].

Research shows that CxT is not one skill but a set of connected abilities. Silva Pacheco and Iturra Herrera [13] define it as a group of mental processes that students can develop through guided educational practices. They created a valid instrument called CTAI to measure these skills. Their findings show that structured measurement tools help evaluate how students progress in thinking abilities during their studies. Portuguese-Castro and Ramírez-Montoya [14] applied an educational approach that uses Scrum and circular economy models. Their study with graduate students found improvements in how learners apply critical, scientific, and innovative thinking. These students also learned to design solutions that support sustainability. The authors showed that active and creative teaching methods improve how learners understand problems and propose responsible solutions. Xu et al. [15] analyzed 60 studies to examine the effects of educational interventions on thinking and performance skills. They found that teaching models such as 4C/ID help learners build CxT. Their findings support the use of well-planned instructional strategies and technology to help students learn advanced skills.

In this sense, Promma et al. [16] studied accounting students and found that AI literacy improves systematic and intuitive thinking. These abilities directly support problem-solving. Their results highlight the need to teach AI-related skills to prepare students for digital tasks. Students who understand AI concepts are better able to think critically and solve problems in digital environments. Suárez-Brito et al. [17] studied engineering students and found that gender, academic stage, and school background influence how students perceive their own thinking abilities.

Similarly, Medina-Vidal et al. [18] found that male and female students often differ in how they develop and report their thinking skills. These results suggest that educators should design inclusive learning environments that support all students in developing these skills. Castillo-Martínez et al. [19] tested an AI platform that measures CxT. Their study found that personalized feedback increased student motivation. The platform helped learners improve critical, scientific, and innovative thinking. These results show that digital tools can support the development and assessment of thinking skills. Sanabria-Z et al. [20] argue that researchers need CxT to connect open science and open innovation. Their study showed that open data alone do not lead to innovation. Researchers must learn how to work across different sectors and understand how to use shared knowledge. They suggest that developing CxT in researchers improves communication and collaboration.

Ibarra-Vázquez et al. [21] explored the link between social entrepreneurship and CxT. Their study found that students who engage in entrepreneurship activities tend to improve their thinking skills. They also showed that prior family experience in business has a smaller impact than hands-on practice.

Moreover, Stoev and Stoeva [22] proposed a teaching method for engineering students that uses real-world problems to support thinking development. They argue that training students to solve real challenges prepares them better for their careers. Their method combines creativity and knowledge from different fields. Ramírez-Montoya and Portuguese-Castro [23] validated the open model of CxT in three countries. Participants viewed the model as useful for training future citizens. They recognized that the model prepares learners to think in ways that support long-term solutions and responsible action. The open model includes actors from education, society, business, and government [4]. It uses flexible learning tools such as micro-credentials, learning technologies, and interdisciplinary methods. It also calls for policies, funding, and institutional support to sustain the development of thinking skills. Together, these elements support a shared vision of education that helps learners think clearly, solve problems, and act responsibly.

Complex thinking plays a vital role in advancing sustainable development by equipping learners with the cognitive tools necessary to understand, evaluate, and respond to environmental, social, and economic challenges. Studies show that critical and scientific thinking are essential to improving awareness and responsibility in sustainability-related contexts. Khasanah et al. [24] demonstrated that dialogic education, through structured collective and deliberative dialog, significantly improved students' abilities to analyze, interpret, and make inferences about real-world sustainability problems such as ocean pollution and air quality. This process also strengthened dispositional aspects of critical thinking, such as truth-seeking and open-mindedness, which are necessary for responsible decision-making in sustainable development.

Similarly, Khuadthong et al. [25] found that scientific literacy directly supports the development of sociological and critical thinking skills, which, in turn, enhances sustainable tourism awareness among younger populations. Their findings suggest that educational initiatives linking literacy and reasoning skills can guide behavioral shifts aligned with sustainability goals. Moreover, systems thinking contributes to sustainable outcomes in organizational contexts. Abonguie et al. [26] reported increasing global interest in applying systems thinking to support the sustainability of small- and medium-sized enterprises, revealing its value in understanding long-term business performance.

In corporate environments, Olazabal and Wyatt [27] showed that evaluative thinking tools such as theory of change and impact frameworks help organizations make reflective and sustainable decisions. Furthermore, Leal Filho et al. [28] highlighted how design thinking – when linked to circular economy principles – helps develop practical and scalable sustainability solutions. Their study underlines the relevance of design-based, human-centered problem-solving for implementing the United Nations SDGs. Altogether, these findings confirm that CxT improves the development of critical awareness, strategic reflection, and practical innovation, all of which are necessary to design and evaluate actions that support sustainable futures.

In summary, CxT serves as a foundational competency for sustainable development by enabling individuals and organizations to critically analyze

challenges, make informed decisions, and implement effective, responsible, and context-specific solutions aligned with long-term sustainability goals.

2.2 Computational thinking

Computational thinking is a problem-solving process involving skills such as abstraction, decomposition, pattern recognition, and algorithmic design. Wing [29] originally positioned CT as a fundamental skill for everyone, not just computer scientists. It encompasses cognitive abilities that transcend programming and enable learners to conceptualize problems in a structured, systematic way. Over time, CT has evolved as a critical twenty-first-century competency, integral to digital literacy and education across disciplines. Theoretical models such as (TPAC)2K expand on the foundational TPACK framework, emphasizing the integration of CT in pedagogical practice to facilitate digital creation and interdisciplinary application [30]. These foundations establish CT as a cognitive framework and also as a transversal educational strategy with implications for lifelong learning and technological adaptability.

Recent studies have significantly enriched our understanding of how CT can be developed across educational levels and contexts. Robledo-Castro et al. [31] demonstrated that CT training, combining unplugged and plugged activities, leads to measurable improvements in executive functions such as working memory and inhibition in primary school children. Similarly, Moreno-León et al. [32] conducted a large-scale study validating the efficacy of unplugged methodologies for CT development in preschool and primary students, with results showing significant gains in core CT concepts such as sequencing and conditionals. Reinhold et al. [33] found that programming entire paths using Scratch and LEGO® robotics-enhanced CT comprehension among second and third graders compared to traditional verbal methods. These studies support the notion that early CT instruction improves both cognitive and metacognitive development, even in low-resource contexts.

Teacher preparation also plays a critical role in scaling CT instruction. Yang [34] proposed a three-phase professional development model, CT4ECE, which effectively increased early childhood teachers' CT-related pedagogical knowledge and classroom engagement. Kong et al. [35] emphasized sustained teacher development, showing that embedded experiences and multiplatform environments enhance educators' understanding of CT, data structures, and procedures. Furthermore, Listiaji and Molnár [36], through a systematic literature review, outlined the dominance of plugged activities and visual programming in teacher education while calling for diversified CT models and evaluation strategies. Monteyne et al. [37] contributed by developing an IRT-based instrument to measure teachers' CT content knowledge, providing a robust framework for assessing professional readiness.

Several studies further explore CT's integration into subject-specific learning and interdisciplinary contexts. Yeni et al. [38] analyzed diverse strategies for embedding CT into subjects such as language arts and biology, finding that students' prior programming experience shaped their receptiveness to CT. Aksakal and Kucuk [39] used a problem-based learning approach to demonstrate the enhancement of CT, collaboration, and project quality in secondary students. Xu et al. [40] found that AI-enhanced educational media can scaffold children's CT development when narratives and dialogs are designed to connect with CT cycles. Schlauch et al. [41] expanded the scope by proposing "narrative computational thinking" through digital

storytelling, promoting CT as a medium for narrative creation. These interdisciplinary insights reveal CT's versatility as a cognitive scaffold across contexts.

CT is cognitively valuable, and it is also pedagogically adaptable to diverse learner profiles. Troiano et al. [42] applied multilevel modeling to show that factors such as Scratch experience, teacher expertise, and game genre significantly predict CT outcomes in constructionist game-based learning. Aldemir et al. [43] found that XR-enhanced maker spaces support CT development among non-CS preservice teachers through iterative design, rule-mapping, and micro-debugging. Sun and Liu [44] compared Python-based and Scratch programming approaches and found that both enhanced CT in sixth graders, with Python producing deeper, sustained effects. These findings align with Yang et al. [45], who caution that coding skills do not automatically translate to CT, emphasizing the need for purposeful pedagogical design.

Moreover, several studies have explored the relationship between CT and higher-order thinking. Wang et al. [46] conducted a scoping review that identified working memory, reasoning, and algorithmic fluency as cognitive abilities with transfer effects to CT. Sa Yang et al. [47] developed a multimodal diagnostic model to evaluate CT mastery, revealing that abstraction remains the most difficult component for students. Rahimi and Sevilla-Pavón [48] examined CT in language learning via virtual exchanges, demonstrating that pattern recognition and strategic abstraction in language tasks support sustained learner engagement. Falloon [49] further validated structured CT curricula in early primary education, revealing that sequencing and algorithm development are achievable and beneficial for six-year-old learners. These findings affirm that CT development is closely linked to cognitive and metacognitive gains that extend beyond the digital domain.

Finally, CT holds promise as a critical enabler of sustainable development. CT promotes systems thinking, decision-making under constraints, and scenario-based modeling, all of which are essential for addressing complex societal challenges such as climate change, energy transition, and equitable education. Barricelli et al. [50] introduced the construct of EUDability, linking end-user development with CT to empower nonprogrammers in shaping technological tools for workplace sustainability. Similarly, embedding CT in educational initiatives enables learners to simulate sustainable practices, model ecological systems, and design adaptive solutions aligned with the SDGs. Integrating CT with sustainability education promotes a generation equipped to understand interdependent systems, evaluate long-term consequences, and act responsibly within local and global contexts.

3. Project relevance

In the current paradigm of knowledge-based economies, lifelong learning is an effective approach to increase competitiveness and be actively involved in the global economy [51]. In this perspective, knowledge economies' key components rely on intellectual capabilities rather than physical inputs or natural resources [52], scaling human resources capabilities up as the core of attention for companies, governments, and civil society. The beneficiaries of this project will be adults, regardless of their digital skills and in the position to use a digital tool to learn. Various resources and media will be offered through a wide range of channels, providing a proper learning experience adapted to each person's capabilities.

With the rapid development of e-learning and the application of information and communication technologies (ICTs) as a fundamental resource to increase knowledge, an increasing gap among adults has been created between those with a stimulating environment for self-development and those without. The advantages of e-learning and ICTs are their convenience and availability; however, certain requirements must be fulfilled to access the content and the channels where these resources are offered. It has been analyzed and proven by many authors and studies that sociodemographic factors, gender, age, disabilities, or location plays a relevant role in the effectiveness of e-learning [53].

Regarding access to training with OER, numerous organizations have undertaken notable efforts to crowdsource educational resources and foster accessible learning ecosystems, offering valuable points of comparison and inspiration for the present project. For instance, Acumen Academy provides OER and training focused on social change, reporting an investment of over \$135 million to support 136 social enterprises across Africa, Latin America, South Asia, and the United States [54]. Similarly, Khan Academy has become a global reference in nonprofit education, offering free, high-quality content across disciplines such as mathematics, science, history, humanities, and life skills, complemented by personalized learning paths and teacher-empowering tools [55].

Additionally, the CxT Academy – launched in 2018 – offered workshops and educational initiatives aimed at developing and evaluating a conceptual framework for CxT, alongside the identification of relevant tools and resources [56]. However, its online activity appears to have ceased after 2021, with limited engagement recorded. Lastly, the MIT Open Learning initiative [57] exemplifies a collaborative, global approach to educational innovation, working with diverse stakeholders to expand access, enhance learning outcomes, and drive societal impact. These cases reflect a broader ecosystem of crowdsourced knowledge production, from which this project draws lessons and seeks to contribute by integrating their best practices and expanding collaborative networks. Still, during the conceptualization of the CTE4A project, to the best knowledge of the research team, there were no strong initiatives to deliver OER and content in CT for Spanish speakers.

Additionally, the collective experience and network of our research group members allow us to build a strong, diverse network of specialists in this topic while creating a specialized knowledge repository from our own research, partner institutions, and project collaborators. This would lead to state-of-the-art CT training for adults. Our research group embodies a variety of profiles and areas of expertise, making it possible to lead the construction, evaluation, selection, and dissemination of the resources to be inserted into the ComplexHub as a path to achieving a relevant position in the international context regarding this topic. We also have the involvement of experienced researchers, early-career researchers, and doctoral students from computational and educational disciplines involved in the project. This project is led by Tecnológico de Monterrey's researchers, who are leaders in research on CT topics. Additionally, valuable research partners from public Mexican institutions and institutions outside Mexico – from Guatemala, Colombia, Peru, and Spain in the Spanish-speaking world – have closely collaborated with the project. Furthermore, occasional collaborators from the University of Leeds and King's College in the UK, and the Massachusetts Institute of Technology in the United States, have contributed their expertise in the development of applications of AI technology and have helped start building the network.

4. Methodology

This project adopts the challenge-based research (CBR) methodology [58], engaging in a collaborative and transdisciplinary process with a diverse range of stakeholders. It is structured as a dynamic and strategic network oriented toward cocreating OER that addresses complex societal challenges – particularly those related to SDGs in the context of an evolving knowledge society. By fostering partnerships among academia, industry, and civil society, the initiative promotes an integrated response to contemporary educational demands.

A distinctive feature of the project is the integration of generative AI to support the creation, adaptation, and evaluation of OER. These resources are developed in alignment with the principles of Education 5.0, which emphasize human-centered, inclusive, and technologically enhanced learning environments. The quality assurance process for OERs is participatory by design, involving active contributions from partner institutions and community members. This inclusive model not only strengthens the reliability and contextual relevance of the resources but also broadens the project's impact through network expansion, knowledge exchange, and sustained dissemination.

In addition, being an educational innovation project, research is conducted, testing the ComplexHub and its content in real scenarios. The methodological approach to gather and analyze the collected data from this process will always employ mixed methods, integrating statistical analysis (quantitative) of the complex reasoning competence achievement, participants' profiles, and behavioral data, with observations, interviews, and usability analysis (qualitative) to validate the user experience and its adequacy to the cultural context. The purpose is to validate the development of competences to foster adequate responses to critical technosocietal issues aligned with sustainable development and lifelong learning.

4.1 Stakeholders

This network has been formed to assemble, generate, collect, and evaluate the content and technological solutions development that will make the implementation possible. To bolster both user experience and sustainability, we have meticulously formulated a holistic strategy that places paramount importance on engaging key stakeholders from the outset of project development through the intervention phase for user experimentation. Our approach emphasizes forging connections with stakeholders at the local, national, and regional levels, encompassing a wide spectrum of interests, including academia, business, community, and government. The project's main stakeholders are as follows:

1. **Academia:** The potential for enriching lifelong competencies among both current and former students lies in the provision of a DLH. This service not only allows our alumni to maintain a lasting connection with their alma mater but also fosters a sense of belonging. Sustaining this lifelong link contributes significantly to strengthening the enduring relationship between the university and its graduates. Furthermore, extending these opportunities to include enrolled and graduated students from other universities, both nationally and internationally, broadens the spectrum of stakeholders involved. Fostering collaborative relationships extends beyond traditional

academic pathways. We cultivate strategic partnerships by facilitating postgraduate and postdoctoral exchanges, as well as mobility scholarship programs. Furthermore, we actively engage in impactful global dialogs, participating in influential international forums such as prestigious conferences and congresses.

2. **Business/industries:** The exponential growth of multinational corporations in Mexico has introduced a fresh array of challenges for skill development institutions. Additionally, lifelong learning emerges as a pivotal solution for entrepreneurial ventures. The ComplexHub seeks to partner with business and industrial leaders and emerging entrepreneurs to establish a dynamic tool for their training and developmental initiatives.
3. **Communities:** This project seeks to generate meaningful impact across diverse social contexts by actively engaging marginalized and underserved communities. Through the provision of accessible lifelong learning opportunities, it equips individuals with essential and future-ready skills. By fostering capacity-building and inclusion, the initiative supports the socio-economic advancement of disadvantaged groups, enabling them to pursue employment in competitive global markets – including multinational enterprises – and ultimately improving their quality of life and community well-being.
4. **Government:** Public entities' participation as a key stakeholder enhances the project's reach and influence. It aligns with governmental goals, fosters inclusivity, and supports competency certification. The initiative serves as a valuable resource for advancing skills in diverse sectors, especially through our strong collaborations with the Secretariat of Education, Science, Technology and Innovation of Mexico City and the Mexican Secretariat of Science, Technology and Innovation.

4.2 Work phases

The methodological process and the key activities for the CTE4A project started in January 2024 and are projected to conclude in December 2026, through the development of three continuous phases, described as follows:

Short term (January–December, 2024): This finalized stage allowed for a deeper conceptualization of the project's objective and expected impact through the understanding and definition of the platform's features and capabilities in six strategic activities:

Benchmark and market analytics: A comprehensive review was conducted to analyze comparable initiatives, identify best practices, and map direct competitors, providing critical insights into the positioning and innovation potential of the project.

Certification standard development: The methodology of CONOCER, the National Council for Standardization and Certification of Labor Competencies in Mexico, was applied and pilot-tested to create a professional certification standard, ensuring both alignment with national qualifications frameworks and the formal approval process for validation.

Platform structural design: Through participatory design processes with the extended research group, the core structure of the digital platform was defined, including essential functionalities, user experience pathways (see **Figure 1**), and resource integration.

Pedagogical model: A pedagogically sound model was developed, incorporating content architecture, educational resources, and delivery channels, all guided by principles of accessibility, relevance, and flexibility.

Validation: For the evaluation of the platform, the Smart Usability instrument was developed and validated [59] in diverse learning environments to assess both the effectiveness of the content and the inclusiveness of the learning experience.

Academic production: Scholarly dissemination accompanied each phase, contributing to the body of knowledge on digital education, certification, and inclusive innovation. The full up-to-date report on the results can be found in the Final Report Stage 1 [59].

Medium term (January–December, 2025): Current development phase. This stage represents a critical period for consolidating the foundations of the project and transitioning from conceptual design to operational deployment. It comprises four key strategic actions:

Technology profiling: Detailed specification and profiling of the platform's technical functionalities are being conducted to ensure the system meets user needs, integrates seamlessly with educational workflows, and supports the development and evaluation of OERs enhanced by AI. The platform is designed to automatically evaluate uploaded resources from content creators (**Figure 2**) before they go through a peer (human) evaluation process. Every participant with at least a master's degree can evaluate a resource based on an invitation received from the platform's system. Once a human has evaluated the resource, a "Human Evaluated" badge will be displayed with the resource.

Business model definition: The formulation of a sustainable business model includes the identification of revenue channels, value proposition, service architecture, and knowledge transfer strategies. Emphasis is placed on balancing open access with economic viability to support long-term operations and innovation [60].

Network formation: A structured process for building a multisectoral collaboration network is underway. This includes issuing formal invitations, signing agreements, and securing letters of intent from higher education institutions, local governments across Mexico and Latin America, and private-sector partners. These alliances are a key to scaling the project's impact and contextual relevance.

Funding applications: Proposals are being submitted to international funding agencies, philanthropic organizations, and corporate sponsors to secure financial support for platform development, resource creation, and pilot implementations.

Long term (January–December, 2026): The long-term phase of the project is oriented toward consolidation, scaling, and systemic integration of its core components. This stage includes three strategic developments designed to ensure sustainability, relevance, and institutional adoption as follows:

Index building: A specialized instrument will be developed to assess and rank the level of CT development promoted by the educational resources integrated into the platform. This index will enable continuous quality monitoring and provide actionable insights for learners, educators, and content developers. It will also foster a culture of evidence-based improvement within the ecosystem of open educational practices.

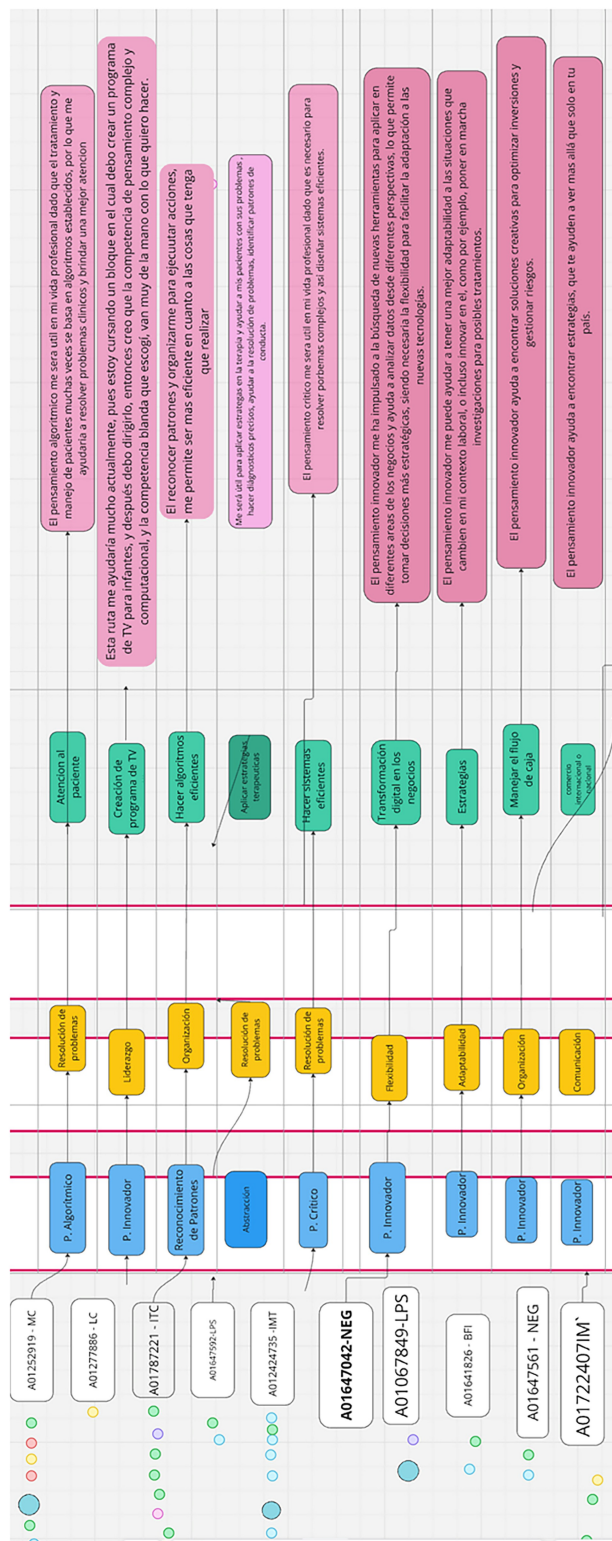
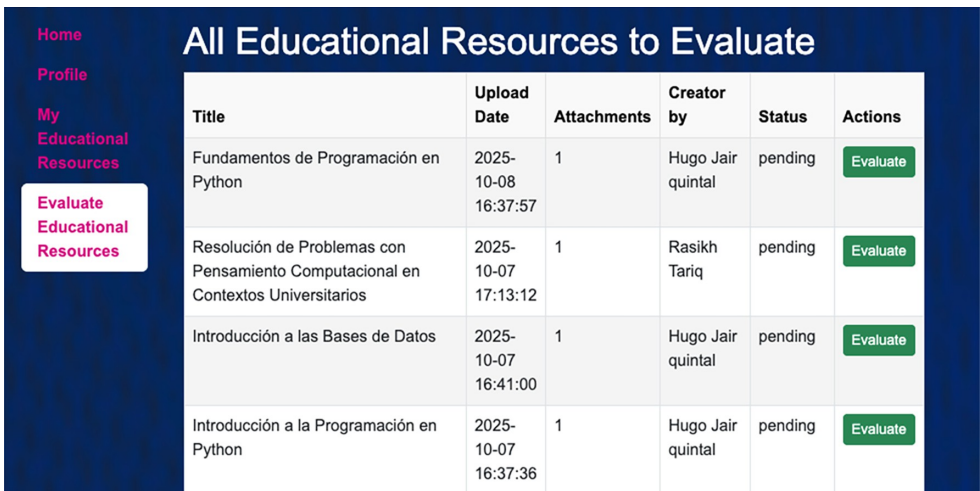


Figure 1.
Interactive online session to identify desirable learning routes for students.



Title	Upload Date	Attachments	Creator by	Status	Actions
Fundamentos de Programación en Python	2025-10-08 16:37:57	1	Hugo Jair quintal	pending	<button>Evaluate</button>
Resolución de Problemas con Pensamiento Computacional en Contextos Universitarios	2025-10-07 17:13:12	1	Rasikh Tariq	pending	<button>Evaluate</button>
Introducción a las Bases de Datos	2025-10-07 16:41:00	1	Hugo Jair quintal	pending	<button>Evaluate</button>
Introducción a la Programación en Python	2025-10-07 16:37:36	1	Hugo Jair quintal	pending	<button>Evaluate</button>

Figure 2.
Board of evaluated resources with the AI-powered quality assessment tool.

Certification credentials: A formal structure for the CONOCER standard for complex and computational thinking was submitted, aimed at validating competencies acquired through the platform. This credential will target diverse stakeholders – including educators, professionals, and students – seeking official recognition of their transversal and higher-order thinking skills in alignment with national labor competency standards.

Training programs: Customized training modules will be developed and offered on a fee-based model to government agencies, private companies, and other organizations. The platform retrieves the preferences and profile of learners (**Figure 3**), so it can offer tailored learning paths for each profile and type of user. These programs will focus on the application of CT in real-world decision-making contexts, fostering organizational innovation, strategic foresight, and sustainable development practices.

5. Results

To this date, in mid-2025, the CTE4A project has achieved relevant results. Regarding the ComplexHub platform (**Figure 4**) development process, a series of collaborative and analytical activities were carried out to ensure its relevance, functionality, and inclusiveness. Across participative conceptualization meetings held with representatives from diverse institutions, we defined the vision and purpose of the platform, drawing upon collective expertise and insights from previous project experiences to guarantee an unbiased and comprehensive approach. Supporting this activity, a comparative review of functionalities from 25 existing platforms was conducted, resulting in a detailed report recommending key features aligned with the project’s goals. An evaluation of usability and accessibility was also performed, applying recognized standards (such as WCAG) to identify strengths and areas for improvement, with the aim of ensuring an intuitive and inclusive user experience. Finally, a functional platform is ready to be

What type of resources do you prefer?

Text-based	Multimedia
☐ Academic texts	☐ E-books and digital publications ☐ Educational videos ☐ Podcasts and audio content
☐ Infographics	☐ Diagrams / mind maps ☐ Explainer animations ☐ Recorded webinars
☐ Essays	☐ Instructional guides and manuals ☐ Digital storytelling ☐ Narrated presentations
☐ Presentations	☐ Educational documentaries

Educational metaverse and AI

| ☐ Interactive exhibitions | ☐ Interactive virtual artifacts ☐ Educational avatars ☐ Educational materials created with AI |

Extended reality (XR)

Interactive
☐ VR laboratories ☐ 360° virtual tours ☐ Simulators ☐ Virtual laboratories
☐ Immersive simulations ☐ Educational AR markers ☐ Serious games ☐ Educational applications
☐ Overlaid 3D models ☐ Augmented books ☐ Learning objects ☐ Interactive quizzes with feedback

Figure 3.
Interactive online session to identify desirable learning routes for students.

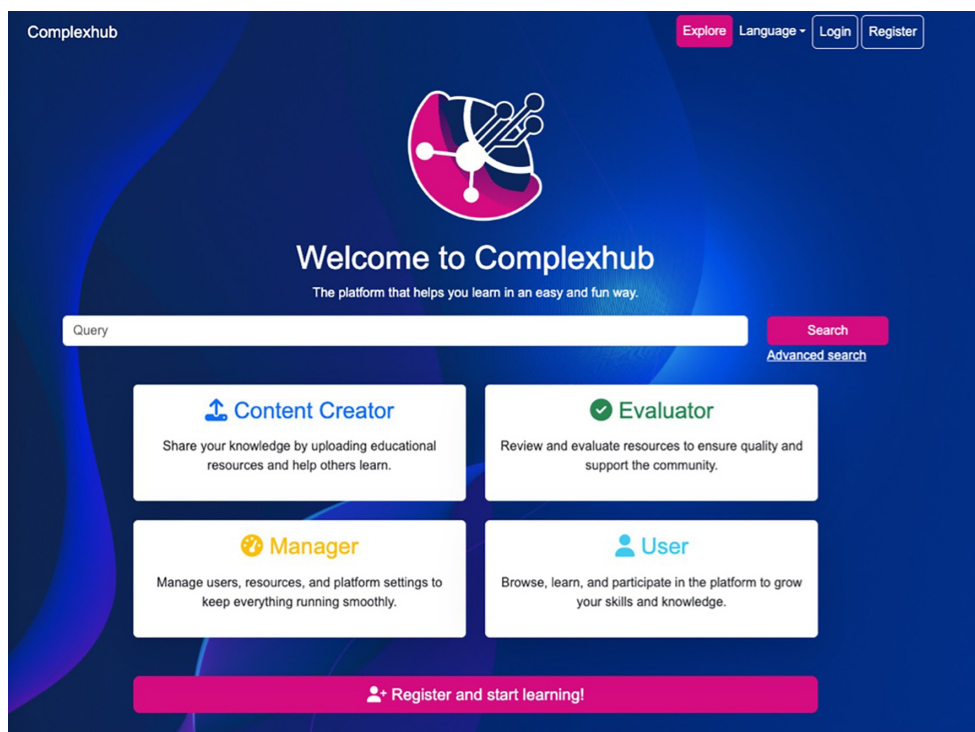


Figure 4.
Welcome page at: <https://complexhub.net/>.

tested with a group of experts and diverse users to ensure that it provides valuable benefits for our learning community.

Another relevant result is the design of the instrument to evaluate the usability of the platform and its validation through expert judgment. The instrument is based on a review of the literature to identify similar instruments, where emphasis was placed on the dimensions evaluated by the instrument and whether it had a reliability analysis. The pilot testing for refinement was conducted with Tecnológico de Monterrey pregrade students from different disciplines across Mexico. This instrument is ready to be included in the ComplexHub to evaluate its usability from the user's perception, including inclusion and evidencing the possible contribution to learning, ensuring an optimal and effective user experience.

As part of the project's dissemination strategy, two key activities were carried out to promote visibility, foster dialog, and engage with broader audiences. Activity 1 focused on the planning and implementation of the first series of webcasts aimed at presenting the project's objectives, initial findings, and progress. A dedicated website (<https://www.research4challenges.world/webcast-2024>) was created to compile all recordings and interactive sessions, supported by a content plan for social media that included a consistent visual identity across promotional materials, the website, and registration forms. Activity 2 involved the planning and execution of interactive sessions with students and potential users to discuss the relevance of the ComplexHub and the learning routes participants would follow in it. Two expert sessions were conducted in November and December 2024, and the insights gathered were also integrated into the dissemination website. Careful

coordination ensured that both webcasts and expert sessions complemented each other without overlap. The impact was tracked through website metrics: The first webcast page received a total of 480 views, and the second, 492 – mostly from Mexico, Colombia, and Guatemala – while the project received more than 2,800 views across social media sites and visits to the subsite, reflecting growing regional interest.

The research derived from this collaboration has produced 30 academic publications on a wide range of topics, reflecting a strong convergence around the advancement of CxT, the use of AI in education, and the validation of instruments to assess transversal competencies. Several studies highlight the role of adaptive learning systems and user profiling in fostering higher-order thinking, while others explore the psychometric validation of instruments to measure competencies in university students. The effectiveness of AI tools such as ChatGPT to support flipped learning and the development of lifelong learning paths underscores the relevance of integrating generative AI in educational innovation. In parallel, multiple studies confirm the importance of gender, diversity, and well-being in learning environments, as well as the contribution of engineering, health, and business education to the development of CxT. A significant number of publications also focus on Education 5.0, platform usability, and the design of learning ecosystems, showcasing cross-institutional collaboration and international coauthorship. Collectively, these findings inform the ongoing development of the ComplexHub platform, certification pathways, and training models, providing a robust research-based foundation for decision-making, policy alignment, and impact measurement.

6. Conclusions

This chapter presents a CBR project developed to meet the demand of Spanish speakers for open and quality complex and computational thinking educational resources. It offers the opportunity for the Hispanic community to access and collaborate in the creation of updated, open, and quality resources to develop two meta-competences: complex and computational thinking. The chapter outlines the project's background, development stages, and the conception of its core functionalities. Collaboration is the core of this project; it is positioned as a foundational value, drawing on the expertise and perspectives of stakeholders from diverse sectors, countries, disciplines, and career moments. Through the design and development of the ComplexHub platform, we have been able to achieve actionable tools to automate activities within the platform's functionalities to make it sustainable in the long term and to enhance the network of participants in any role: educators, learners, content creators, or evaluators.

The CTE4A project is still in progress, although the results presented offer valuable insights for initiatives that require collaborative and open approaches, particularly in contexts where generative tools can enhance the creation of relevant and sustainable educational resources. This work aims to contribute meaningfully to ongoing discussions on the integration of AI strategies to support sustainable open education projects. In the long term, such efforts can promote the development of key workforce competencies and enhance society's capacity to respond to the complex challenges of our time.

Acknowledgments

The authors would like to thank Tecnológico de Monterrey for the financial support provided through the Challenge-Based Research Funding Program 2023, Project ID #IJXT070-23EG99001, entitled Complex Thinking Education for All (CTE4A): A Digital Hub and School for Lifelong Learners.

Author details

Inés Alvarez-Icaza*, Rasikh Tariq and Leonardo David Glasserman-Morales
Monterrey Institute of Technology, Mexico City, Mexico

*Address all correspondence to: i.alvarezicaza@tec.mx

IntechOpen

© 2025 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Cruz-Sandoval M, Vázquez-Parra JC, Carlos-Arroyo M, Del Angel-gonzález MV. Complex thinking and its relevance in professional training: An approach to engineering students in a Mexican university. *International Journal of Engineering Pedagogy (IJEP)*. 2023;13(3):100–119. DOI: 10.3991/ijep.v13i3.36885
- [2] Markandan N, Osman K, Halim L. Integrating computational thinking and empowering metacognitive awareness in STEM education. *Frontiers in Psychology*. 2022;13:872593. DOI: 10.3389/fpsyg.2022.872593
- [3] Li L. Reskilling and upskilling the future-ready workforce for Industry 4.0 and beyond. *Information Systems Frontiers*. 2024;26:1697–1712. DOI: 10.1007/s10796-022-10308-y
- [4] Ramírez-Montoya MS, Basabe FE, Carlos-Arroyo M, Patiño-Zúñiga IA, Portuguese-Castro MI Modelo educativo abierto de pensamiento complejo para el futuro de la educación. Monterrey: Octaedro; 2024. Available from: <https://hdl.handle.net/11285/652033> [Accessed: 2025-December-3]
- [5] Marushchak O, Muliarevych O, Saienko V, Hurbanska A, Nowak B. Digital learning hubs as a component of the information and digital learning environment. *Journal of Curriculum and Teaching*. 2023;12(5):1–10. DOI: 10.5430/jct.v12n5p1
- [6] Khang A, Muthmainnah M, Seraj PM, Al Yakin A, Obaid AJ. AI-aided teaching model in Education 5.0. In Khang A, Shah V, Rani S, editors. *Handbook of Research on AI-Based Technologies and Applications in the Era of the Metaverse*. Hershey, PA: IGI Global Scientific Publishing; 2023. p. 83–104. DOI: 10.4018/978-1-6684-8851-5.ch004
- [7] United Nations. *Transforming our world: The 2030 Agenda for Sustainable Development* [Internet]. New York: United Nations; 2015 Available from: <https://sdgs.un.org/2030agenda> [Accessed: 2025-July-31].
- [8] Keller E, Rexford J. The “Platform as a Service” model for networking. *INM/WREN*. 2010;10:95–108
- [9] Qin M, Su CW, Umar M, Lobonț OR, Manta AG. Are climate and geopolitics the challenges to sustainable development? Novel evidence from the global supply chain. *Economic Analysis and Policy*. 2023;77:748–763
- [10] Gandhi MK. *Towards New Education*. New Delhi, India: Namaskar Books; 2025
- [11] Baistrocchi S, Morin E. Seven complex lessons in education for the future. *Early Years Educator*. 2018;20(6):38–40. DOI: 10.12968/eyed.2018.20.6.38
- [12] Cadavid-Ramírez LM, L.a R-R. Base complexity: System in the complex thought of Edgar Morin. *Revista Lasallista de Investigación*. 2023;20(1):22–33. DOI: 10.22507/rli.v20n1a2
- [13] Pacheco CS, Herrera CI. Development and validation of the Complex Thinking Assessment Instrument (CTAI). *Thinking Skills and Creativity*. 2023;48:101305. DOI: 10.1016/j.tsc.2023.101305

- [14] Portuguese-Castro M, Ramírez-Montoya MS. Transformative economies and complex thinking: Enhancing sustainability competencies in business education. *The International Journal of Management Education*. 2025;23:101223. DOI: 10.1016/j.ijme.2025.101223
- [15] Xu H, Deng T, Xu X, Gu X. The effectiveness of educational interventions on thinking and operational skills in complex learning—A meta-analysis. *Thinking Skills and Creativity*. 2024;53:101574. DOI: 10.1016/j.tsc.2024.101574
- [16] Promma W, Imjai N, Usman B, Aujirapongpan S. The influence of AI literacy on complex problem-solving skills through systematic thinking skills and intuition thinking skills: An empirical study in Thai Gen Z accounting students. *Computers and Education: Artificial Intelligence*. 2025;8:100382. DOI: 10.1016/j.caeai.2025.100382
- [17] Suárez-Brito P, Elizondo-Noriega A, Lis-Gutiérrez JP, Henao-Rodríguez C, Forte-Celaya MR, Vázquez-Parra JC. Differential impact of gender and academic background on complex thinking development in engineering students: A machine learning perspective. *On the Horizon*. 2025;33:14–31. DOI: 10.1108/OTH-11-2023-0036
- [18] Adriana MV, Vázquez-Parra JC, Cruz-Sandoval MA, Clavijo-Loor MA. Complex thinking and its relationship with gender and age in a group of Mexican students. *Learning and Motivation*. 2023;84:101937. DOI: 10.1016/j.lmot.2023.101937
- [19] Castillo-Martínez IM, Argüelles-Cruz AJ, Piñal-Ramírez OE, Glasserman-Morales LD, Ramírez-Montoya MS, Carreon-Hermosillo A. Towards the development of complex thinking in University students: Mixed methods with ideathon and artificial intelligence. *Computers and Education: Artificial Intelligence*. 2023;5:100186. DOI: 10.1016/j.caeai.2023.100186
- [20] Sanabria-Z J, Cruz-Sandoval M, Moreno-Romo A, Bosch-Gómez S, Ramírez-Montoya MS. Research foresight in bridging open science and open innovation: Overview based on the complex thinking paradigm. *International Journal of Innovation Studies*. 2024;8:59–75. DOI: 10.1016/j.ijis.2023.08.002
- [21] Ibarra-Vázquez G, Ramírez-Montoya MS, Miranda J. Data analysis in factors of social entrepreneurship tools in complex thinking: An exploratory study. *Thinking Skills and Creativity*. 2023;49:101381. DOI: 10.1016/j.tsc.2023.101381
- [22] Stoev P, Stoeva M. Methodology for complex thinking in solving problems in engineering training. *IFAC-PapersOnLine*. 2024;58:100–105. DOI: 10.1016/j.ifacol.2024.07.133
- [23] Ramírez-Montoya MS, Portuguese-Castro M. Expanding horizons for the future with an open educational model for complex thinking: External and internal validation. *On the Horizon*. 2024;32:32–48. DOI: 10.1108/OTH-12-2023-0042
- [24] Khasanah A, Yang JC, Chang CC, Shein PP. Dialogic education for sustainable development as a pathway to critical thinking. *Thinking Skills and Creativity*. 2025;57:101783. DOI: 10.1016/j.tsc.2025.101783
- [25] Khuadthong B, Rattanapong T, Imjai N, Aujirapongpan S. Sustainable

tourism awareness in Thai Gen Z tourists: Roles and themes associated with scientific literacy and sociological and critical thinking skills. *Journal of Hospitality and Tourism Management*. 2025;**64**:101316. DOI: 10.1016/j.jhtm.2025.101316

[26] Abonguie DF, Nyam YS, Hoeyi PK. A systematic analysis of systems thinking and the sustainability of small and medium size enterprises (SMEs): A global evaluation. *Scientific African*. 2025;**28**: e02738. DOI: 10.1016/j.sciaf.2025.e02738

[27] Olazabal V, Wyatt A. Designing for sustainability: A case in corporate philanthropy and evaluative thinking. *Evaluation and Program Planning*. 2025;**111**:102577. DOI: 10.1016/j.evalprogplan.2025.102577

[28] Leal Filho W, Schmidberger I, Sharifi A, Vargas VR, Rampasso IS, Dibbern T, et al. Design thinking for sustainable development: A bibliometric analysis and case study research. *Journal of Cleaner Production*. 2024;**455**:142285. DOI: 10.1016/j.jclepro.2024.142285

[29] Wing JM. Computational thinking. *Communications of the ACM*. 2006;**49** (3):33–35. DOI: 10.1145/1118178.1118215

[30] MacCallum K. Integrating computational thinking through digital creation: The (TPAC)2K model. *Teaching and Teacher Education*. 2025;**161**:105056. DOI: 10.1016/j.tate.2025.105056

[31] Robledo-Castro C, Castillo-Ossa LF, Hederich-Martínez C. Computational thinking training and its effects on working memory, flexibility, and inhibition: Randomized controlled trial in fifth-grade children. *Journal of Applied Developmental Psychology*.

2025;**100**:101850. DOI: 10.1016/j.appdev.2025.101850

[32] Moreno-León J, Román-González M, Martín-Barroso E, Zapata-Cáceres M, Jiménez M, Robles G. Enhancing computational thinking skills in early education: Exploring the efficacy and feasibility of unplugged methodologies. *Thinking Skills and Creativity*. 2025;**58**:101879. DOI: 10.1016/j.tsc.2025.101879

[33] Reinhold F, Sprenger P, Staniczek G. Introducing computational thinking to second and third graders: Programming whole paths outperforms step-by-step navigation in maze tasks. *Computers and Education Open*. 2025;**8**:100260. DOI: 10.1016/j.caeo.2025.100260

[34] Yang W. A three-phase professional development approach to improving robotics pedagogical knowledge and computational thinking attitude of early childhood teachers. *Computers & Education*. 2025;**231**:105282. DOI: 10.1016/j.compedu.2025.105282

[35] Kong SC, Lai M, Li YG. Scaling up a teacher development programme for sustainable computational thinking education: TPACK surveys, concept tests and primary school visits. *Computers & Education*. 2023;**194**:104707. DOI: 10.1016/j.compedu.2022.104707

[36] Listiaji P, Molnár G. Integrating computational thinking into teacher education: A systematic literature review. *International Journal of Educational Research*. 2025;**133**:102682. DOI: 10.1016/j.ijer.2025.102682

[37] Monteyne S, Struyve C, Gesquière N, Neutens T, Wyffels F, van

- Braak J, et al. Teachers' computational thinking content knowledge: Development of a measurement instrument. *Computers & Education*. 2025;225:105181. DOI: 10.1016/j.compedu.2024.105181
- [38] Yeni S, Nijenhuis-Voogt J, Saeli M, Barendsen E, Hermans F. Computational thinking integrated in school subjects – A cross-case analysis of students' experiences. *International Journal of Child-Computer Interaction*. 2024;42:100696. DOI: 10.1016/j.ijcci.2024.100696
- [39] Aksakal H, Kucuk S. Secondary school students' computational thinking skills, group cohesion, and performance in problem-based programming education. *Journal of Systems and Software*. 2025;230:112535. DOI: 10.1016/j.jss.2025.112535
- [40] Xu Y, Pan EZ, Levine J, He K, Thomas T, Warschauer M. The effects of interactions with AI-enhanced media characters on learning computational thinking. *Learning and Instruction*. 2025;98:102149. DOI: 10.1016/j.learninstruc.2025.102149
- [41] Schlauch M, Sylla C, Gil M. More than words: Conceptualizing narrative computational thinking based on a multicase study. *International Journal of Child-Computer Interaction*. 2024;42:100704. DOI: 10.1016/j.ijcci.2024.100704
- [42] Troiano GM, Abdollahi A, Cassidy M, Puttick G, Machado T, Hartevelt C. Leveling the computational playing field: Inquiring about factors predicting computational thinking in constructionist game-based learning. *Computers & Education*. 2025;237:105347. DOI: 10.1016/j.compedu.2025.105347
- [43] Aldemir T, Moon J, Bicer A, Byun G, Perez CM, Sabanwar V. How non-CS preservice teachers conceptualize and engage with computational thinking through 3D game design: Insights from an XR-enhanced maker experience. *Computers & Education: X Reality*. 2025;6:100099. DOI: 10.1016/j.cexr.2025.100099
- [44] Sun L, Liu J. Comparative study of codecombat-based Python programming and Scratch programming effects on sixth graders' computational thinking: Interaction effects of gender and programming experience. *Thinking Skills and Creativity*. 2025;57:101852. DOI: 10.1016/j.tsc.2025.101852
- [45] Yang Z, Blake-West J, Yang D, Bers M. The impact of a block-based visual programming curriculum: Untangling coding skills and computational thinking. *Learning and Instruction*. 2025;95:102041. DOI: 10.1016/j.learninstruc.2024.102041
- [46] Wang J, Yang W, Yeung MK. Cognitive foundations in the interplay between computational thinking and creativity: A scoping review. *Thinking Skills and Creativity*. 2025;56:101729. DOI: 10.1016/j.tsc.2024.101729
- [47] Yang S, Zhu S, Qin W. Enhancing computational thinking assessment: A multimodal cognitive diagnostic approach. *Thinking Skills and Creativity*. 2025;56:101752. DOI: 10.1016/j.tsc.2025.101752
- [48] Rahimi AR, Sevilla-Pavón A. Scaling up computational thinking skills in computer-assisted language learning (CTsCALL) and its fitness with language learners' intentions to use virtual exchange: A bi-symmetric approach. *Computers in Human*

Behavior Reports. 2025;17:100607. DOI: 10.1016/j.chbr.2025.100607

[49] Falloon G. Advancing young students' computational thinking: An investigation of structured curriculum in early years primary schooling. *Computers & Education*. 2024;216:105045. DOI: 10.1016/j.compedu.2024.105045

[50] Barricelli BR, Fogli D, Locoro A. EUDability: A new construct at the intersection of End-User development and computational thinking. *Journal of Systems and Software*. 2023;195:111516. DOI: 10.1016/j.jss.2022.111516

[51] Tchamyou VS, Asongu SA, Odhiambo NM. The role of ICT in modulating the effect of education and lifelong learning on income inequality and economic growth in Africa. *African Development Review*. 2019;31(3): 261–274. DOI: 10.1111/1467-8268.12388

[52] Powell WW, Snellman K. The knowledge economy. *Annual Review of Sociology*. 2004;30:199–220. DOI: 10.1146/annurev.soc.29.010202.100037

[53] Rizvi S, Rienties B, Khoja SA. The role of demographics in online learning: A decision tree based approach. *Computers & Education*. 2019;137: 32–47. DOI: 10.1016/j.compedu.2019.04.001

[54] Acumen. Jacqueline Novogratz. Acumen Founder and CEO. [Internet]. 2020 Available from: <https://acumen.org/jacqueline-novogratz/> [Accessed: 2025-July-31]

[55] Khan Academy. For every student, every classroom. Real Results [Internet]. 2023 Available from: <https://www.khanacademy.org/> [Accessed: 2025-July-31]

[56] Complex Thinking Academy. Home [Internet]. 2021 Available from: <https://www.complexthinking.org/> [Accessed: 2025-July-31]

[57] Jameel World Education Lab. Community Jameel & Massachusetts Institute of Technology [Internet]. 2023 Available from: <https://www.jwel.mit.edu/> [Accessed: 2025-July-31]

[58] Ooi YM, Husted K. Problem-solving and organisation of public-funded challenge-based research projects using a wicked problem lens. *Innovation: The European Journal of Social Science Research*. 2025;38(2):1052–1071. DOI: 10.1080/13511610.2024.2347283

[59] Tariq R, Alvarez-Icaza I, Ramírez-Montoya MS Final Report Stage 1. challenge-based research funding program 2023. Complex Thinking Education for All (CTE4A): A Digital Hub and School for Lifelong Learners. 2025. <https://hdl.handle.net/11285/703243>

[60] Valenzuela-Arvizu SY, Roza-García HA, García-Peñalvo FJ, Ramírez-Montoya M-S. SmartUsability: Educational Platform Assessment [Data set]. Zenodo. 2025. DOI: 10.5281/zenodo.15306205

Chapter 5

Crowdsourcing and the Creation of a Historical Reference Tool

Thomas Dublin

Abstract

This chapter provides a detailed description of the crowdsourcing process employed in assembling the *Online Biographical Dictionary of the Woman Suffrage Movement in the United States*, a freely accessible online database consisting of more than 3,760 biographical sketches of grassroots woman suffrage activists in the United States. Following a methodology section, it proceeds to a collective biography of more than 450 Black women suffragists included in the database, offering a comparison of Black women suffragists in the 1870s with a similar cohort from the 1910s. Analysis of the biographical sketches illuminates the tremendous growth over five decades and emphasizes how woman suffrage for Black women activists was embedded in broader campaigns for full citizenship for African Americans.

Keywords: crowdsourcing, biographical sketches, Black women's activism, woman suffrage, race and gender, segregation, civil rights

1. Introduction

The *Online Biographical Dictionary of the Woman Suffrage Movement in the United States* (OBD) is an online research resource that emerged from work on the online journal *Women and Social Movements in the United States since 1600* (WASM) over 15 years, 2010–2025. This database provides biographical sketches of more than 3,760 grassroots women suffragists active principally in the period 1890–1920. The OBD can be accessed at <https://documents.alexanderstreet.com/VOTESforWOMEN>. While I have published earlier in-process pieces discussing preliminary findings from the project, this article is the first that reflects on the crowdsourcing process that created this database [1, 2]. As this project has advanced, its historiographical significance has become clearer. Recent scholarship by Martha S. Jones and Cathleen D. Cahill has illuminated the place of women of color in the woman suffrage movement [3, 4]. The OBD moves beyond the critical leaders to offer rich evidence on the grassroots Black recruits in the movement. We see the tremendous growth of Black suffrage activism between 1870 and 1920 in terms of its numbers and its geographical spread. We see, as well, new interracial alliances among women suffragists and yet continuing cleavages as white women accommodated racial barriers to women's voting in the South after 1920.

2. The crowdsourcing process

Work that contributed to the emergence of the *Online Biographical Dictionary* began when I contacted Rosalyn Terborg-Penn in 2008 and proposed that we collaborate to reprint online the writings of the Black women suffragists Terborg-Penn had listed in an appendix to her 1977 Howard University dissertation and expanded with the 1998 publication of *African American Women in the Struggle for the Vote, 1850–1920* [5, 6, 7]. Professor Terborg-Penn liked the idea, and we launched the project. Working with students at SUNY-Binghamton, I focused on identifying writings by and about some 70 Black women suffragists in that appendix. Professor Terborg-Penn contacted scholars, inviting them to participate in the project by writing introductory essays on the most significant movement leaders among those suffragists. We planned that the suffragists' writings and the scholarly introductions would be published serially in issues of WASM. We anticipated that the project might post online about 500 writings of 70 suffrage activists.

As this project proceeded, another woman suffrage-related proposal came to me in my capacity as WASM coeditor. In June 2014, we received an email inquiry from independent historian Jill D. Zahniser, asking if we would be interested in publishing online a database she had prepared of National Woman's Party (NWP) protesters who picketed the White House in 1917–1919. She had prepared a spreadsheet noting 225 NWP activists who had taken part in the picketing. Biographical sketches for about 30 of these suffragists already existed as entries in the reference resource *Notable American Women*, and we secured permission to include those sketches in her database. Then we built upon her initial proposal and decided that we would publish the NWP spreadsheet and invite volunteers to create biographical sketches of the lesser-known activists among the picketers. Zahniser agreed to prepare six exemplary biographical sketches of notable suffragists that would serve as models for about 190 crowdsourced sketches that we would solicit from users of the website [8].

In December 2014, we sent out our first call for volunteers, encouraging women's history faculty at colleges and universities to engage their students in the research and writing of the bio sketches. We wrote in an email appeal: "We seek 20 faculty in U.S. women's history to mentor students in their classes between April 2015 and June 2017 in the methods of researching and writing the remaining 190 biographical sketches of militant suffragists in this database." Jill Zahniser agreed to edit the new sketches, and we anticipated publishing the sketches in WASM in the fall of 2017. The response to our call was so robust that I asked Jill Zahniser to identify additional militant suffragists affiliated with the NWP. Between the suffragists proposed by Zahniser and new names of NWP activists discovered in the research process, we soon had a group of more than 400 NWP suffrage activists.

As the NWP work proceeded, Rosalyn Terborg-Penn and I were identifying writings by Black women suffragists. In the course of this work, our group of Black women suffragists increased from 70 to 175 by the spring of 2017. We then decided to solicit bio sketches of the lesser-known Black suffragists to complement the sketches of the NWP suffragists. Finally, to include a fuller representation of suffragists in the project, we began to examine potential published sources for lists of mainstream suffragists. In this way, we discovered 700 pages of detailed state suffrage reports for the period 1900–1920 in the *History of Woman Suffrage*, Vol. 6 (1922), published by the National American Woman Suffrage Association (NAWSA). That source included some 2,700 names of NAWSA activists distributed

across all states and the District of Columbia [9]. In a revised call for volunteers that went out in June 2017, we wrote: “we are looking for volunteers to research and write bio sketches for 2,800 + suffragists between now and the centennial of the adoption of the Nineteenth Amendment in August 2020. Contributors will receive author credit as the work is published online.”

With this exponential increase in numbers, we realized that the nature of our crowdsourcing effort had to change. Individual solicitations and the recruiting of faculty to work with students in their classes would not move the project forward at a pace that could be completed in a timely way. I decided to seek state coordinators who would take on the work of outreach to potential contributors, as well as the copyediting and fact-checking of completed sketches. Eventually, we secured coordinators for 42 of the 48 states that voted on the suffrage amendment in 1919–1920. As we built up our corps of volunteers, we learned of statewide efforts to commemorate the 19th Amendment, and we coordinated our work with those efforts. In this way, we joined with six state efforts already underway.

To expand our reach, we submitted additional calls for volunteers through organizations that had a substantial Internet presence. Our most successful outreach venues included H-Women, the American Library Association, and the American Association for State and Local History (AASLH). This crowdsourcing strategy involved a leap of faith on my part. In a call sent out for volunteers in June 2017, I noted that “we have perhaps 300 bio sketches in hand of the 2,800 + we will eventually need.” My faith felt justified when, in the week after our first announcement in the AASLH Newsletter, I received almost 250 emails from prospective volunteers.

Other support soon developed for the crowdsourcing effort. Several volunteers offered to copyedit and fact-check completed sketches. Genealogists traced the family connections of suffragists. Librarians at Louisiana State University and the University of North Carolina coordinated with fellow librarians in their state systems. Some volunteers were great organizers of their students and colleagues. One faculty member eventually coauthored 28 sketches. Another volunteer wrote 36 sketches, making her contributions a post-retirement project.

The database kept growing. We were always identifying new suffragists to add to the database. We began with about 70 Black women suffragists identified by Rosalyn Terborg-Penn in 2008. The number had increased to 175 in June 2017, 240 in February 2018, and 467 as I write in June 2025. The number of militant NWP suffragists increased over time from 225 to 420, while NAWSA-affiliated suffragists increased by about 200 over the course of the project. Individual volunteers and state coordinators made numerous recommendations for additions, almost all of which I accepted. As the numbers of suffragists increased, so did the racial diversity of our suffragist list. In Delaware, Maryland, and Rhode Island, we added significant numbers of Black women suffragists not listed in the NAWSA state reports. Currently, the *OBD* includes more than 3,760 sketches written by more than 1,900 volunteers.

I continued to make additions to the database at six-month intervals after the first installment in March 2019. The crowdsourcing dimension of the project persisted. With each addition to the *OBD*, we posted a list of suffragists deemed “impossible to find.” We encouraged users of the site to contact us if they knew one of these women and could write a bio sketch. Over the years, we have added 20 bio sketches in this way and have shortened our “impossible to find” list. In addition, I receive email

from users of the *OBD* who write to ask if they might add to particular bio sketches. In each issue of *WASM*, we add bio sketches for new suffragists or revisions of earlier sketches based on my review of these email submissions. This process has slowed in recent months, but it continues.

3. The findings

What can we learn from this collection of bio sketches? The strength of the database is its coverage of the diversity of the suffrage movement. It includes three major groups: militant suffragists affiliated with the NWP, Black women suffragists, and NAWSA activists from the mainstream of the suffrage movement. For NAWSA suffragists, the database draws on reports from all 48 states and the District of Columbia, assuring wide geographical coverage [9]. These sketches, taken together, provide a framework for comparing and contrasting the collective portrait of Black women suffragists with that of militant and mainstream white suffragists.

Also related to this work is a second resource that I've created – a digitized collection, "Writings of Black Women Suffragists," published as part of the *WASM* database. This collection includes more than 1,900 published and unpublished writings by or about Black women suffragists [10].

In addition to the sketches and writings, there is a database recording about 50 variables for each of the Black suffragists whose biographies are in the *OBD*. The potential of this database can be seen by focusing on two cohorts in the group – Black women suffragists active in the 1870s and those active in the 1910s. We can learn a great deal about Black women's social justice activism by comparing these two groups and by placing their collective biographies within the broader context of the woman suffrage movement and American politics in these decades.

Comparing these two groups, we see a great expansion in the numbers of Black activists over this 50-year period and the dispersion of the movement from a focus in Washington, DC, in the 1870s to northern and western urban centers more generally by the 1910s. This expansion depended on the Great Black Migration and the growth of the Black women's club movement [11]. These developments gave Black women a particularly important public voice in the expansion of Black political activism in the early twentieth century – leadership that has continued to the present.

The woman suffrage movement was just getting launched in the early 1870s, emerging as a divided presence with the rivalry of the National Woman Suffrage Association (NWSA) and the American Woman Suffrage Association (AWSA). The divisive issue of granting Black male suffrage while sidetracking woman suffrage lay behind this split. Black women activists supported both of these national organizations. Mary Ann Shadd Cary, formerly a Canadian expatriate and the editor and publisher of the *Provincial Freeman*, supported the National, while noted abolitionist, lecturer, and author Frances E.W. Harper aligned with the AWSA [12, 13].

In the 1870s, after the passage of the 14th and 15th Amendments, Black women joined white suffragists in pressing for women's right to vote. Developments in Washington, DC, provide good examples. In 1869, Julia Wilbur and another white woman were accompanied by Louisa Butler and Eliza Anderson, two Black suffragists, in an unsuccessful effort to register to vote. In 1871, Shadd Cary was one of 63 women in the District who attempted to register to vote. Julia Wilbur tried

again, this time with Josephine Griffing and Black activist Amanda Wall. Accompanying the trio to the Registrar was the longtime supporter of woman suffrage, Frederick Douglass [12, 14]. None of these women was able to vote. Similar efforts in Rochester, St. Louis, and Vineland, NJ, also failed. The editors of *The Selected Papers of Elizabeth Cady Stanton and Susan B. Anthony* tabulated numerous attempts by women to register and vote in the period 1868–1873 and found 82 separate groups totaling more than 1,750 individuals. African American women comprised more than 12% of this number [15]. Only a handful of women actually had their votes counted, and the 1875 Supreme Court decision in *Minor v. Happersett* closed the door to women's voting, short of multiple state actions or a federal constitutional amendment.

With the failure of individual registration efforts, the NWSA focused first on federal legislation and then on a constitutional amendment. These efforts began in Washington, DC, where Black activists were well represented in these campaigns. In November 1876, Stanton, Anthony, and Matilda Joslyn Gage sent out a call for the NWSA annual suffrage convention to be held in the nation's capital on January 16–17, 1877. Their goal was: "[to] demand a 16th Amendment to the U.S. Constitution, that shall secure this right [to vote] to the Women of the Nation." They printed the text of a petition, calling on local activists "to print, and send out petitions to reliable friends in every county." They then called on supporting organizations "to send delegates to this Convention, freighted with mammoth Petitions for a 16th Amendment" [16].

Those petitions came forward with "a total of 40,000 signatures from 35 states and 5 territories" [17]. At least four petitions came from Washington, DC. The most hefty DC petition included the signatures of 310 men and 438 women, including Amanda Wall and Louisa Butler, who had tried to register to vote eight years earlier. Three petitions came from citizens of Uniontown, a DC neighborhood that had received a substantial influx of freedpeople as earlier refugees fleeing slavery settled in Reconstruction Washington, DC. One of the Uniontown petitions specifically identified the signers as "Colored Men" and "Colored Women." The bodies of these petitions were printed and used the same language, calling for a constitutional amendment "to prohibit the several States from Disfranchising United States Citizens on account of Sex" [17]. The first signers of the "Colored" petition were Frederick Douglass, Jr. and Rosetta Douglass Sprague, a son and daughter of Frederick Douglass. They shared the petition with friends and acquaintances, including African American settlers on the former Barry Farm – a planned settlement organized by the Freedmen's Bureau, with small lots sold to freedmen and freedwomen at low monthly installments. More than a third of the "Colored" petition signers lived in this neighborhood, less than a mile from the homestead, Cedar Hill, where Frederick Douglass lived [18]. The three Douglass sons – Lewis, Charles, and Frederick, Jr. – all purchased lots at Barry Farm. Lewis submitted a second women's suffrage petition in 1878 [19].

Focusing on the Uniontown petition signers of 1878 illuminates how Black women's support for woman suffrage fit within the broader Reconstruction context. Fifteen Colored women signed the petition, and thus far, we have generated biographical sketches for 12 of them. Seven lived in homes in the Barry Farm subdivision, made possible and subsidized by the Freedmen's Bureau. Three had deposits in the Freedman's Savings and Trust; two received monetary aid from the Freedmen's Bureau; and one taught in the neighborhood school supported by the

Bureau. The Freedmen's Bureau was the agency in the early, hopeful years of Reconstruction that represented the commitment of the Republican Party to help former slaves make a successful transition to freedom. Assisting the destitute, helping to fund public education, encouraging thrift and home ownership – these were among the initiatives that the Freedmen's Bureau undertook in the District. As Black men took on the mantle of citizenship offered by Reconstruction, it is understandable that some Black women sought to join them, with the right to vote serving as the fitting marker of their claims [20].

Among the signers of the January 1878 petition were Caroline and Elizabeth Chase, mother and adult daughter. In 1860, the Chases lived together in Ward 2 in Northwest DC and worked as washerwomen. Elizabeth received \$6 in cash relief from the Freedmen's Bureau. Caroline was recorded in the 1870 census as owning real property valued at \$200 [21, 22]. These funds enabled the Chases to purchase nearby lots on Elvans Avenue in Uniontown before 1871. By 1873, Elizabeth resided in her new neighborhood and was running an eating saloon, a decided step up from domestic labor. In April 1874, Augustus Straker, a Black lawyer employed by the Treasury Department, lectured at the nearby Pioneer Lyceum on "Citizenship, its rights and duties – woman suffrage" [5, 6, 23]. Whether Chase attended that lecture is unknown, but the petition confirms their support for women's suffrage. The Chases' support was not a fleeting fancy, as they both signed a second suffrage petition in 1880 that Douglass family members circulated [24, 25].

Why did Washington, DC, emerge as the center for early woman suffrage agitation in the 1870s, with 22 of 40, or 55%, of Black women suffragists in the *Online Biographical Dictionary* active in that decade residing in the city? The nation's capital saw a confluence of reform efforts in the post-Civil War years that contributed to this focus. The political struggles that led to the passage of the 13th, 14th, and 15th Amendments played a significant part. Accompanying this campaign to secure national citizenship and voting rights for Black men was the movement to secure home rule for the nation's capital and Black voting rights in local elections [14]. Parallel to these political efforts came demands to provide public education for Black residents of the District and housing for the vastly increased Black population as refugees from slavery poured into the city. Lastly came the expectation that the federal government would provide a reasonable share of federal jobs for Blacks who had shown their loyalty to the Union and to the Republican Party. The Freedmen's Bureau provided modest relief expenditures to refugees, supported the first public schools, and, in the Barry Farm neighborhood, took first steps to address the city's housing shortage. The existence of a substantial body of Radical Republicans in Congress, energized by their struggle with Andrew Johnson, and other sympathetic northerners drawn to the city by the prospect of a broad Reconstruction of American society, gave reasons to believe that the Union victory in the war would lead to real change in the circumstances and prospects for Black Americans [14]. Black women suffragists emerged within this broader local and national context.

This broad view of the emergence of women's suffrage as an issue during the years of Reconstruction can be fleshed out considerably with reference to the biographical sketches of Black women suffragists active during these years. These resources permit us to draw a collective portrait of the women and explore the campaigns they joined.

As their husbands, fathers, and sons were securing citizenship rights based on the passage of the Civil War amendments, Black women in the District joined white

women in demanding these rights for themselves. Black women suffragists active in D.C. in the 1870s were typically recent migrants to the city. Only four of the Black suffragists active in the 1870s – 10% – had been born in D.C., even though eventually 21 – or 59% – came to reside in the city and focus their reform efforts there. Congress passed legislation, overriding President Andrew Johnson’s initial veto, that granted Black men in the District voting rights in January 1867. As Black men voted and stood for elective office, Black women asserted their right to join them. This expansion of the franchise is one reason there was such a vibrant suffrage movement among Black women in the District, as Amanda Wall, Louisa Butler, Eliza Anderson, Mary Ann Shadd Cary, and others sought to register to vote, claiming that the 14th and 15th Amendments confirmed their citizenship and provided the basis for this right.

The experience of Mary Ann Shadd Cary across the decade speaks to broader change over time. Shadd Cary, born a free Black in Delaware, migrated to Canada with her family when the passage of the Fugitive Slave Act in 1850 increased the vulnerability of free Blacks in the north. She had taught for 10 years, and she continued at a missionary-supported school in western Ontario. For four years, she published and edited a weekly newspaper, the *Provincial Freeman*, and until 1860, she lived in Chatham, Ontario, with its sizable Black emigrant community. With the outbreak of the Civil War, she returned to the United States and worked to recruit Black soldiers for the Union Army. After some time in Detroit, she settled in Washington, DC, in 1869, and taught in Black schools. She was 42, widowed, with two children [26].

In the District, she became an advocate of woman suffrage and a vocal supporter of the NWSA. In 1871, she attempted to register to vote, and she continued to be active in the NWSA throughout the decade. In January 1872, she gave testimony to the House Judiciary Committee on the “Right of Women to Vote.” In that speech, Shadd Cary noted that Black women and men alike were denied the right to vote under slavery. Now that Black men had been granted the right to vote by the 14th and 15th Amendments, she called for extending that right to women as well. She drew on the same arguments that Stanton and Anthony made: “Taxed, and governed in other respects, without their consent, they respectfully demand, that the principles of the founders of the government may not be disregarded in their case; but as there are laws by which they are tried, with penalties attached thereto, that they may be invested with the right to vote as do men, that . . . they may in future be governed by their own consent” [27].

NWSA held its annual meeting in January 1874 in the District of Columbia and Shadd Cary showered its leaders with praise in the pages of Frederick Douglass’s paper, the *New National Era*. She called the event “the most harmonious and the most practical in every way of any one ever held” [28]. She emphasized particularly the testimony of Sara Spencer and Belva Lockwood before the House Judiciary Committee on behalf of woman suffrage [29]. Susan B. Anthony, in a letter written at the conclusion of the meeting, summed up the NWSA strategy at this date: “Gen. [Benjamin] Butler is bound to put the question of Woman Suffrage, pure & simple to the House first – & that will be on striking Male from the District of Columbia suffrage clause” [24, 3:36]. We see once again in Shadd Cary’s account and Anthony’s comments the interconnection between national and local causes that gave Washington, DC, and its suffragists such a leading role in the movement.

The woman suffrage efforts of the 1870s brought white and Black suffragists together, under the umbrella of the two predominantly white suffrage associations,

to focus on registering to vote, testifying before Congress, and circulating and signing petitions. Each time Julia Wilbur, a white abolitionist, sought to register, she was accompanied by Black and white friends who joined in the attempt. Mary Ann Shadd Cary joined white suffragists Sara Spencer and Belva Lockwood in speaking to a Congressional committee. While Frederick Douglass Jr. and Virginia Douglass Sprague circulated a petition among Colored residents of Uniontown, Lewis Douglass's petition had white and Black signers, as did the mammoth DC petition with more than 700 signers. There was no separate Black suffrage movement in the 1870s and no evidence that the two predominantly white suffrage associations discouraged Black participation.

Judging from this cohort of Black suffragists, the suffrage movement attracted Black participants across class lines. Fourteen of 27 Black suffragists in the database, active in the 1870s, with known occupations, were teachers or educators, three had business or professional occupations, and four were domestic servants. The group is certainly of higher status than the Black community in D.C. as a whole, but it was not limited to the city's Black elite. On average, these suffragists were active suffrage supporters for almost 17 years. They were also joiners in a range of other social justice organizations. At least eight were active in the Woman's Christian Temperance Union (WCTU), and 13 were members of a club belonging to the National Association of Colored Women (NACW). These multiple memberships reflect the way that woman suffrage, for Black supporters, was folded into efforts to elevate the standing of the race.

Much changed for Black women between the 1870s and the 1910s. Black churches grew dramatically during these decades; Black women became increasingly active in various voluntary organizations – first in the WCTU and later in Black women's clubs more generally. By 1909, we see Black women active in the founding of the National Association for the Advancement of Colored People (NAACP), the originator of the early civil rights movement in the United States.

The first thing to say about the 1910s cohort is how much larger the group had become over four decades. From 40 Black women suffragists active in the 1870s, that number grew to 268 in the decade of the 1910s. While the earlier suffragists had been concentrated in Washington, DC, by 1910, there were significant concentrations of Black women suffragists in DC, New York, Chicago, Baltimore, Wilmington, DE, Oakland, CA, and Portland, OR. The Great Black Migration to northern cities fed the emergence of suffrage activism. Twenty of these suffragists were born in New York State; fully 57 died there. Other major destinations were Illinois, California, and Oregon. Virginia led all states in terms of outmigrant suffragists: 32 were born there, but only three died in the state. Georgia, South Carolina, and Tennessee were other southern states that lost outmigrant suffragists in substantial numbers – 36 were born in these states, but only five died in the states of their birth. It is reasonable to say there wouldn't have been a Black woman suffrage movement without the Great Black Migration of the period 1890–1920 [30, 31].

There are other points of comparison for these two cohorts. There were far fewer Black suffragists in the 1870s than four decades later, but they were active in the suffrage movement for much longer periods of time. On average, Black suffragists active in the 1870s participated in the movement for 17 years; in the 1910s, the comparable figure was just 8 years. The earlier suffragists typically became active for the first time at 30 years of age and continued working in the movement until a mean age of 56. The comparable age range for those active in the 1910s stretched from 38 to 48.

A strong commitment to individual education and to the education of the race characterized both cohorts. In the four decades between the two groups, Black education made very significant strides. For the 1870s group, eight of 20 – 40% – for whom the level of education is known, had some higher education. For the later cohort, fully 68% had attended college or normal school, a full 70% more than the proportion for the earlier group. For both groups, the strength of their education led many into teaching for their race. For the 1870s group, 52% with known occupations became teachers or educators; in the 1910s, the comparable figure was 43%.

The numbers themselves do not reveal the full significance of education in the lives of Black suffragists. The parents of suffragists had a high regard for the importance of education for their children, and many had the resources to make that education possible. At least seven of the suffragists had tutors or attended private schools, either because the local public schools did not admit Black children or due to the poor quality of segregated schools provided for Black children. Several – including Charlotte Forten and Rosetta Douglass – moved away from their families for periods of time and boarded where they could receive quality instruction without experiencing discrimination or outright segregation.

Many of these early suffragists drew upon their sound educations to become teachers of freedmen and women. Virginia Hewlett Douglass taught in a “Colored” D.C. school in the 1870s, Charlotte Forten taught in the Sea Islands of South Carolina, and Louisa Jacobs taught freedmen in Alexandria, VA. Maria Baldwin, younger than these others, taught first in Maryland and then had a career of almost 40 years as a teacher and school principal in Cambridge, MA. A belief in the importance of education for the advancement of the race motivated these careers. The same commitment, in turn, led these women to advocate for woman suffrage so that they could support improved public education for their race with their votes.

Racial uplift motivated the careers of both cohorts, as we can see in the expansion of their organizational activity, the central strategy for collective progress. For the earlier cohort, eight suffragists – or 20% – were active in the WCTU. Several suffragists served as Superintendents of Colored Work in the WCTU. For the 1910s cohort, fully 64% were members of clubs within the NACW umbrella. This greater organizational activity was also reflected in membership in the newly founded NAACP, as 42% of suffrage activists in this latter period were NAACP members or joined in the association’s suffrage activities.

While the NACW and the NAACP were not formally suffrage organizations, both came to support the cause as part of their wider commitment to civil rights. The existence of these additional venues for activism contributed to the strength of Black women’s suffrage activism. Suffragists in the 1910s cohort who were definitely members of an NACW club averaged 10 years of suffrage activism; for those without any mention of club membership, the comparable figure was only 4 years. NAACP activity was also associated with significant suffrage commitment. Those with definite connections to the NAACP averaged 11 years of suffrage activity; those not so identified with the NAACP averaged 6 years.

The growth of the Black women’s club movement and the early civil rights movement, exemplified by the NAACP, contributed to Black women’s suffrage activism. That activism, in turn, was associated with interaction with the leading civil rights advocate of the era, W.E.B. Du Bois. Du Bois had correspondence with at least 111 of the Black women suffragists, more than 28% of the Black women suffragists in the database who were still living in 1909. Those with no

correspondence with Du Bois were active, on average, for 6 years in the suffrage movement; those with 10 or more letters with Du Bois were active, on average, for 15 years. Cause and effect are hard to establish, but whatever the direction of causation, the association here is strong [32].

Individual life stories speak to the group patterns evident in the statistical profiles and confirm that women who became suffrage activists had migrated from the South in the early years of the Great Black Migration. Alice Wiley Seay of rural Virginia and then Brooklyn provides a case in point. Born enslaved in 1858 in South Central Virginia, she was one of seven children of James Baugh, a farm laborer after emancipation, and Diannah Baugh. In 1886, Alice married a tobacco farmer, Pleasant Wiley, and in 1888 the couple moved to Brooklyn, NY. Pleasant found work in various jobs – coachman, blacksmith, and janitor; Alice worked as a dressmaker but was particularly active in the Concord Baptist Church and the Black women's club movement of the city. In 1905, she was elected president of the Northeastern Federation of Colored Women's Clubs, and in 1908, she helped found the Empire State Federation of Women's Clubs. After the death of her husband in 1906, she remarried in 1910 to another tobacco farmer, James Alfred Seay, from her hometown of Giles. Her husband worked his Virginia farm, while she continued to live in Brooklyn until 1916, when the Dorcas Home Missionary Society of her church sponsored a testimonial dinner and gave her a Victrola as she moved back to her husband's farm in Giles. She lived in Virginia another 20 years, but after her passing in December 1937, more than 300 former friends and neighbors attended a memorial service in Brooklyn in her honor [33].

Chicago was another northern node for Black women's suffrage activism. Like Brooklyn, the Black community on Chicago's south side was the product of Black migration [31]. Ida B. Wells-Barnett played a leading role as the cofounder of the Alpha Suffrage Club [34]. The club mobilized Black women to register to vote and participate in Chicago's vibrant politics after the state legislature, in 1913, approved women's presidential and municipal suffrage. Wells-Barnett was born in Mississippi and was publishing a newspaper in Memphis when her antilynching journalism made living in the South impossible. A white mob burned down the paper's office, destroying its printing press while Wells-Barnett was out of town, and she got word that it would be unsafe for her to return to Memphis [35]. She settled in Brooklyn initially but moved to Chicago after marrying Ferdinand Barnett in June 1895 [36]. There, she quickly became active in the city's Black club movement and was one of the founders of the NACW in 1896. Other leaders in Chicago's Black women's suffrage campaigns were also fellow migrants: Viola Hill, from Georgia; Vera Greene, from Missouri; Ada McKinley, from Texas; Theresa Macon, from Kentucky; and Irene Goins, from southern Illinois.

When the Illinois state legislature approved women's presidential and municipal suffrage, Black women of the Alpha Suffrage Club joined a massive car parade in July 1913, celebrating the victory [37]. The club sponsored numerous meetings at which Republican, Democratic, and Progressive candidates outlined their platforms to club members and residents of Ward 2 more generally. Club members went door-to-door encouraging voter registration and generally worked to educate newly enfranchised Black women voters. By the following February, women made up a third of voters in Ward 2 in the primary election, and a Black candidate for Alderman came within a few hundred votes of upsetting the incumbent white candidate backed by the Republican machine [46, 85–88; 21, 345–48; 35].

Organized Black women made such a strong impression that, shortly after the primary, two Republican Party stalwarts (one Black, one white) paid a visit to the Alpha Suffrage Club to win their support for the general election. Concerned that the women might encourage a Black independent candidate, the Republicans offered assurances that, when the next aldermanic vacancy appeared, the party would throw its support behind a Black candidate. The bargain held, and in 1915, a Black Republican, Oscar DePriest, won election in Ward 2 and became the first Black member of Chicago's Board of Aldermen. In 1928, DePriest became the first Black politician elected to Congress from the North [38, 39, 47].

Chicago's narrative in 1913 and after proved to be a dress rehearsal for Black women's political engagement that accompanied the adoption of the 19th Amendment in 1920. While suffragists created separate organizations along racial lines, the existence of distinct groups did not preclude alliances. One such alliance developed in Tennessee, which was the 36th and final state needed to ratify the Amendment in August 1920. Earlier, the state legislature had approved a bill providing women municipal and state suffrage. In the run-up to local elections in Nashville, white and Black women's suffrage leaders joined forces. As one historian has written, white suffrage leader "[Catherine] Kenny forged a political relationship with Frankie J. Pierce and Dr. Mattie Coleman, two African American activists. The Black activists agreed to support white reform candidates in the 1919 local Nashville elections. In return, Kenny promised white support for Pierce's legislative priority, a state vocational school for African American girls" [40].

Pierce and Coleman addressed racially mixed suffrage audiences. Dr. Coleman spoke at the annual convention of the Tennessee Equal Suffrage Association in June 1919. As the *Nashville Tennessean* recorded her speech: "The negro woman stands for purity and uplift. . . . We ask merely to be treated right. This war work we have been doing has done more to bring us into close touch with you women than any other thing." After quoting further from Coleman's speech, the article noted that "Dr. Coleman was made chairman of the Tennessee negro women's suffrage organization," and assured the paper's (white) readers that she would be working "under the supervision" of white suffragists. Another newspaper account named that organization as the Negro Women's Reconstruction League, noting that it had already registered 1,600 voters [41, 48].

The next spring, Kenny "invited Frankie Pierce to address the meeting" of the Tennessee League of Women Voters. "Pierce told the [LWV] convention that her sisters would use the vote to 'uplift our people' and asked only for a 'square deal'" [40, 42]. Dr. Coleman, for her part, registered some 2,500 Black women for the 1919 election. In 1921, the state legislature provided for the establishment of a girls' vocational school, which opened in October 1923. By forging this alliance and exercising their newfound voting rights, Black women gained resources for the Black community [43].

Anita Shafer Goldstein, who has examined this interracial alliance, concluded that "the alliance produced concrete gains and demonstrated the importance of organization within the African American community. . . . The decision to support reformers against machine candidates in the city was a bid for access to the growing agencies of state government." Goldstein emphasized the agency of Black women suffragists, noting, "It was not 'apathy, accommodation, and caste' that characterized them, but vigorous action, the offer of cooperation in return for concrete benefits, and an eagerness to make use of any breach in the walls of separate sisterhoods" [44].

Wilmington, Delaware, provides a second example of an interracial alliance emerging out of the work of segregated organizations. Like Nashville, Wilmington was located in a border state with a sizable Black population and a lengthy history of segregation. Events in Nashville demonstrate how Jim Crow practices could actually contribute to the emergence of a strong Black women's suffrage movement. Teachers at the all-Black Howard School became the nucleus of the Black suffrage movement. Because of residential segregation, the teachers lived in a few square blocks centered on East 10th and 11th Streets, the city's Black middle-class enclave, a neighborhood informally named "Teachers' Row" [45, 46, 49].

Some of the Black faculty joined with other women in March 1914 and founded the Equal Suffrage Study Club (ESSC), with the goal of "arousing interest in the suffrage movement among colored women" [50, 51]. Many of these women had earlier worked together supporting two Black institutions, the Home for the Aged and the Garrett Settlement House [52]. The club held twice-monthly meetings focused on "questions of municipal, state, national, and international interest." In May 1914, members joined the city's white suffragists and "marched, in a separate contingent, in Wilmington's first [woman] suffrage parade," with Blanche Stubbs serving as marshal of the "colored' section" [50].

White and Black women continued to work together to secure women's suffrage in a 1915 effort to amend the state constitution and a 1919–1920 campaign to convince the state legislature to ratify the 19th Amendment. In the latter campaign, schoolteacher and ESSC member Alice Baldwin joined a group of National Woman's Party (NWP) members who "lobbied the governor to convene a special session of the legislature to consider ratification." According to her biography, "Two days later, she was the only African American speaker at an NWP 'suffrage mass meeting' held at the (segregated) Majestic Theater in Wilmington. . . . Alice Baldwin's address was entitled, 'The Colored Teacher's Tale'" [53].

The state legislature did not support the 19th Amendment, but Delaware women won the vote with the Amendment's ratification in August 1920. Immediately, ESSC members renamed their club the Colored Women's Republican Committee, "blocked out the city into workable districts," and registered Black women voters. Their efforts came off smoothly, and Alice Baldwin reported in a letter to the NAACP that "things passed off here very nicely and peaceably. Many women voting . . . intelligently and honestly" [54]. The parallel here with the work of the Alpha Suffrage Club in Chicago in 1913–1915 is striking.

What we see in the 1910s is a dramatic expansion of the political activity that Washington, DC, experienced in the period 1867–1874, but four decades later, the stage also included Chicago, Nashville, Wilmington, and Portland. Earlier, Black women struggled, largely unsuccessfully, to register to vote; now, they were full players in the local political game.

Virginia and North Carolina were two additional centers for women's suffrage activism.

Following the ratification of the 19th Amendment, the NAACP sent its field secretary, Addie Hunton, into Tidewater, Virginia, to gather evidence of registrars' practices when Black women tried to register to vote in September and October 1920. Hunton, one of the Black suffragists in the database, filed reports on Phoebus and Hampton, where multiple subterfuges were employed to deny Black applicants the right to vote [55, 56]. Glenda Gilmore has chronicled Black women's efforts in Salisbury, North Carolina, and surrounding towns to register. Success was limited

given white opposition, but Gilmore's conclusion as to the broader meaning of these efforts is probably true across the South more generally:

The number of black women who voted in 1920 may have been small, but their significance in the state's racial politics was large. For the first time since 1896 black voters approached the registrars en masse. They assembled as the result of a coordinated subversive campaign, a gendered attack on gender-based white supremacy. By their presence at the polls, black women dared whites to use violence and won the dare. When turned away, African American women refused to keep quiet, enlisted outside help, and sought to inspire their communities to greater activism [57].

Gilmore's conclusion here is underscored by the continued Black resistance that followed the limited gains in the November 1920 election.

After filing her report on the practices of white registrars in Virginia in the weeks before the November elections, Addie Hunton returned to her job as field secretary in the New York headquarters of the NAACP. She launched an intense campaign to mobilize NAACP members to attend a NWP convention scheduled for mid-February to address the future agenda of the NWP. [58] Noted white suffrage advocates Harriet Stanton Blatch and Mary White Ovington wrote to Alice Paul, urging her to invite Mary B. Talbert, immediate past president of the NACW, to speak at the conference and to call for a federal investigation into the refusal of southern registrars to permit Black women to vote as provided by the 19th Amendment. Hunton followed up on these efforts by urging NAACP members to come to D.C. to meet with Alice Paul and to lobby for the inclusion of a demand for an investigation as a formal resolution of the NWP. In the end, a delegation of 60 NAACP women from 14 states and the District of Columbia, led by Hunton, met with Paul to make their case [59]. Paul made only a token gesture in response to these demands, permitting an NACW representative to come forward and lay a wreath at the base of the marble statue of Stanton, Anthony, and Lucretia Mott that was being unveiled in the Capitol Rotunda at this time [60–61]. There would be no invited Black speaker at the convention and no addressing of the concerns of Black women suffragists in the convention's agenda. At the convention itself, the resolution was briefly discussed, but it was quickly voted down [31, 32, 33]. The NWP's actions left Black women to struggle on their own for Black voting rights, a struggle that continued for more than four decades and only made substantial progress with the passage of the Voting Rights Act in 1965.

The database of Black women suffragists illuminates the early years of this struggle. Political affiliation is evident for only a minority of the 1910s cohort of suffragists, but we find 92 women active within the Republican Party, three among the Democrats, and five active in the Socialist, Communist, or Progressive parties (though a migration to the Democratic Party began to be evident with FDR's election in 1932). Both major parties played roles in cementing Black loyalty to the Republican Party for several generations – the Republican Party in passing the 13th, 14th, and 15th Amendments, which enfranchised freedmen after the Civil War, and the Democratic Party in the South in overthrowing Reconstruction and then disenfranchising Black men in the 1890–1910 period. This political alignment was fixed in place well before the passage of the 19th Amendment, and Black women suffragists did not hold back when they had the

opportunity. Moreover, they did not just follow the lead of Black men in politics. They had, in fact, developed a critique of the ineffectiveness of Black men in the years when only men could vote [11], and they built on their decades of organizing in the Black women's club movement and carved out a place for themselves in city, state, and national politics.

Black suffragists' post-1920 activism reinforced alliances that had been established in the struggle for the vote. Recall that Wilmington Black activists spoke at a mass meeting of the NWP in the joint effort to get the Delaware state legislature to ratify the 19th Amendment. Three years later, the leading Delaware Black suffragist, Alice Dunbar-Nelson, convinced the Delaware Federation of Colored Women's Clubs to endorse the newly proposed Equal Rights Amendment promoted by the NWP [62]. Even at a time when Black suffragists were pressing the NWP to lobby for the 19th Amendment's enforcement in the South, they could find other grounds on which to join with the NWP in pressing for broadened rights for women.

4. Conclusion

Between the individual biographical sketches assembled in the *Online Biographical Dictionary* and the analysis that emerges from the collective biography of these grassroots Black activists, we gain a much more nuanced view of the character and significance of Black women's suffrage struggles from the 1860s to the 1920s. Our new understanding rests on the collective portrait that emerges from the 3,760 biographical sketches in the *OBD*. These sketches, in turn, were only possible because of our reliance on crowdsourcing. No solo historian, working on their own, would have undertaken a project of this scale.

Drawing on this new evidence enables one to construct a clearer view of change over time. What began as a racially mixed campaign for universal suffrage in the immediate post-Civil War years became more racially divided as the nation itself became more racially divided with the emergence of Jim Crow. With the institution of segregation in the federal workforce during the Wilson administration, Jim Crow went national [63]. It is not so surprising, then, that Alice Paul sought to relegate Black suffrage supporters to the back of the NAWSA suffrage parade in DC in March 1913, or that NAWSA denied formal affiliation to Black women's clubs in 1919 [36, 64]. The white resistance to Black participation in suffrage activism reinforced the already-existing sentiment among Black women that suffrage was a tool in the broader Black Freedom Struggle rather than a goal in and of itself. Folding the call for woman suffrage into the broader race struggle led to a growing presence of women in the early civil rights movement. It is no coincidence that so many of the Black women suffragists noted here were among the founders and activists in the early NAACP. And the legacy of their activism is still visible today. They launched traditions of civic engagement that showed the way for Ella Baker, Fannie Lou Hamer, Shirley Chisholm, and Stacey Abrams, who have brought these citizenship struggles into our time. Whether it is the Black Lives Matter movement or today's fight against voter suppression, the struggles launched by Black women suffragists are still being fought fully a century later.

Additional information

This chapter builds on an earlier publication, “A Crowdsourcing Approach to Revitalizing Scholarship on Black Women Suffragists,” *Journal of the Gilded Age and Progressive Era* 19 (Fall 2020), 575–90. Copyright, 1920, reprinted with permission.

Author details

Thomas Dublin
State University of New York at Binghamton, Binghamton, United States

*Address all correspondence to: tdublin@binghamton.edu

IntechOpen

© 2025 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Dublin T. A crowdsourcing approach to revitalizing scholarship on Black Women Suffragists. *Journal of the Gilded Age and Progressive Era*. 2020;**19**:575–590
- [2] Dublin T. Crowdsourcing as a tool for studying the Woman Suffrage movement. *New York History*. 2017;**98** (3-4):465–474
- [3] Jones MS. *Vanguard: How Black Women broke barriers, won the vote, and insisted on equality for all*. New York: Basic Books; 2020
- [4] Cahill CD. *Recasting the Vote: How Women of color transformed the suffrage movement*. Chapel Hill: University of North Carolina Press; 2020
- [5] Straker DA. *Citizenship, Its Rights and Duties—woman Suffrage; a Lecture Delivered by D. Augustus Straker, Esq., at the Israel A. M. E. Church, and before the Pioneer Lyceum, at Hillsdale, Washington, DC, Apr. 13–14, 1874*. Washington, DC: Library of Congress; 1874. Available from: www.loc.gov/item/09032738
- [6] “D. Augustus Straker,” online bio sketch in Wikipedia
- [7] Terborg-Penn R, “Afro-Americans in the Struggle for Woman Suffrage,” [Unpublished Ph.D dissertation], Howard University, 1977
- [8] Zahniser JD. “Biographical Database of Militant Woman Suffragists” WASM march 2015;**19**(1):197–213
- [9] Harper IH. *History of Woman Suffrage*. Vol. 6. New York: National American Woman Suffrage Association; 114
- [10] “Writings of Black Women Suffragists,” WASM Database Online
- [11] White DG. *Too Heavy a Load: Black Women in Defense of Themselves, 1894–1994*. New York: W. W. Norton; 1999. p. 51–52,60–62
- [12] Rhodes J. *Mary Ann Shadd Cary: The Black Press and Protest in the Nineteenth Century*. Bloomington: Indiana University Press; 1998
- [13] Logan SW. *Frances Ellen Watkins Harper: Social Activist*. Accessible Online in WASM. 2014;**3**:645–654
- [14] Masur K. *An Example for All the Land: Emancipation and the Struggle over Equality in Washington, D.C.* Chapel Hill: University of North Carolina Press; 2010
- [15] Gordon AD, editor. *The Selected Papers of Elizabeth Cady Stanton and Susan B. Anthony*. New Brunswick: Rutgers University Press; Vol. 6: 1997–2013
- [16] “Memorial to the Senate and House of Representatives of the United States in Congress assembled, from Elizabeth Cady Stanton. Gage MJ, Anthony SB. National Woman Suffrage Association. In: *Petitions and Memorials, 45th Congress (1877-1879)*. Committee on the Judiciary. HR45A - H11.7. Washington DC: National Archives Building; 1890
- [17] Douglass Jr F, and Other Residents of the District of Columbia, 1878. *Petition for Woman Suffrage, Petitions and Memorials, Resolutions of State Legislatures, and Related Documents Which Were Referred to the Committee*

on the Judiciary during the 45th Congress (HR45A-H11.7), Records of the U.S. House of Representatives, 1789–2015, record group 233, no. 7330216, National Archives, Washington, DC

[18] “Cedar Hill: Frederick Douglass’s Home in Anacostia,” National Park Service, Washington, DC. Available from: <https://www.nps.gov/frdo/learn/historyculture/places.htm> [Accessed: 2025-November-26]

[19] Hutchinson LD, List of First Settlers of Barry Farm/Hillsdale, 1867–1871, 1981, History of Place research files, box 1, folder 13, Anacostia Community Museum, Washington, DC

[20] Lundquist-Wentz C, “The Hillsdale Petitioners: Black Suffragists and Settlers in 19th Century Washington, D.C.,” OBD. Available from: <https://documents.alexanderstreet.com/d/1011147796>

[21] Lundquist-Wentz C. Biographical sketch of Caroline Chase. OBD. 2017; Available from: <https://documents.alexanderstreet.com/d/1010220408> [Accessed: 2025-November-26]

[22] Lundquist-Wentz C, Biographical sketch of Elizabeth Chase, OBD. Available from: <https://documents.alexanderstreet.com/d/1010220409>. [Accessed: 2025-November-26]

[23] Terborg-Penn R. African American Women in the Struggle for the Vote, 1850-1920. Bloomington: Indiana University Press; 1998

[24] “Two Petitions of Citizens of the District of Columbia,” 1880, SEN 46A-H11.2, Box 179

[25] Douglass H, Meigs RJ, Clancey MA, Cowperthwaite H, and other citizens

of Washington, DC, Petition, asking for an amendment to the Constitution prohibiting the several states from disfranchising United States citizens on account of sex, Petitions and Memorials, Resolutions of State Legislatures, and Related Documents Which Were Referred to the Committee on the Judiciary during the 45th Congress (HR45A-H11.7), Louis [sic] Records of the U.S. House of Representatives, 1789–2015, record group 233, folder 15 of 25, National Archives, Washington DC. 2015

[26] Rhodes J, *et al.* “Mary Ann Shadd Cary;” biographical sketch for MASC. In Edward TJ editor, *Notable American Women, 1607-1950: A Biographical Dictionary*. Cambridge, MA: Harvard University Press 1971;300–301

[27] Cary MAS. “Speech to Judiciary Committee,” Mary Ann Shadd Cary Papers. Washington, DC: Moorland-Spingarn Research Center, Howard University; 2017

[28] *New National Era*, Washington, DC, 1874, p. 1

[29] Tiven RB, “Biographical Sketch of Sara Jane Andrews Spencer,” OBD. Available from: <https://documents.alexanderstreet.com/d/1011002066>. [Accessed: 2025-November-26]

[30] Gregory JN. *The Southern Diaspora: How the Great Migrations of Black and White Southerners Transformed America*. Chapel Hill: University of North Carolina Press; 2005

[31] Grossman JR. *Land of Hope: Chicago, Black Southerners, and the Great Migration*. Chicago: University of Chicago Press; 1989

- [32] B WE. Du Bois Papers, 1803-1999, Robert S. Amherst: Cox Special Collections and University Archives Research Center, University of Massachusetts; 2017
- [33] *New York Age*, Dec. 14, 1905, P. 3; Dec. 28, 1916, P. 8; Feb. 28, 1938, P. 12
- [34] Materson LG. For the Freedom of Her Race: Black Women and Electoral Politics in Illinois, 1877–1932. Chapel Hill: University of North Carolina Press; 2009
- [35] Hendricks WA. Gender, Race, and Politics in the Midwest: Black Club Women in Illinois. Bloomington: Indiana University Press; 1998
- [36] Giddings PJ. Ida: A Sword among Lions: Ida B. Wells and the Campaign against Lynching. New York: Amistad; 2008. p. 177–87,207–08
- [37] "The Alpha Suffrage Club," Chicago Defender, July 5, 1913, p. 1
- [38] Hendricks WA. Ida B. Wells-Barnett and the Alpha Suffrage Club of Chicago. In Wheeler MS, editor. One Woman, One Vote: Rediscovering the Woman Suffrage Movement. Troutdale, OR: NewSage Press; 1995. p. 270–274
- [39] "Oscar Stanton De Priest," in Wikipedia, accessed online at https://en.wikipedia.org/wiki/Oscar_Stanton_De_Priest. [Accessed: 2025-November-26]
- [40] Bucy CS. Catherine Kenny: Fighting for the Perfect Thirty-Sixth. In Lindenmeyer K, editor. The Human Tradition: Ordinary Women, Extraordinary Lives; Women in American History. Lanham, MD: SR Books 2000;197–213
- [41] Nashville Tennessean, June 6, 1919, July 2, 1920
- [42] Carole Bucy, biographical sketch of Catherine Kenny: OBD, accessed online at <https://documents.alexanderstreet.com/d/1009932459>. [Accessed: 2025-November-26]
- [43] Walker K, *et al.*, "Biography of Mattie E. Coleman, 1870–1943," OBD, accessed online at <https://documents.alexanderstreet.com/d/1009805439> [Accessed: 2025-November-26]
- [44] Goldstein AS. A Rare Alliance: African American and White Women in the Tennessee Elections of 1919 and 1920. *Journal of Southern History*. 1998;64:245–246
- [45] Clampitt S, "Biography of Caroline B. Williams," OBD, accessed at <https://documents.alexanderstreet.com/d/1009594393> [Accessed: 2025-November-26]
- [46] Boylan AM, "Biography of Fannie Hopkins Hamilton," Online Biographical Dictionary of the Woman Movement (hereafter cited as the *OBD*) <https://documents.alexanderstreet.com/d/1009594397>. [Accessed: 2025-November-26]
- [47] Hendricks W. 'Vote for the Advantage of Ourselves and Our Race': The Election of the First Black Alderman in Chicago. *Illinois Historical Journal*. 1994;87(3):171–184
- [48] Smith JC. Notable Black American Women, Book II. Detroit, MI: Gale Research; 1996. p. 125–128
- [49] Boylan AM, "Biography of Mary E. Taylor," OBD. Available from: <https://documents.alexanderstreet.com/d/1009805450>. [Accessed: 2025-November-26]

- [50] Scott CA, "Biography of Blanche Williams Stubbs," OBD. Available from: <https://documents.alexanderstreet.com/d/1009054791> [Accessed: 2025-November-26]
- [51] Boylan AM. Votes for Delaware Women. Newark: University of Delaware Press; 2001
- [52] Boylan AM, "Biography of Helen W. Anderson (Webb)" OBD. Available from: <https://documents.alexanderstreet.com/d/1009805437>. [Accessed: 2025-November-26]
- [53] Lewis A, "Biography of Alice Gertrude Baldwin" OBD. Available from: <https://documents.alexanderstreet.com/d/1009054793>. [Accessed: 2025-November-26]
- [54] Alice G. Baldwin, Portia M. Wiley, 14 November 1920, in NAACP Papers, microfilm edition, part 12, Selected Branch Files, 1913–1919, part B: The Northeast, reel no. 1
- [55] Hunton A, "Phoebus" and "Hampton," two reports to the NAACP, October, 1920, in folder "Discrimination, Voting, Oct. 21-31, 1920, General," Box C284, Group I, NAACP Records, 1842–1999, Manuscript Division, Library of Congress, Washington, DC
- [56] Duster AM, ed.. Crusade for Justice: The Autobiography of Ida B. Wells. Chicago: University of Chicago Press; 1970
- [57] Gilmore GE. Gender and Jim Crow: Women and the Politics of White Supremacy in North Carolina, 1896–1920. Chapel Hill, NC: The University of North Carolina Press; 1996. 218–224 p. quote on p. 224
- [58] Dublin T. How Did Black Women Struggle to Bring White Suffragists to Their Citizenship Cause in 1921? Women and Social Movements in the United States (Hereafter WASM). 2023;27(1)
- [59] Addie W. Hunton to James Weldon Johnson, 1921, NAACP Papers, Group 1, Series C, Administrative Files, Box 407, Library of Congress, Washington, DC
- [60] "E M. Coleman Wreath Laying Ceremony," AAHGS Nashville (blog), Available from: <https://aahgsnashville.org/2017/10/12/dr-mattie-e-coleman-wreath-laying> [Accessed: 2025-November-26]
- [61] Hunton AW. "The National Woman's Party and the N.A.A.C.P.," The [NAACP] Branch Bulletin, 1921, 14–15. Schomburg Center for Research in Black Culture, New York, NY
- [62] Negro Women Appeal Against Ku Klux Klan. Wilmington News Journal. 1923;4
- [63] Unger N. How Did Belle La Follette Oppose Racial Segregation in Washington, D.C., 1913-1914? WASM. 2004;8(2)
- [64] Spruill MJ. Race, Reform, and Reaction at the Turn of the Century: Southern Suffragists, the NAWSA, and the 'Southern Strategy' in Context. In Baker JH, editor. Votes for Women: The Struggle for Suffrage Revisited. New York: Oxford University Press 2002; 102–107

Section 2

Crowdsourcing and Digital Collaboration

Chapter 6

A Study on Theories and Methods of Distributed Cognition–Driven Intelligent Design for Crowdsourced Products

Yuming Guo

Abstract

User demand-driven crowdsourced product innovation is inherently uncertain, characterized by a decision-making process where design cognition evolves from vague to precise and from abstract to concrete. To tackle the challenges posed by perceptual change propagation resulting from design uncertainty in intelligent information sharing during crowdsourced product design, this study proposes a theoretical framework and methodology centered around distributed cognition-driven intelligent design. To this end, a systematic framework is established from the perspectives of individual designers, concept development, and designer community evolution. The mechanisms of distributed cognition, informed by design experiences and activities within intelligent design environments, are thoroughly analyzed. Furthermore, the study offers theoretical models and solution approaches for addressing key challenges in collective intelligence innovation, serving as a valuable reference for the practical application of distributed cognition-driven intelligent design. This research aims to effectively construct a unified theoretical framework that bridges conceptual gaps between human–machine collaboration, cognitive modeling, and artificial intelligence (AI)-augmented design. It specifically addresses the cross-domain challenge of “change propagation under perceived design uncertainty,” thereby establishing a new interdisciplinary field.

Keywords: crowdsourced design, intelligent design, collective intelligence innovation, distributed cognition, designer experience, design environment intelligence

1. Introduction

Crowdsourcing is an innovative model that harnesses the collective wisdom and resources of individuals via the internet to collaboratively address specific tasks or solve problems. Crowdsourcing design employs internet platforms to aggregate public creativity and insights for the execution of design tasks [1]. This approach

decomposes and distributes innovation tasks among geographically diverse participants (such as global designers working together on product design), effectively overcoming the spatial and temporal limitations associated with traditional centralized research and development (R&D). Therefore, this facilitates a parallelized and modularized innovation process. Both models synergistically propel crowdsourcing design into a low-cost and high-efficiency innovation paradigm; however, they rely on digital platforms to coordinate cooperation and competition, reflecting the strategic choices made by product design decision-makers within interactive contexts.

In the realm of crowdsourced design research, attention has predominantly centered on socialized product development, crowdsourced creative design, and crowdsourcing product platform design. For instance, Jiao et al. [2] explored the role of crowdsourcing in product design and assessed the moderating effects of user expertise and network connections. In light of the rapidly evolving technological environment, Queiroz et al. [3] proposed the integration of artificial intelligence (AI) support in crowdsourcing to unlock the value embedded in digital services. Durward et al. [4] investigated how task characteristics and economic compensation jointly influence crowdsourcing workers' perceptions, aiming to elucidate shifting trends in digital labor. Acknowledging the increasing significance of AI in creative evaluation, Freisinger et al. [5] examined the role of AI-enhanced crowdsourcing and analyzed the behavioral responses of human crowd contributors toward AI. Bell et al. [6] researched AI-assisted creativity, presenting a theory-based creative screening model for crowdsourcing competitions. Kittur et al. [7] highlighted future challenges confronting crowdsourcing research, including AI-guided crowds, crowds guiding AI, synchronous collaboration, product platforms, work design, and motivation. Zhu et al. [8] mainly focused on the expertise of creative specialists and the engagement of co-creators within the context of crowdsourcing-based new product development. Zahay et al. [9] noted the challenges associated with integrating crowdsourcing into new product development, emphasizing that insufficient processes and infrastructure often result in product line extensions rather than the creation of genuinely novel products.

Technological innovation in crowdsourcing design is underpinned by an innovation ecosystem fostered through social networks. Knowledge management and research into collaborative design behaviors serve as essential tools for optimizing this process [10–12]. Considering the adaptive nature of human factors in design contexts, cognitive organization stemming from social interactions acts as a catalyst for intellectual engagement in group innovation processes. Significantly, the essence of decision-making in crowdsourcing product innovation design lies in how designers generate ideas and tackle challenges [11], alongside their capacity to adeptly identify, perceive, and manage design problems in a collaborative product design environment. Within the Industry 5.0 environment, human-centered design, manufacturing, and service throughout the entire product lifecycle promote effective real-time human–machine information interactions while concurrently addressing various sources of design uncertainty.

Under the influence of digital collaboration, industrial big data, and AI, the crowdsourcing design environment has emerged as a critical factor in addressing design uncertainties for crowdsourced product innovation. Through human–machine interactions, the crowdsourcing design process must account for subsystem interactions and multidisciplinary integrated design, implement multi-objective

mechanisms to balance cross-disciplinary impacts, and investigate optimal integrated solutions. Presently, methodologies such as user observation, brainstorming, sketching, design documentation, and prototyping are employed during the intelligent design phase of product families. Nevertheless, in open crowdsourcing design contexts, knowledge across diverse domains often exhibits fuzziness, uncertainty, and divergence. The analysis of data in Crowdsourced Product Design (CPD) is fraught with various uncertain variables, and the lack of effective design knowledge management impedes the structuring and ordering of the CPD process.

In essence, within a dynamically uncertain crowdsourcing design environment, the evolution of designers' knowledge is a cyclical process encompassing innovative discovery, deep internalized learning, specialized differentiation, systematic integration, and adaptive filtering mechanisms. This evolution is fundamentally about the creative reconstruction and value re-creation of knowledge, rather than the mere reuse of information. While humans play a pivotal role in crowdsourcing product design, conventional methods struggle to capture the distributed cognition characteristics inherent in addressing design uncertainties – specifically, the individual cognitive tendencies and experiences contextual to design. Thus, it is imperative to explore the variation and propagation of design uncertainty perception in crowdsourcing product design through the lens of human–machine hybrid intelligence.

Current research often treats crowdsourcing design and the design agent (designer) as two independent information distributions, assuming that the relationship between the product family and the design agent is merely a linear mapping. This perspective overlooks the symbiotic relationship between crowdsourcing design and stakeholders within the framework of personalized customization goals, which can lead to weak coupling and propagation of Distributed Cognitive Characteristics (DCC). Consequently, semantic associations are inadequately mined and leveraged, resulting in significant limitations in the usability, flexibility, and semantic richness of knowledge-based integrated intelligent design systems. Although data-driven intelligent design for crowdsourced products has made considerable strides, there remains a gap in addressing the evolution of distributed cognition within the design environment. The crowdsourcing design environment commonly serves as a digital collaborative product development support system and forms the foundational infrastructure for internet-based collaborative design. In human–machine interactive design, geographically distributed design teams can effectively contribute to product development through information sharing [13]. During the processes of design uncertainty perception and change propagation within a design environment, it is essential to evaluate whether machine learning models could reliably address the intended challenges and enrich the understanding of design issues grounded in empirical models [14]. This approach aims to achieve explainable AI that articulates reasoning processes and decision bases in a manner comprehensible to designers.

In contrast to the crowdsourcing design theories and methods mentioned above, distributed cognition is fundamental to understanding the mechanisms behind group intelligence formation. It highlights that design cognitive activity is an interdependent process involving all entities engaged in design cognition, including individual designers, stakeholder groups, and artifacts, which together constitute a product family development system. Distributed cognition elucidates the group

intelligence perceptual characteristics concerning design uncertainty. Its core components are rooted in individual cognitive tendencies and experiences shaped by design contexts [15, 16]. This understanding is vital for elucidating the mechanisms of design innovation activities, fostering interdisciplinary integration, and enhancing the innovative capabilities of design agents within the framework of group intelligence. Furthermore, through the deep integration of AI and digital collaborative technologies, a crowdsourcing design innovation model can be established that encompasses full-lifecycle product design aligned with group intelligence.

Rooted in the examination of change propagation under perceived design uncertainty, this study offers dual contributions by bridging ontological gaps among agents involved in crowdsourced digital innovation and by establishing a distributed cognitive framework. It thereby lays a theoretical foundation for social product development that imparts mechanistic insights while outlining pathways for practical implementation. The remainder of this chapter is organized as follows: first, it summarizes the implications, characteristics, and advantages of the theory of crowdsourcing design driven by DCC; subsequently, it reviews the current state of research and the challenges encountered in the evolution of crowdsourcing design within the context of distributed cognition. From the perspectives of the design agent, design concept development, and the evolution and aggregation of the crowdsourcing designer family in group intelligence innovation propelled by DCC, an intelligent design system framework for crowdsourced products is constructed. Furthermore, it conducts a comprehensive analysis of the group intelligence innovation mechanism influenced by distributed cognition, drawing upon designers' experiences, the iterative evaluation of product family conceptual design based on these experiences, and the dynamics of designer experience propagation – including learning, discovery, and game-theoretic regulation – within a series of crowdsourcing design activities. For this purpose, corresponding theoretical models and solutions to these research challenges are proposed.

2. Theoretical and methodological framework for intelligent design of crowdsourced products driven by DCC

2.1 Connotations, characteristics, and advantages of intelligent design for crowdsourced products based on distributed cognition

Intelligent design of crowdsourced products driven by DCC leverages adaptive design features and reconstruction principles inherent in distributed cognition to achieve optimization through human-machine interactive design. This methodology establishes a crowdsourced product development system characterized by efficient design iteration, facilitated by the exploration of propagation patterns related to changes in design uncertainty perception. Under conditions that require adaptive management of various types of design uncertainty, this approach fosters the emergence of human-machine hybrid intelligence in CPD. The integration of distributed co-creation enhances design semantics, particularly designer experience, thus addressing the demand for large-scale personalized customization.

Currently, the majority of crowdsourced product development focuses on optimizing task allocation, digital platform architecture, and incentive mechanisms.

In this context, the developer acts as a distributed design–manufacturing system. However, the intelligent design of crowdsourced products driven by DCC prioritizes the dynamic adaptability of cognitive individuals, the design of artifacts, and the cognitive reconstruction of group intelligence innovation. This perspective can be viewed as a manifestation of designer experience–driven human–machine hybrid environmental intelligence, and its main characteristics can be itemized as follows:

2.1.1 Dynamic adaptability of cognitive individuals

In a CPD environment composed of distributed cognitive agents, the presence of multiple design uncertainties throughout the product life cycle and the complexities associated with multi-scale behavioral models during design coupling necessitate that individuals within the group or system adopt specific cognitive roles. These roles can include being processors, transmitters, or coordinators of product functionality, behavior, and structural information. Through interactive design and consideration of environmental factors, participants actively refine their cognitive strategies to align with the design requirements of distributed design–manufacturing systems.

2.1.2 Artifact design

Artifacts serve as both carriers and extensions of the cognitive functions of individual designers. They manifest information through design visualization, symbolic reasoning, and product structuring, enhancing the capability of individuals or groups to comprehend and process complex design information. As media for customized products, artifacts promote cognitive collaboration among diverse participants by leveraging the cognitive processes of the subjects. This encompasses a dynamic process of integrating, differentiating, and reintegrating experiential knowledge. By centering on the user, this process leads to the progressive refinement of product functions, performance, and user experience, allowing the product to evolve from a preliminary, simple version into a fully developed and mature final product.

2.1.3 Cognitive reconstruction in group intelligence innovation

Artifact design and human cognitive processes co-evolve, each influencing the other. To create personalized custom products, it is essential that they align with human perceptual patterns, including visual preferences and metaphorical reasoning. Conversely, sustained interaction with artifacts modifies the cognitive strategies employed by crowdsourcing designers, facilitating more effective forms of information representation. The reciprocal adaptation of product information and cognitive representation, along with the restructuring of social cognitive networks, allows for the independent regulation of design iteration through collaborative efforts among humans, machines, and environments. Crowdsourcing designers rapidly exchange information, offer feedback, and engage in discussions to ensure seamless advancement in cross-domain collaborative design within the crowdsourcing framework.

2.1.4 Human–machine hybrid environmental intelligence

Since product innovation emerges from the intricate interplay of the human–machine–environment system and necessitates the effective management of

knowledge among multiple individual designers, the perspectives of these innovative designers remain inherently limited. Distributed cognitive theory offers a robust analytical framework that captures the entire range of cognitive activities in CPD. Its fundamental premise is that the cognitive and computational attributes of the system can be elucidated through the organized dissemination and constraints of information. The experiential representations within this context encompass participants, artifacts, environments, and culture, which coalesce alongside machines, evolving to form a hybrid intelligent system. In this system, continuous human feedback propels the evolution of machines.

The main advantages of intelligent design for crowdsourced products, as influenced by DCC, are as follows:

- (1) Dynamic adaptability of individual cognition lies in the ability to flexibly integrate external resources – such as technical tools, social networks, and environmental cues – to optimize cognitive strategies in real-time. This adaptability enhances data accessibility and model convergence, improves product performance, and mitigates the complexity associated with multi-parameter design coupling. Designers are transformed from isolated cognitive units to active participants who adjust their roles in product development to align with the evolving demands for personalized customization.
- (2) The key advantage of artifact design is its potential to externalize, extend, and reorganize the cognitive processes of crowdsourcing designers. Through multidisciplinary and multi-task collaborative optimization, it fosters efficient coupling and precise alignment between design agents and artifacts. By scrutinizing the engineering innovation decision-making processes, as well as the design, engineering implementation, and realization phases of crowdsourcing participants from a cognitive viewpoint, one can identify the practical modes of subjects throughout the innovation journey, thereby highlighting the importance of cognitive distribution.
- (3) Digital collaboration platforms facilitate the integration and cross-fertilization of heterogeneous viewpoints. By aligning with the requirements of crowd-sourced design, the innovation process can be visualized and iteratively refined. Utilizing a cross-domain collaborative representation of the experiential semantics of crowdsourcing designers, coupled with a multi-granularity framework for design intentions and adaptive multi-level evaluation metrics, enhances the richness of the experiences of crowdsourced product designers. This approach enriches and extends existing theories and methods in design thinking, thereby providing vital technical support for CPD within the context of personalized customization.

2.2 Foundations and challenges of intelligent design for crowdsourced products based on distributed cognition

Intelligent design for crowdsourced products is a specifically structured process grounded in the design environment, aimed at addressing the varying needs of diverse customer groups through the development of a related series of products. Currently, data-driven approaches for navigating uncertainty in intelligent design

decision-making enable users to achieve large-scale yet personalized experiences, thereby enhancing design efficiency. This section provides an overview of domestic and international research concerning innovative design, design thinking, and product family design, all driven by DCC, while also addressing the challenges encountered in these domains.

2.2.1 Innovative design

With the advancement of intelligent manufacturing technologies, both domestic and international scholars have conducted comprehensive research on the conceptual design of product families, primarily leveraging CPD and development [17–19], alongside data-driven collaborative design approaches. The key topics in this domain mainly include design conflicts [20], digital twin systems [21], big data-driven innovation in intelligent product design within the furniture sector [22], patent data analysis and functional network evaluation for innovative product platform design [23], blockchain-empowered “manufacturing information as a service” systems for crowdsourcing [24], human-centered generative design frameworks [25], and design strategy networks that articulate generative design methodologies [26].

In the modular design of products based on product analysis data, numerous intelligent methods have emerged [27], including the knowledge-graph-assisted conceptual knowledge models [28] and the feature-transfer-based adaptive knowledge push methods for intelligent product design [29]. In addition, TRIZ tools have been utilized to enhance system-level conceptual design efforts [30], and hybrid prototyping strategies have been applied to integrate physical models and generative AI to foster innovation in conceptual design [31]. Further, specific design prediction techniques have been implemented to amalgamate sequence learning with game theory [32], functional decomposition integrated with conflict resolution has been utilized to facilitate resilient conceptual design amid uncertainty [33], and uncertainty-driven decision-making processes have been implemented in conceptual design based on digital threads [34]. Additionally, hybrid intelligent methodologies have been used for product platform configuration with uncertain module selection [35], and remanufacturing scheme integration design approaches that account for carbon emissions and customer demand have been established [36]. Finally, patent- and NLP-driven functional modeling strategies have been implemented for system problem analysis networks in product conceptual design [37], and machine learning–based iterative design methodologies have been used for predicting user satisfaction in intelligent product-service systems [38].

While significant progress has been made in research on data-driven intelligent design methods for product families, the processes of crowdsourcing design and evolving product family conceptual design are inherently multi-stage, iterative, and highly interconnected decision-making activities. These endeavors often grapple with a multitude of semi-structured or unstructured challenges, with original data frequently manifesting in various uncertain forms. Data-driven product design often contends with latent cognitivism and cognitive safety-reliability concerns [39]. Consequently, achieving coherence in multidisciplinary design knowledge to develop consistent product solutions remains challenging. In traditional cognitive models, cognitive tasks are typically managed by a single individual. However, within a stakeholder-based distributed cognitive framework, cognitive tasks are shared across

a network of individuals who collaboratively engage to fulfill the cognitive tasks. Thus, distributed cognitive theory elucidates the dynamic interactions between uncertainty perception in product family conceptual design and design activities, highlighting potential endogeneity issues (where multiple variables within the model correlate with uncertainty) that warrant further investigation.

2.2.2 Design thinking

Designers' experience significantly shapes their cognitive approaches. Design thinking leverages designers' sensitivity and intuition to convert feasible technologies and business strategies into customer value and market opportunities that effectively address user requirements [40–42]. Up until now, some scholars have explored specific aspects such as creativity within crowdsourcing platforms [43–46]; the impact of product portfolio diversity and the relationship between design iteration and new product performance through the lens of experience and learning [47]; stage-based negotiation frameworks as co-design methodologies informed by participatory design experience and actor-network theory [48]; prototyping strategies aimed at engaging stakeholders during the early phases of design [49]; card-based design techniques that assist both designers and non-designers in addressing collaborative participation issues throughout the design process [50]; multi-task, context-aware methods for recommending design-experience knowledge in collaborative product design [51]; sketch understanding [52]; the integration of design thinking methodologies and conceptual knowledge theory into product configuration projects [53]; the role of design uncertainty in driving metacognitive monitoring and control of the design process [54]; the influence of cognitive style and design problem framing on the perception of design ideation [55]; and the proposal of self-adaptive cognitive manufacturing network models utilizing industrial knowledge graphs and multi-agent reinforcement learning [56].

Crowdsourced creative design and conceptual design of product families represent concrete applications and manifestations of design thinking within the design process. Researchers have proposed various models and algorithms aimed at enhancing the efficiency of design iteration. Product family design and stakeholder design requirements originate from various information distributions, resulting in explicit semantic gaps. Transforming personalized customization information into stakeholder descriptions necessitates effective coordination of product semantic entities – including emotional resonance, information transmission, and enhanced usability. This process involves varying design agents collaborating through information interaction to accomplish distinct design tasks aligned with a shared design goal, alongside situational reasoning. Such reasoning progresses from product value through needs, functions, and attributes, ultimately leading to iterative design concerning product form and usage conditions, thereby revealing latent semantics. Consequently, a coupling model integrating product family design and stakeholders' distributed cognition can be constructed, facilitating pertinent semantic mapping from the intelligent design semantics of crowdsourced products to stakeholder requirement descriptions.

2.2.3 Product family conceptual design driven by DCC

Industry 5.0 emphasizes a human-centered design philosophy that prioritizes worker well-being and sustainability. This philosophy enhances the humanization of

products and services by focusing on user experience and needs. In the realm of product design, this principle encourages the inclusion of stakeholder expertise within the design team, which encompasses marketing, engineering, design, management, suppliers, and production. This approach suitably aligns with research addressing the social connectedness inherent in crowdsourcing task cognition [57–62]. Therefore, Industry 5.0 transcends being a mere technological evolution; it articulates the future trajectory of manufacturing by defining the interplay between human and AI collaboration, essential for driving innovation and sustainability in this sector.

Related cognitive manufacturing studies encompass concepts such as cognitive digital twins, which serve as enhanced methods for equipment maintenance and management. Through ontology modeling, cognitive information is disseminated throughout the digital twin ecosystem across the entire product lifecycle – including design, manufacturing, operation, maintenance, and service – thereby addressing the challenges posed by information silos in product innovation and development [63]. The progression of manufacturing systems has moved from traditional methodologies to closed-loop control automation, followed by autonomous manufacturing with fault tolerance. Looking ahead, future manufacturing systems will necessitate cognitive manufacturing that is capable of perception, decision-making, and responsive actions to confront the challenges posed by distributed intelligent manufacturing [64]. While research on cognitive systems and interoperability within enterprises, such as cognitive digital twins and cognitive cyber–physical networks, has advanced, the transition from AI-integrated components to systems that emulate human cognitive behaviors demands significant effort. The crux of this transformation lies in integrating cognitive principles with AI-supported applications to facilitate human–machine collaboration. As the learning and adaptation capabilities of cognitive systems enhance, ensuring stable, robust control and predictability becomes increasingly vital [65].

Moreover, developing cognitive models for product family design that integrate individual designers, stakeholder groups, and artifacts into a human–machine interactive design behavior system remains a crucial area for further investigation. A dynamically co-constructive symbiotic relationship exists between cognitive organization and group intelligence. Cognitive organization transforms individual cognition into shareable, iterative group cognitive assets through structured knowledge frameworks and collaborative mechanisms. In return, group intelligence contributes to the evolution of organizational cognitive capabilities through the emergent effects of distributed cognitive networks. The transition from individual cognition to distributed cognition is a significant cognitive hallmark of humanity’s adaptation to the complexities of the information society. In this distributed cognition framework, individuals conceptualize a self-configuring system adept at processing both internal and external representational information, empowering subsystems to coordinate efficiently to fulfill diverse functions.

2.3 Intelligent design system framework for crowdsourced products driven by DCC

This chapter employs the principles of distributed cognition to examine the issue of change propagation in the context of perceived design uncertainty, which emerges in the investigation of intelligent information sharing for CPD. The

framework of the intelligent design system for crowdsourced products, mainly derived from DCC, is illustrated in **Figure 1**.

For micro-level tasks in crowdsourced product development, the experiences of crowdsourcing designers form a comprehensive knowledge system accumulated by DCC through prolonged perceptual and cognitive activities. This system comprises both external perceptual inputs, such as intuitive impressions derived from vision and touch, and internally constructed representations resulting from cognitive processing, which include design analysis, induction, and reflection.

In this digital collaborative design ecosystem, the elemental state model of experience transmission effectively embodies the dynamic integration of perceptual information and cognitive construction. Through repeated interactions with the environment, the crowdsourcing design agent converts transient perceptions into stable cognitive patterns, encompassing design skills and judgments critical to product design decision-making. In turn, this cognitive framework reshapes new modes of perception, thereby enabling both design experts and users to cultivate sharper professional observations.

Consequently, within the context of design intentions for crowdsourced products, innovation activities stem from clear problem recognition and a value-oriented approach. This intention compels designers to leverage existing design experiences, which involve explicit methodologies, such as design specifications, alongside implicit intuitive assessments, like esthetic evaluations of creative designs. Through iterative practical validation and the distributed dissemination of collective cognition across crowdsourcing platforms, this experience progressively evolves into a tacit knowledge repository of innovative design insights.

Influenced by DCC, design experience reflects the designer’s capacity to effectively identify, perceive, and address design challenges within conceptual design contexts. The evolution of design experience constitutes the process through which units of experiential knowledge are innovated, transmitted, and recombined. With respect to product family conceptual design tasks, research concentrates on the natural grouping and aggregation of distributed intelligent design agents. However, the product development process often involves multiple stakeholders pursuing various design objectives, with individual designers exhibiting

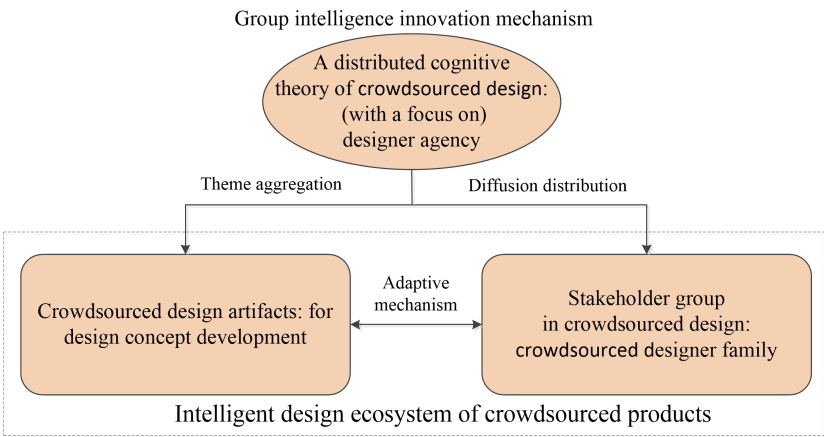


Figure 1.
An intelligent design system framework for crowdsourced products driven by DCC.

varying design perceptions and cognitions, which serve as the driving forces behind their design endeavors.

The design data are extensive and stem from heterogeneous, multi-source datasets, leading to knowledge gaps or diverse design uncertainties. Human perceptual capabilities allow individuals to seek specific objects within complex environments and process them effectively. The thematic style of convergence revolves around the integration of feature information with differing attributes into a unified situational perceptual experience, thereby facilitating the innovative design of artifacts. This integration enables design coupling and collaborative mapping among requirements, functions, principles, structural characteristics, and the perceiver's insights, which reduces the computational burden of navigating multiple design scenarios and enhances product design quality and performance. The concurrent advancement of intelligent design for crowdsourced products and digital collaboration fosters a paradigm shift from artifact design to networked design intelligence.

Distributed cognitive theory suggests that human cognition encompasses not only the thematic style of convergence but also the distribution of diffusion, reflecting the diversity and multidimensionality inherent in cognitive processes. "Diffusion" and "convergence" are conceptualized as two cognitive modes operating within a shared mechanism, interacting at varying levels and contexts to form complex cognitive networks.

Since innovative design fundamentally aims to meet latent user needs, crowdsourcing designer communities are often unable to fully ascertain all causal relationships among design variables. Therefore, it is essential to cultivate a friendly and rich collaborative perceptual work environment that harnesses the influence of group design experience within crowdsourcing contexts on the emergence of individual creativity. Additionally, elucidating the key mechanisms through which experiential knowledge associations bolster the novelty of ideas addresses the research gap in understanding the relationship between group experiential knowledge sharing and individual creativity. This, in turn, provides a fairly solid scientific foundation for optimizing enterprise crowdsourcing design, encouraging diverse knowledge contributions, and elevating the efficiency and quality of crowdsourcing innovation.

Moreover, equipping crowdsourcing designers with an adaptive interaction environment that alleviates cognitive load during interaction design and enhances the generalization capabilities of models constitutes a pivotal aspect of distributed cognition-based crowdsourcing design systems.

3. Research on the theory and method of intelligent design for crowdsourced products driven by DCC

Distributed cognition serves as a robust framework for investigating the propagation of perceptual changes induced by design uncertainty within the realm of CPD and intelligent information sharing. Building on this foundation, the theory and methodology for intelligent design in crowdsourced products, which are driven by the characteristics of distributed cognition, consist of two primary components: the mechanisms through which experience influences the distributed intelligent design agent (i.e., the designer) and the theoretical framework encompassing the intelligent design environment for crowdsourced products. The former addresses micro-level tasks, concentrating on the crowdsourcing design

process undertaken by the innovation subject, while the latter analyzes intelligent product design initiatives on crowdsourcing innovation platforms from the vantage point of the design environment.

At the micro-task level, this study extends interactive design theory by first elucidating the impact of product functional–behavioral–structural characteristics on design perception. It subsequently explores the cognitive generation of CPD, which combines design perception characteristics, facilitates structural and semantic decoupling enabled by distributed cognition, and examines the fusion mechanism linking design perception and cognition – specifically, how designers’ experiences influence product family conceptual design.

At the design environment intelligence level, grounded in human–machine hybrid intelligence and attuned to user needs, this study advances an innovation ecosystem for the intelligent design of crowdsourced products. By addressing crowdsourcing design requirements through the lens of a human–machine hybrid intelligence-driven ecosystem, it investigates design iterative evaluation models according to designers’ experiences within distributed human–computer interaction processes. Utilizing context-aware design features for iterative assessment, the study illustrates the dynamic mechanisms by which designer experience propagates, as driven by DCC. It further delves into game-theoretic regulatory frameworks of designer experience within distributed cognition and investigates the adaptive principles guiding the evolution of designer experience in support of CPD systems.

The current research essentially focuses on the mechanisms through which experience influences the distributed intelligent design agent – namely, the crowdsourcing designer – in facilitating CPD. It seeks to address the challenges related to adaptive representation modeling of the design agent while mitigating the complexities and computational burdens associated with various design uncertainty factors. A design iteration model is developed, mainly anchored in designers’ experiences, incorporating stakeholder feedback for iterative evaluation to tackle cognitive coupling challenges present in distributed human–computer interaction processes. Lastly, the study examines the evolutionary mechanisms governing product family conceptual design, influenced by designers’ experiences characterized by distributed cognition within crowdsourcing platforms. The main aim is to rectify the deficiencies in intelligent semantic representation for product family design and address issues of system adaptive regulation. This research aspires to generate comprehensive semantic descriptions for personalized customization while providing autonomous regulation strategies driven by integrated human–machine–environment intelligence, ultimately facilitating the seamless dissemination and adaptable expression of intelligent information in conceptual design.

The theory and methodology of intelligent design for crowdsourced products, informed by DCC, are illustrated in **Figure 2**. This demonstrates the mutual support between theory and method in interdisciplinary research on crowdsourcing platforms, aligned with research objectives, and ensures the practical implementation of intelligent design theory for crowdsourced products.

3.1 Mechanism of experience influence on the distributed intelligent design agent (designer)

To establish semantic associations between CPD and design cognition, this study considers the product family conceptual design system as a complex systems

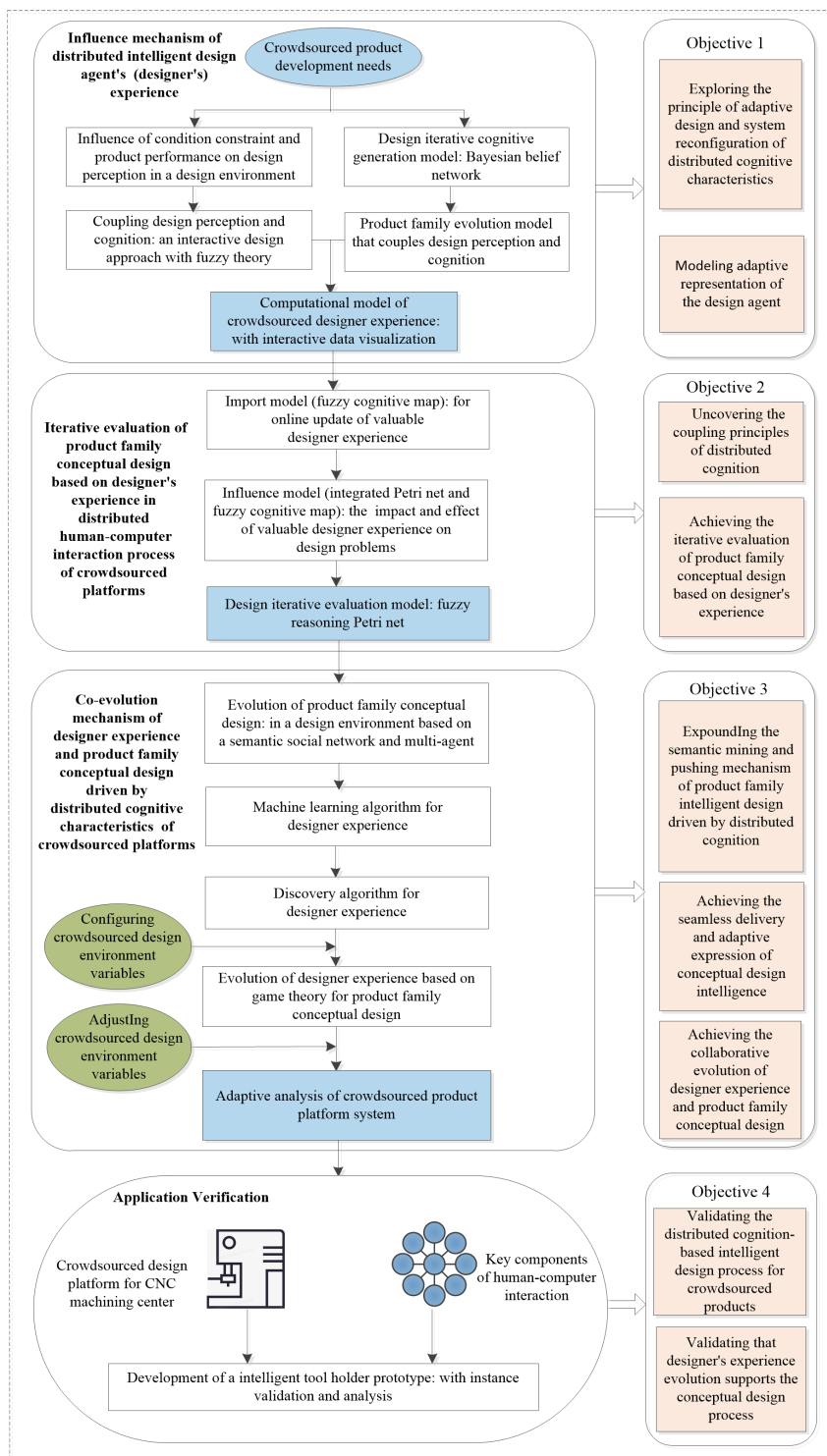


Figure 2.
Theory and method of intelligent design for crowdsourced products driven by DCC.

engineering challenge that involves multidisciplinary knowledge integration. It emphasizes the need to balance and optimize multiple design dimensions – such as cost, quality, and reliability – to achieve optimal system performance. However, the uncertainties inherent in full life-cycle product design have led to increased correlations and dimensionality among stochastic design variables, which complicate the accuracy and efficiency of intelligent design methods and hinder further research and practical applications in this domain. This study addresses the challenges of adaptive representation-based reconstruction and optimization of product functions, behaviors, and structures. It investigates how designer experience, augmented by distributed cognition, influences CPD and employs design decoupling to facilitate a divide-and-conquer approach on crowdsourcing platforms. This strategy aims to mitigate the overall uncertainty associated with life-cycle design for crowdsourced products. Furthermore, it applies semantic citation to crowdsourcing design for personalized customization, constructs a designer experience computing model, and enhances the accuracy and adaptability of CPD. The overall process can be described as per the following items.

3.1.1 Cognitive generation of CPD, coupling design perception characteristics

From the perspective of product semantics, a product is an intrinsic entity that fulfills users' individualized needs. Designers, when ascribing this intrinsic role, often rely on subjective and emotional preferences. In the conceptual design of product function–behavior–structure, designers analyze elements such as form, construction, and materials to establish a distinctive symbolic system model for the product. This model effectively conveys the design intent and rationale, leading to a cognitive framework for CPD. A lack of design knowledge, or a lack of trust in the available information, could result in perceived design uncertainty. This study investigates the strategies employed in human–machine interaction with information by designers (design cognition). First, based on fuzzy theory, it explores the vagueness and imprecision of design descriptions during the conceptual phase of products. Utilizing the TRIZ innovation design method, it analyzes discrepancies in opinions among experts from various domains concerning optimal design solutions, highlighting inconsistencies in the generation of these solutions. Grounded in error theory, it examines the discrepancies between predicted performance parameters and actual measured values obtained through testing, reflecting the designer's confidence in factual estimations and areas for design enhancement. By leveraging interactive design methods, it investigates various alternative schemes and the design instability encountered during conceptual design iterations. Incorporating the element of perceived design uncertainty, it develops a cognitive decision-making model for the conceptual design of product families.

3.1.2 Iterative cognitive generation model for product function–behavior–structure design based on the crowdsourcing design environment

Given that the scenario design for product function–behavior–structure is inherently characterized by significant external interactions, the process of clarifying design objectives involves ongoing engagement with the design environment. By identifying, determining, converging, and explicitly articulating the variable parameters of the crowdsourcing design environment, this study refines the inputs

and outputs of environmental variables in relation to the design objectives. This iterative process not only clarifies these objectives progressively but also facilitates iterative cognitive generation for product family conceptual design. Beginning with a design problem or a crowdsourcing requirement, a Bayesian belief network is employed to describe the design environment, exploring the design problem-solving space through a design cognition generation model grounded in designers' experiences. The main characteristics of designer experience encompass the structure of the design problem, the convergence conditions of the design iteration optimization process, the quantification of performance indicators for design solutions, and the interaction with design resources. Designers' affective and cognitive states are mainly influenced by changes within the design environment. By validating the authenticity and integrity of multisource heterogeneous data within the design context, this approach bridges the uncertainties and gaps between the design cognition generation model and personalized customization, thereby guiding design information processing activities. The extraction, structured representation, and construction of a knowledge base from designer experiential knowledge underpin the evolution of the design problem-solving space.

3.1.3 Mechanism of coupling between design perception and cognition in CPD

Problem-solving in CPD necessitates the deconstruction of distributed design elements through symbolic representation, ultimately leading to the emergent synthesis and reconstruction of innovative solutions within the constraints of design requirements. However, the substantial volume of design data, which originates from diverse and heterogeneous sources, results in gaps or uncertainties in design knowledge. This can hinder designers' comprehensive understanding of specifications and objectives. Therefore, there is a pressing need for methodologies that can effectively extract design information and simplify the mapping relationship between product features and the design environment. This study effectively utilizes a Bayesian belief network to model the design problem-solving space, examining the dynamics of the coupling between design perception and cognition in conceptualizing product families on crowdsourcing platforms (see **Figure 3**). Key components of this approach include: (1) utilizing Bayesian belief network modeling for qualitative analyses of design decision variables, constraints, and performance; (2) employing Bayesian belief network modeling for quantitative assessments of the correlation between confidence in design perception and cognitive generation mechanisms; (3) conducting result analyses concerning confidence levels in crowdsourcing design solutions; and finally, (4) developing a designer experience computing model to generate a designer experience knowledge graph. This model effectively addresses the data-driven requirements of CPD, managing complex relationships and uncertainties among entities within the knowledge graph, while enhancing the accuracy of design decision-making through probabilistic reasoning.

3.2 Theoretical framework of the intelligent design environment for crowdsourced products

The intelligent design environment for crowdsourced products is constructed upon the mechanism of experiential influence exerted by distributed intelligent

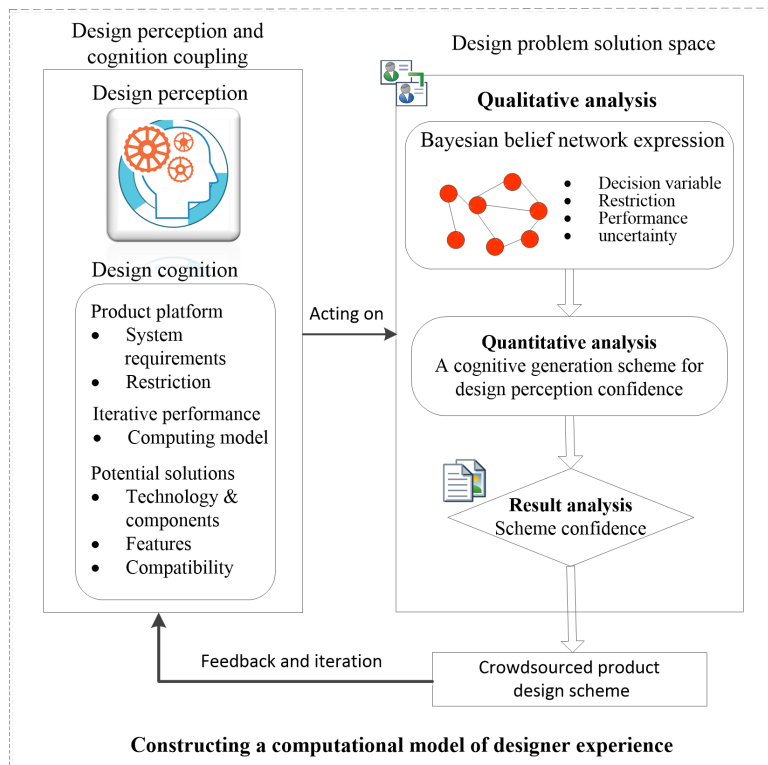


Figure 3.
Mechanism of coupling between design perception and cognition.

design agents, conceptualizing crowdsourcing as an extension of human cognitive capabilities that complements AI in digital collaboration. Focusing on the development of design concepts, this framework emphasizes the variability and propagation of design uncertainty perception as key elements, leveraging the diverse experiences of the crowd to facilitate continuous feedback and enhancement in CPD.

First, there is an inherent semantic gap between CPD and the experiences of designers, as they belong to distinct cognitive domains. In interactive human-machine design, designers engage in the continuous transformation, experiencing, and interpretation of extensive datasets related to personalized customization. This process fosters the accumulation of cognition and understanding pertaining to conceptual design. To bridge the gap, it is essential to extract semantic entities and associations from CPDs, further investigate their mapping relationships to experiential semantics, and elucidate the coupling mechanisms of distributed cognition. As a result, addressing personalized customization needs necessitates the application of distributed cognitive coupling and evaluation between CPD and designers' experiences, culminating in the construction of experiential semantic mappings among DCC.

Second, for the intelligent design of crowdsourced products to effectively fulfill personalized customization needs, it must be recognized and experienced by designers and stakeholders before it can be meaningfully articulated and translated into human-machine interactive dialog corpora that align with users' conversational

expectations. Dialog serves not only as a form of experience but also as a process for exchanging and constructing experiences. By uncovering and integrating the semantics of design experiences within CPD data and interactive design processes, the intelligent design of crowdsourced products could enable the learning, discovery, and dissemination of experiences shaped by DCC. This approach aims to render the human–machine interactive design process more engaging, semantically enriched, and adept at optimizing and customizing products. Therefore, a thorough examination and discovery of experiential semantics within the data of crowdsourced product platforms is imperative to elucidate the dynamics of learning, discovery, and propagation of designers’ experiences driven by DCC.

3.2.1 Iterative evaluation theory of product family conceptual design based on the designers’ experience

For CPD initiatives, the exploration of associations within distributed cognitive coupling evaluations for design iterations remains inadequate, impacting both the semantic expressiveness of conceptual design and the precision of customized products. Building upon the designers’ experience computing model, this research integrates distributed cognitive coupling with multi-task collaborative optimization techniques to achieve distributed cognitive coupling and model refinement between personalized customization and stakeholders. By employing data classification and mining methods grounded in Bayesian belief networks, designers’ experience is continually updated, applied, and assessed iteratively throughout the design process, as illustrated in **Figure 4**.

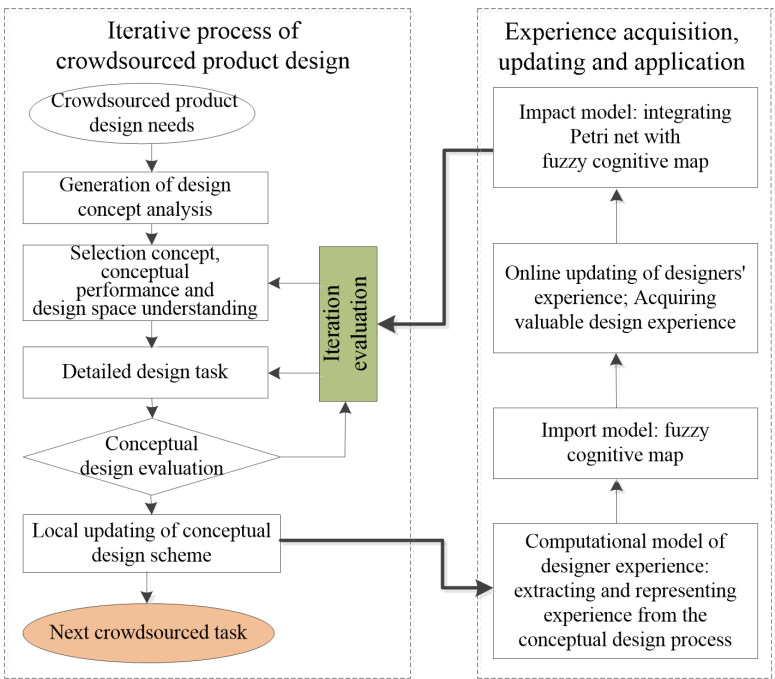


Figure 4.
A designer experience–based theoretical framework for design iteration modeling.

(1) Online updating of designers' experience

First, the product conceptual design process is analyzed based on the needs identified through crowdsourced product development, leading to the establishment of an important model utilizing fuzzy cognitive maps. Given that the designers' experience computing model generates raw experiential data by integrating heterogeneous data from multiple sources, it is essential to address issues of missing, noisy, and redundant data. Moreover, unstructured and semi-structured experiential data must be transformed. Subsequently, a network dynamic data mining algorithm is employed to extract valuable insights from the designers' experience encapsulated within the computing model. This network dynamic data mining is constructed upon the Bayesian belief network framework and incorporates a fuzzy cognitive map classifier to elucidate the update mechanism of designers' experience.

(2) Application of the designers' experience

Next, an influence model is developed by integrating Petri nets with fuzzy cognitive maps. Utilizing the imported experiential data, an inference process is undertaken, enabling CPD to use designers' expertise in evaluating uncertainty perception related to design iteration behavior. This approach captures the causal relationships between design uncertainties and design parameters, thereby providing robust decision support for the product conceptual design process.

(3) Iterative evaluation of the crowdsourcing design

The crowdsourcing design environment serves as a condition-constraining factor during design iterations, encompassing characteristics of uncertainty propagation, often referred to as environmental orientation, which impacts the efficiency of design iterations. This study selects iterative evaluation indicators for crowdsourcing design and establishes a corresponding evaluation function within the design environment. Leveraging design context-aware features, it explores optimized combinations of uncertain design feature variables. Utilizing a constraint network generated from conceptual feature parameters of interconnected components, the study computes multi-attribute values for design context parameters to identify design uncertainties, analyzes interrelations among internal features, and classifies design uncertainties based on constraint knowledge. This constraint knowledge is derived from a design evaluation information base.

Employing the theory and methods of fuzzy reasoning Petri nets (FRPN), the design knowledge base is processed to uncover associations between conceptual design element parameters and perceptions of uncertainty. A decision table addressing conceptual design uncertainty is then established. Utilizing fuzzy production rules, the FRPN-based approach is capable of modeling the perception and cognition of uncertainty in product platform components during the conceptual design of product families, followed by the establishment of a model inference algorithm. The workflow pertaining to design iterations within the product family conceptual design process is examined, and design iteration evaluations are conducted with a focus on design context-aware features, thereby facilitating the optimization of CPD.

3.3 Designer experience learning theory driven by DCC

The primary objective of AI-enabled crowdsourcing design is to cultivate product innovation within a sustainable and socially responsible innovation ecosystem, enhance crowdsourcing design processes, and improve user experience. Assessing uncertainty in the conceptual design phase and developing strategies for conceptual design iteration necessitate a thorough investigation into the mechanisms of designer experience learning, discovery, and propagation within a digital collaborative design environment. This process involves leveraging semantic social networks and multi-agent technology to analyze the influence of designer experience on design problem-solving. Based on conceptual design requirements, cognitive gaps among designers stimulate experiential learning and discovery, and the semantic associations of designer experience are scrutinized for their significant role in exploring and shaping the design space.

The crowdsourcing designer community actively shares design experiences to establish product development workflows that are aligned with user needs, thereby facilitating the simulation of CPD. Given the multi-scale and multi-granularity characteristics of environmental intelligence in intelligent product family design and among stakeholders, current crowdsourcing design methods often fall short in harnessing distributed cognition for stakeholder feedback, design iteration, and optimized design solutions. This highlights the urgent need for research focused on design agent interactions, machine learning informed by designer experience, and mixed unlabeled data learning, as demonstrated in **Figure 5**.

(1) Design agent interaction

In the semantic social network model, agent relationship analysis is mainly conducted based on the exchange of design information and emotional interactions between agents. The message format is defined as $\langle \text{Sender}, \text{Receiver}, \text{Content} \rangle$, and an example of a conversation between designer agents has been demonstrated in **Figure 5**. The designer agents retrieve methods for resolving design conflicts, where the strategy function $\pi_i : S \rightarrow \text{Act}$ represents the action (method) chosen by the agent a_i in a given state S . The utility function $U_i : S \times \text{Act} \rightarrow \mathbb{R}$ signifies the utility of the agent a_i for a specific state (S)–action pair. According to the retrieved utility results, instance methods are evaluated, the effects on designers' perception and cognition are assessed, and it is then decided whether to perform interactive learning and extract design knowledge.

(2) Designer experience–based machine learning

In **Figure 5**, experiential semantic links within the design environment yield a wealth of data. Nonetheless, the varied sources of design information for analyzing semantic link data do not ensure convergence in emotion recognition. Supervised learning techniques, such as neural networks and similarity models, perform machine learning tasks by deriving functions from labeled training feature sets. Designers sharing similar interests are mainly inclined to concentrate on analogous design topics and may exchange messages through the semantic social network. Thus, the alignment in interest perception between two adjacent designers serves as a metric for the potential of experiential learning when they encounter specific information.

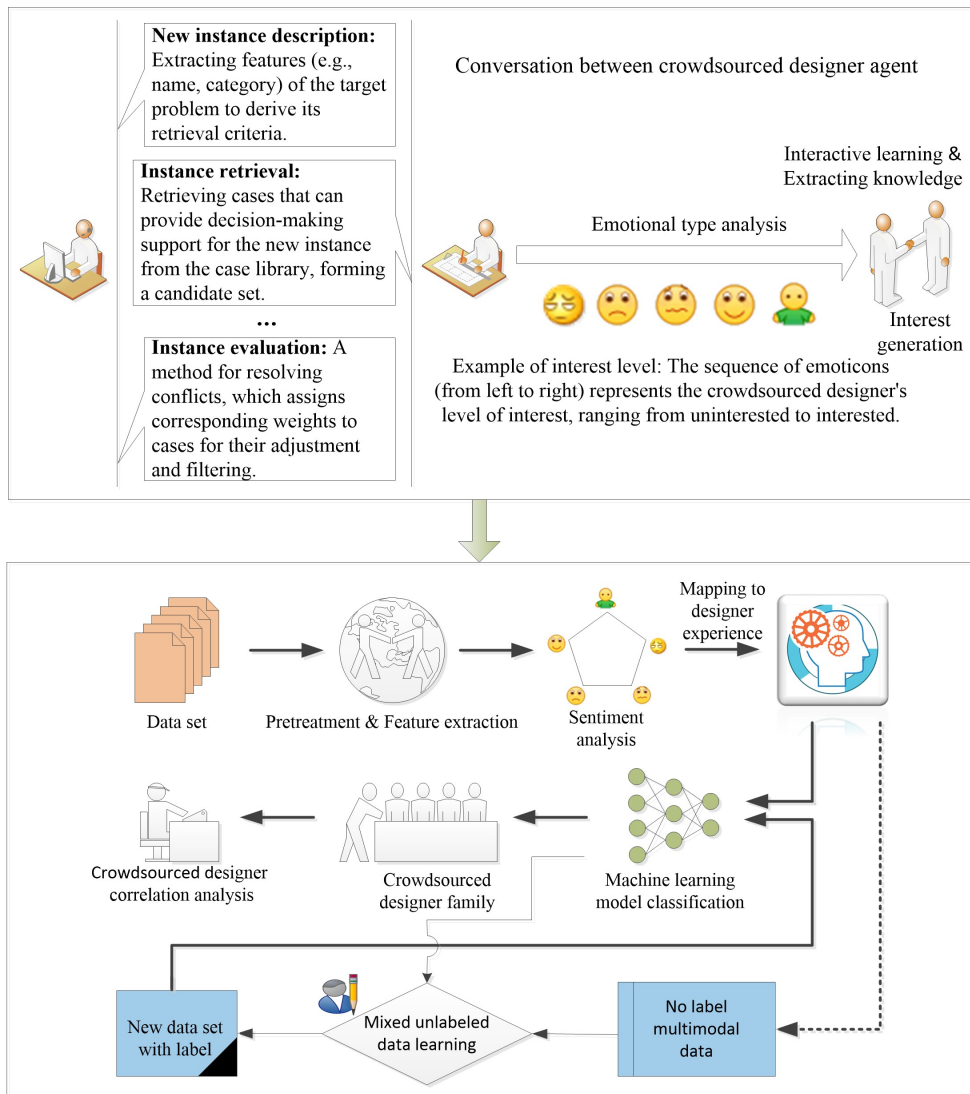


Figure 5.
A designer experience-based learning framework.

(3) Designer experience-based mixed unlabeled data learning

On the surface, the concept of designer experience interest learning seems to be constituted by experiential semantic links; however, it fundamentally represents a process of the coupled evolution of design parameters. Merely retrieving emotional similarities from the viewpoint of conceptual design feature values within a product family diminishes the efficacy of the acquired experiential learning. To address the challenge of unlabeled emotional data, an entropy-based model (mixed unlabeled data learning) is implemented on top of the similarity model. In the realm of information theory and probabilistic statistics, entropy serves to quantify the uncertainty associated with a random variable. This mixed model is employed to label previously

unlabeled data, which is subsequently incorporated into the original labeled dataset. This approach better aligns with the cognitive reality of designer experience during the actual process of product innovation and development.

3.4 Designer experience discovery theory driven by DCC

The social network formed by designer experience through semantic links constitutes a complex system that integrates cognition related to designer experience with network topology. In semantic social networks, the acquisition of design experience establishes robust connections between designers and their design environments. However, relying solely on stable experience–semantic learning links does not adequately address personalized user requirements. Utilizing probabilistic models, designer experience–semantic community discovery identifies novel experience–semantic relationships primarily by detecting communities within the experience–semantic network that exhibit specific relational characteristics to align with learning interests. The theoretical framework for designer experience community discovery is illustrated in **Figure 6**.

(1) Designer experience–based discovery model

In **Figure 6**, users with similar demand information within the experience semantics are treated as the basic community structure. Concepts that exhibit experience–semantic associations with conceptual design are identified to expand designers’ experience. By performing a comprehensive analysis of the correlations between product design and manufacturing component modules, coupled with their experience–semantic relationships and the application of unsupervised clustering algorithms (e.g., K-means), communities characterized by high semantic–emotional similarity and strong structural connections are derived. The perception of social trust, informed by designer experience, plays a pivotal role in propelling product

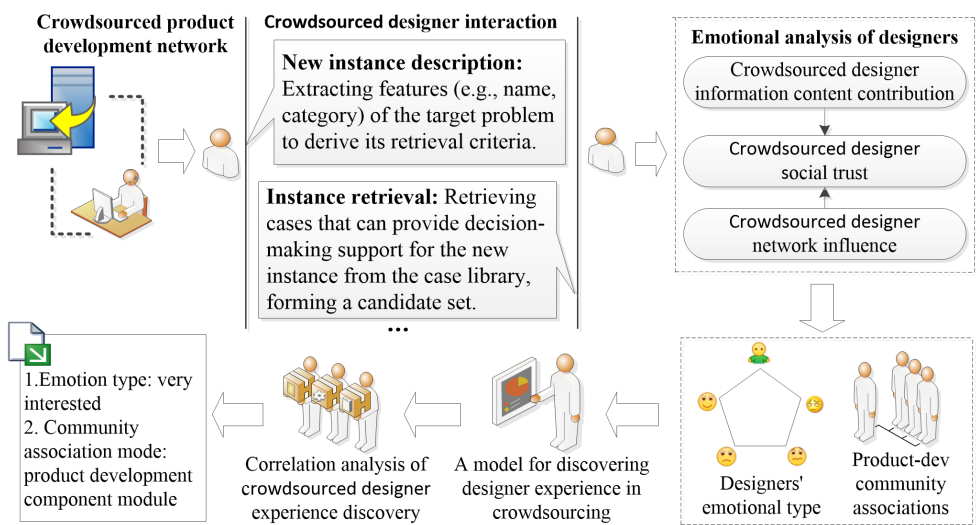


Figure 6.
A designer experience-based discovery framework.

innovation and development. The coupling value of a designer's network influence, alongside their contribution to informational content, serves as an indicator for assessing social trust. This contribution of informational content is derived through statistical data analysis of social connection strength, which primarily encompasses the frequency, quantity, and feed-back count of design experience content disseminated by the crowdsourcing designer community within a specified timeframe.

(2) Design environment–based game-theoretic regulation of designer experience

Aiming for the cross-integration of design experience, this process effectively locates the reorganization of product functional, behavioral, and structural information. This reorganization represents a strategic selection process within the crowdsourcing designer community. By examining the game-theoretic motivations for the propagation of designer experience, we can enhance the diversity of design experience and prevent overly narrow optimization within the design space. The dynamics of designer experience propagation are articulated through a shared mechanism characterized by various forms of information dissemination, including publishing, sharing, reposting, and endorsement. The Nash equilibrium, also referred to as the non-cooperative game equilibrium, is employed to construct a motivational model for participants engaged in the designer experience propagation process. The behavioral motivations of the crowdsourcing designer community are analyzed at any point within the product development network, represented as a function of interest, social trust connections, and design performance preferences. By integrating the game-theoretic motivation model with the designer experience propagation process model, designers can select the most advantageous results from their candidate propagation nodes as the subsequent recipients of the information.

(3) Designer experience–based adaptive analysis of the product platform

By configuring specific design environment variables, encompassing parameters related to user requirements and enterprise product development capabilities, and leveraging the dynamics associated with designer experience propagation, the conceptual design process for the product family can be effectively simulated. This approach facilitates the development of a CPD methodology founded on the evolution of designer experience. In alignment with user-driven design change requirements, an investigation is conducted into the depth and breadth of designer experience–evolution information dissemination within the crowdsourcing product development network. A model supporting the dissemination of product conceptual design information, grounded in designer experience evolution, is formulated alongside relevant evaluation indicators to assess the adaptability of the crowdsourcing product development system.

By thoroughly considering the probability of change propagation among design nodes within the crowdsourcing product development network and the extent of rework implications, a designer experience information dissemination model is established. This model factors in elements of opportunity, trust, design performance preferences, and motivation. Under design constraint conditions and with the objective of maximizing benefits, evolutionary game theory is applied as the basis for designers' decision-making processes concerning information dissemination. Adjusting design environment variables

facilitates the analysis of pertinent performance indicators for the product platform, including product adaptability, the adaptability of comprehensive product lifecycle data and knowledge, the adaptability of design solution methodologies, and the adaptability of the design process itself. Through the examination of the adaptability of the crowdsourcing product platform, the collaborative evolution patterns between designer experience and the conceptual design system of the product family are elucidated.

4. Appendices and nomenclature: Application verification

4.1 Experimental approach

To explore the influence mechanism of designer experience and the co-evolution dynamics that underpin product family conceptual design in response to mutable operating conditions, driven by distributed cognition, it is imperative to conduct experimental assessments of pertinent characteristic parameters. This can be achieved by integrating the perceptual and cognitive dimensions of design subjects (i.e., designer experience). The essential components of the human–machine interaction experiment are illustrated in **Figure 7**. The primary focus of the experiment centers on the relationship between the dependent variable (i.e., product function–behavior–structure parameters) and the independent variable (i.e., crowdsourcing design requirements) as informed by designer experience. Focusing on the design feature attributes throughout the product lifecycle and utilizing a design uncertainty prototype (design state) derived from multisource heterogeneous data within the design environment, an initial parse prototype of design perception (pp0) is developed in response to the personalized

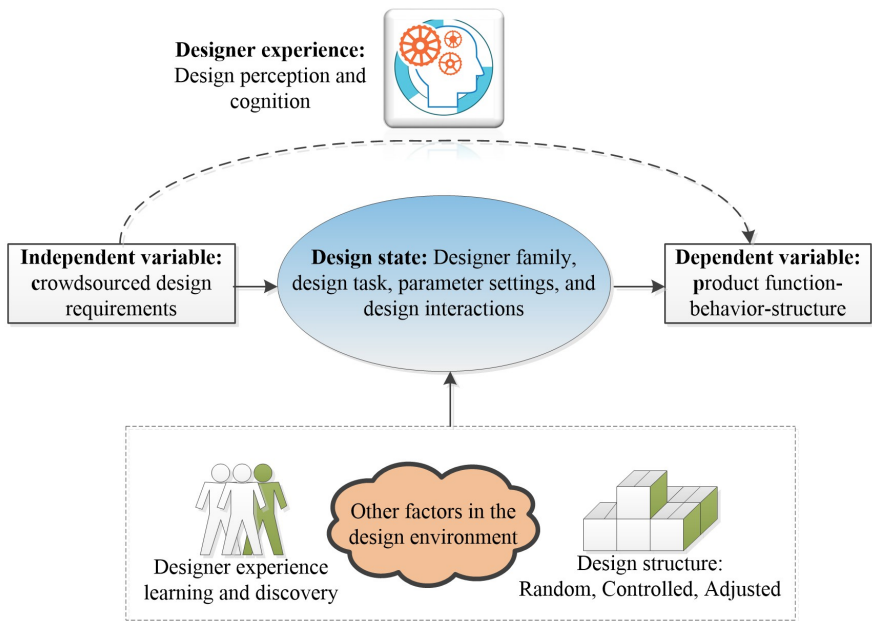


Figure 7.
Key components of the human–machine interactions experiment.

crowdsourcing design requirements articulated by users. Following this, the designer engages in a structured process, progressively translating user needs into specifications for product function–behavior–structure requirements, establishing a well-defined design problem, and generating a subsequent parse prototype of design cognition (pp1). The interplay and mapping between the design uncertainty prototype (design state), perception parse prototype (pp0), and cognition parse prototype (pp1) culminate in the formation of a designer experience computing model. In this context of an uncertain and dynamic design environment throughout the product lifecycle, the design representation is refined through the learning and discovery processes inherent to designer experience, encompassing product function–behavior–structure information. Through iterative design and structural control analysis, a hierarchical model for product family conceptual design representation is established to effectively address the needs arising from crowdsourced product development.

Based on the theoretical model of key components in human–machine interaction experiments, the selection of the intelligent tool holder product family design for a CNC machine tool composite machining center in Jiangxi serves as a representative application. The automatic control system of the CNC composite machining center entails mechatronic design and is fundamental in regulating the movement of mechanical execution components. The intelligent tool holder acts as a key component within this automatic control ecosystem. Given that the tool directly interacts with the workpiece, it is susceptible to vibrations that can adversely affect the surface quality of the machining process. Therefore, various sensors, including temperature and force/torque sensors, are integrated into the tool holder. These sensors are interconnected with a microprocessor, enabling functionalities such as tool wear monitoring, vibration detection, and fracture alarms.

Current methodologies for collecting tool-tip response data typically involve sensor placements on the workpiece material or the machine spindle, which are distanced from the cutting location. However, due to the intricacies of the end-cutting system, the transmission of vibration between the tool tip and the stationary sensors introduces noise, thereby complicating the analysis of tool-tip dynamic response and diminishing the accuracy of finely detailed phenomena. To fully elucidate dynamic end-cutting issues such as tool chatter, wear, and failure, it is essential to observe the tool-tip response characteristics directly during the cutting process. Integrated sensors are employed to facilitate precise perception of the primary cutting forces. By analyzing the signals of these forces and implementing compensation measures, cutting thickness can be accurately assessed. This approach allows for dynamic monitoring of the tool cutting state, thus ensuring the machining quality and reliability of the CNC composite machining center equipped with the intelligent tool holder.

In light of this engineering context, and commencing with an analysis of the functional components and characteristics of the intelligent tool holder, combined with relevant design standards and specifications for CNC machine tool design, this study investigates how the interplay between design perception and cognition influences the product family design of the intelligent tool holder for the CNC composite machining center under personalized user requirements. Furthermore, it seeks methodologies for the co-evolution of designer experience and product family conceptual design.

- (1) Relevant characteristic parameters pertaining to design perception and cognition in the intelligent tool holder product family design are collected and validated through on-machine experiments conducted on the CNC product

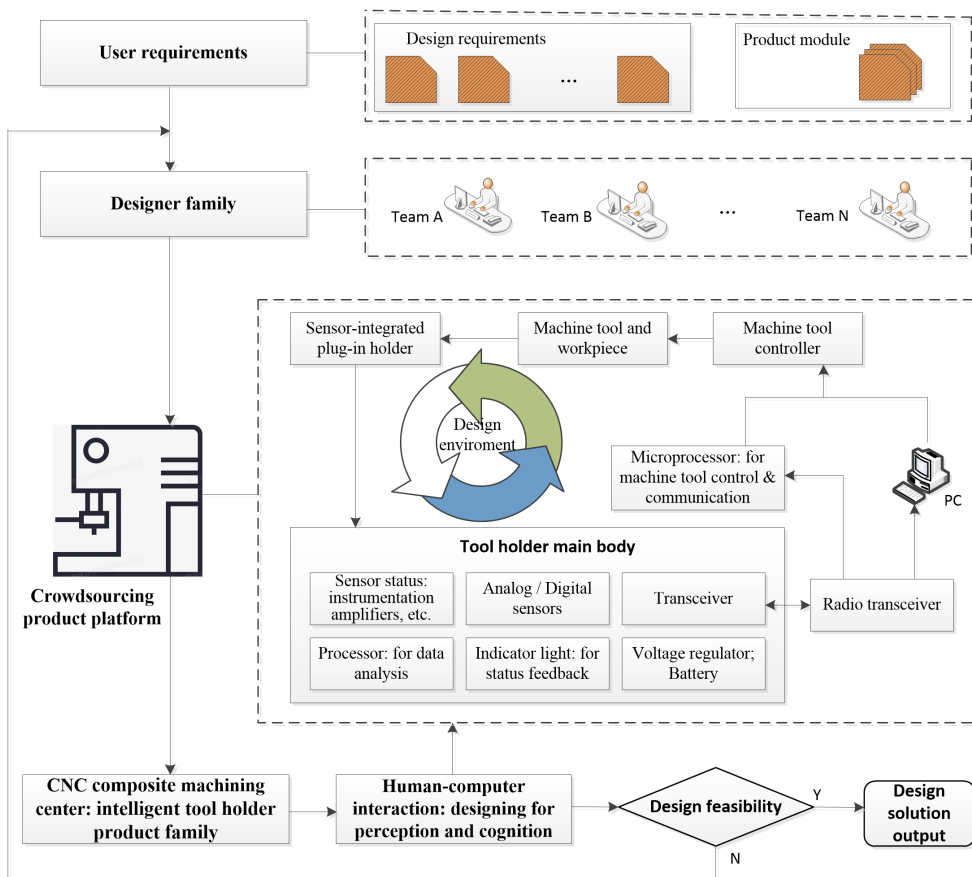


Figure 8.
An experimental planning scheme for CNC composite machining center–intelligent tool holder product family design.

platform. The experimental planning scheme for the CNC composite machining center–intelligent tool holder product family design is depicted in **Figure 8**. It primarily encompasses user requirements, the crowdsourced designer family, the crowdsourced product platform (machine controller, machine tool, workpiece, sensor-integrated tool holder, tool holder body, wireless receiver/transmitter, microprocessor, and PC), human–machine interaction (design perception and cognition), iterative design solutions, and output.

- (2) Experiments are conducted to examine the impact of design environment variables on the function–behavior–structure parameters of the intelligent tool holder. Additionally, the influence of design perception–cognition coupling on design iteration and the regulation of collaborative evolution of the intelligent tool holder product family, based on designer experience, are investigated. Data concerning the development of the intelligent tool holder product family are collected and analyzed using consistent processes, workpieces, and machining programs. Considering the parameters associated with machining conditions, iterative optimization calculations for the intelligent tool holder product family design are performed based on the

updated product family design iteration model, which integrates perception and cognition. Complementing this, human-machine interaction experiments are conducted to gather data on design situational perception, design intent, and machining errors induced by the intelligent tool holder. A multi-objective, multi-parameter design iteration evaluation program is employed to assess the iterative performance of the intelligent tool holder design. The optimization of parameters within the designer experience computing model, influence model, and other analytical frameworks – alongside dynamics analysis parameters related to machine structure, control, sensors, and human-machine interaction design – is carried out. The machining error parameters caused by the intelligent tool holder are measured and compared with those from alternative product family design schemes to validate the collaborative evolution mechanism of the designer experience-based conceptual design system for the intelligent tool holder product family.

- (3) Utilizing the designer experience computing model, import model, influence model, propagation dynamics model, and adaptive analysis within the product family conceptual design system, a prototype system is constructed for the evolution of product family conceptual design grounded in designer experience. The modular design of the intelligent tool holder effectively leverages the designer experience evolution model to balance corresponding design objectives, thereby influencing the innovative design of the CNC composite machining center model. These results can facilitate the analysis of machining strategies, cutting parameters, and product model selection, ultimately shaping the innovation design evolution strategy for the CNC composite machining center-intelligent tool holder product family.

4.2 Discussion

A distributed cognition-driven intelligent design theory and methodology for crowdsourced products is proposed. This approach, when combined with case-based model construction and validation procedures, is compared to existing intelligent design methodologies, incorporating three key techniques based on the analytical framework presented in the third section: (1) A product family conceptual design iteration model is constructed based on the design environment, integrating perception and cognition; this model serves as the theoretical basis for multi-objective evaluation and strategic regulation in personalized customization. (2) A multi-parameter and multi-objective comprehensive evaluation function for product family conceptual design iteration is established by integrating design context feature parameter identification rooted in designer experience. This function is crucial for translating the influence of designer experience on the evolution of product family conceptual design into practical applications, significantly enhancing the quality and efficiency of product platform design. (3) An adaptive analysis of the crowdsourcing product platform is conducted, utilizing multisource heterogeneous data from product development networks and focusing on the evolution of designer experience. The platform dynamically perceives variations in the design environment and product performance, facilitating the construction of an adaptive product family conceptual design system characterized by autonomous perception, intelligent decision-making, and efficient execution.

Methodological limitations: Within the realm of multi-agent modeling of the design environment, employing Bayesian networks to depict the design behavior of crowdsourcing individuals enhances the representation of uncertainty and causal reasoning. However, at the micro-level of individual cognition in intelligent design for crowdsourced products, while Bayesian networks effectively convey probabilistic cognitive updating of agents, accurately constructing network topologies and conditional probability tables significantly relies on experiential knowledge and faces challenges in capturing implicit processes, such as creative generation dynamically. At the macro-scalability level, multi-layer Bayesian networks introduce multisource heterogeneous data and leverage designer experience to elucidate relationships in design change propagation across groups or levels, thereby increasing model complexity and necessitating commensurate computational resources to support intelligent design in crowdsourced product groups. Furthermore, the integration of multimodal physiological and behavioral design data, encompassing dimensions such as designers' emotions, cognitions, and motivations, remains a significant limitation and challenge in achieving intelligence within distributed cognition-driven crowdsourcing design environments.

5. Conclusions

Intelligent design of crowdsourced products represents an emerging paradigm that integrates collective knowledge, machine intelligence, and distributed collaboration. This approach is increasingly becoming a frontier in digital innovation, significantly enhancing both the efficiency and creativity of crowdsourced product development. To further advance the study of theories and methods pertinent to the intelligent design of crowdsourced products, driven by DCC, this chapter identifies the limitations inherent in conventional crowdsourcing design theories and methods, particularly within the context of digital collaborative innovation. It proposes a comprehensive framework encompassing the connotations and characteristics of a distributed cognition–driven approach, while also addressing the accompanying challenges.

From dual perspectives – namely, the experience-influence mechanism of the distributed cognition–driven design agent and the dynamics of crowdsourcing-based digital collaboration – this work explores and constructs innovative theories and methods for the intelligent design of crowdsourced products. Application validation is conducted through a pilot case study involving an intelligent tool-holder prototype system tailored for a crowdsourced product platform, utilizing a CNC machining center. This study discusses the pivotal technologies that harness DCC to propel the intelligent design of crowdsourced products.

The findings present a novel perspective on distributed co-creative design iteration within human–machine–environment systems, thus expanding existing theories and methodologies surrounding CPD while laying a technical foundation for personalized customization. Furthermore, this research addresses the complexities of change propagation amid perceived design uncertainty, emphasizing that designer experience – comprising emotion, cognition, and motivation – necessitates the integration of multimodal physiological and behavioral data. This convergence represents a significant hurdle in achieving enhanced intelligence within crowdsourced design environments.

As an exploratory study, the theories and methods articulated herein provide fresh insights into crowdsourcing design, albeit with the recognition that further refinement and elaboration are requisite. The primary directions for future research are threefold. First, the research will examine the influence mechanisms of distributed intelligent design agents (i.e., designer experience), with the aim of alleviating the compounded uncertainties and computational complexities associated with multiple design elements, thereby facilitating a natural semantic grouping and representation of distributed experiences. Second, it will seek to integrate the asymmetric cognition characteristic of product family design and stakeholder-distributed autonomy, interpreting the principles of distributed cognitive coupling and mapping, and undertaking coupled design evaluations while preserving cognitive characteristics and ensuring effective design iteration performance. Third, a framework for the intelligent design of product families – driven by DCC – will be established. This framework will capitalize on context-aware distributed cognitive optimization to analyze design expression and perception, resulting in the construction of a model adept at adaptive environmental intelligence, semantic mining, and application.

It is anticipated that this work will offer valuable insights into the development of distributed cognition-driven theories of intelligent design for crowdsourced products, thereby fostering the generation of original results in future research endeavors focused on crowdsourced digital collaborative innovation within this interdisciplinary field. This study exemplifies an innovative pathway toward scalable personalized customization by establishing a distributed cognitive framework for crowdsourced product development that integrates human–AI hybrid intelligence.

Acknowledgments

The authors would like to express their gratitude to EditSprings (<https://www.editsprings.com>) for the expert linguistic services provided. This work was supported by the National Natural Science Foundation of China [grant number 51465020] and the Jiangxi Provincial Key Laboratory of Modern Agricultural Equipment [grant number 20242BCC32127].

Author details

Yuming Guo
School of Mechanical and Electrical Engineering, Jinggangshan University, Ji'an, China

*Address all correspondence to: gyuming_scut@126.com

IntechOpen

© 2025 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Ghezzi A, Gabelloni D, Martini A, Natalicchio A. Crowdsourcing: A review and suggestions for future research. *International Journal of Management Reviews*. 2018;**20**(2):343–363. DOI: 10.1111/ijmr.12135
- [2] Jiao Y, Wu Y, Lu S. The role of crowdsourcing in product design: The moderating effect of user expertise and network connectivity. *Technology in Society*. 2021;**64**:101496. DOI: 10.1016/j.techsoc.2020.101496
- [3] Queiroz MM, de Sousa Jabbour ABL, Bagherzadeh MC-EAI. Unlocking value in digital services. *International Journal of Production Economics*. 2025;**283**:109586. DOI: 10.1016/j.ijpe.2025.109586
- [4] Durward D, Blohm I, Leimeister JM. The nature of crowd work and its effects on individuals' work perception. *Journal of Management Information Systems*. 2020;**37**(1):66–95. DOI: 10.1080/07421222.2019.1705506
- [5] Freisinger E, Unfried M, Schneider S. The AI-augmented crowd: How human crowdvoters adopt AI (or not). *Journal of Product Innovation Management*. 2024;**41**(4):865–889. DOI: 10.1111/jpim.12708
- [6] Bell JJ, Pescher C, Tellis GJ, Füller J. Can AI help in ideation? A theory-based model for idea screening in crowdsourcing contests. *Marketing Science*. 2024;**43**(1):54–72. DOI: 10.1287/mksc.2023.1434
- [7] Kittur A, V NJ, Bernstein M, et al. The future of crowd work. In: *Proceedings of the 2013 conference on Computer supported cooperative work* (CSCW '13); [Accessed: 23-27 February 2013]; San Antonio Texas USA: Association for Computing Machinery, New York, NY, United States; 2013. p. 1301–1318
- [8] Zhu JJ, Li SY, Andrews M. Ideator expertise and cocreator inputs in crowdsourcing-based new product development. *Journal of Product Innovation Management*. 2017;**34**(5):598–616. DOI: 10.1111/jpim.12400
- [9] Zahay D, Hajli N, Sihi D. Managerial perspectives on crowdsourcing in the new product development process. *Industrial Marketing Management*. 2018;**71**:41–53. DOI: 10.1016/j.indmarman.2017.11.002
- [10] Cricelli L, Grimaldi M, Vermicelli S. Crowdsourcing and open innovation: A systematic literature review, an integrated framework and a research agenda. *Review of Managerial Science*. 2022;**16**(5):1269–1310. DOI: 10.1007/s11846-021-00482-9
- [11] Allen BJ, Chandrasekaran D, Basuroy S. Design crowdsourcing: The impact on new product performance of sourcing design solutions from the “crowd”. *Journal of Marketing*. 2018;**82**(2):106–123. DOI: 10.1509/jm.150481
- [12] Fu ZL, Guo W, Wang L, Ma J, Shi LW, Lin M. Ecological network evolution analysis in collective intelligence design ecosystem. *Advanced Engineering Informatics*. 2023;**58**:102150. DOI: 10.1016/j.aei.2023.102150
- [13] Guo Y. Optimization of privacy-aware cloud crowdsourcing resource combinations for product

development. *Expert Systems with Applications*. 2023;227:120176. DOI: 10.1016/j.eswa.2023.120176

[14] Kotseruba I, Tsotsos JK. 40 years of cognitive architectures: Core cognitive abilities and practical applications. *Artificial Intelligence Review*. 2020; 53(1):17–94. DOI: 10.1007/s10462-018-9646-y

[15] Jiang J, J KA, K CC, et al. A situation awareness perspective on human-AI interaction: Tensions and opportunities. *International Journal of Human–Computer Interaction*. 2023;39(9):1789–1806. DOI: 10.1080/10447318.2022.2093863

[16] Smith ER, Collins EC. Contextualizing person perception: Distributed social cognition. *Psychological Review*. 2009;116(2):343. DOI: 10.1037/a0015072

[17] Lyu M, Li X, Chen CH. Achieving Knowledge-as-a-Service in IIoT-driven smart manufacturing: A crowdsourcing-based continuous enrichment method for Industrial Knowledge Graph. *Advanced Engineering Informatics*. 2022;51:101494. DOI: 10.1016/j.aei.2021.101494

[18] T CS, Cornelius PB, Gokpinar B, Körpeoğlu E, Tang CS. Product development in crowdfunding: Theoretical and empirical analysis. *Manufacturing and Service Operations Management*. 2024;26(2):701–721. DOI: 10.1287/msom.2022.0344

[19] Niu XJ, Qin SF, Vines J, Wong R, Lu H. Key crowdsourcing technologies for product design and development. *International Journal of Automation and Computing*. 2019;16(1):1–15. DOI: 10.1007/s11633-018-1138-7

[20] Feng Y, Zhao Y, Zheng H, et al. Data-driven product design toward intelligent manufacturing: A review. *International Journal of Advanced Robotic Systems*. 2020;17(2):172988142091125. DOI: 10.1177/1729881420911257

[21] H LKY, Zheng P, H CC, et al. A digital twin-enhanced system for engineering product family design and optimization. *Journal of Manufacturing Systems*. 2020;57(10):82–93. DOI: 10.1016/j.jmsy.2020.08.011

[22] P TY, H WC, Y LK, et al. Unlocking the power of big data analytics in new product development: An intelligent product design framework in the furniture industry. *Journal of Manufacturing Systems*. 2022;62:777–791

[23] Song B, Luo J, Wood K. Data-driven platform design: Patent data and function network analysis. *Journal of Mechanical Design*. 2019;141(2):021101,10. DOI: 10.1115/1.4042083

[24] Song M, Gong X, J JR, et al. A blockchain-enabled information as a service (IaaS) system for crowdsourced manufacturing: A crowdsourcing case study of tank trailer manufacturing. *Journal of Industrial Information Integration*. 2025;45:100844

[25] O DH, H GM, Li X, et al. Human-centered generative design framework: An early design framework to support concept creation and evaluation. *International Journal of Human–Computer Interaction*. 2024;40(4):933–944. DOI: 10.1080/10447318.2023.2171489

[26] Raina A, Cagan J, McComb C. Design strategy network: A deep hierarchical framework to represent

- generative design strategies in complex action spaces. *Journal of Mechanical Design*. 2022;**144**(2):021404. DOI: 10.1115/1.4052566
- [27] Wang Z, Zheng P, Li X, et al. Implications of data-driven product design: From information age towards intelligence age. *Advanced Engineering Informatics*. 2022;**54**:101793
- [28] Li X, H CC, Zheng P, et al. A knowledge graph-aided concept–knowledge approach for evolutionary smart product–service system development[J]. *Journal of Mechanical Design*. 2020;**142**(10):101403. DOI: 10.1115/1.4046807
- [29] Hong Y, Li W, Li C, et al. Adaptive knowledge push method of product intelligent design based on feature transfer. *Advanced Engineering Informatics*. 2024;**59**:102260
- [30] Fiorineschi L, S FF, Rotini F, et al. Exploiting TRIZ Tools for enhancing systematic conceptual design activities. *Journal of Engineering Design*. 2018;**29**(6):259–290. DOI: 10.1080/09544828.2018.1473558
- [31] Zhang H, Chen P, Xie X, et al. A hybrid prototype method combining physical models and generative artificial intelligence to support creativity in conceptual design. *ACM Transactions on Computer-Human Interaction*. 2024;**31**(5):1–34. DOI: 10.1145/3689433
- [32] Bayrak AE, Sha Z. Integrating sequence learning and game theory to predict design decisions under competition. *Journal of Mechanical Design*. 2021;**143**(5):051401. DOI: 10.1115/1.4048222
- [33] Guo X, Liu Y, Zhao W, et al. Supporting resilient conceptual design using functional decomposition and conflict resolution. *Advanced Engineering Informatics*. 2021;**48**:101262
- [34] Singh V, Willcox KE. Decision-making under uncertainty for a digital thread-enabled design process. *Journal of Mechanical Design*. 2021;**143**(9):091707. DOI: 10.1115/1.4050108
- [35] Wang T, Wang J, Jin G, et al. Product platform configuration decision in NPD with uncertain demands and module options. *International Journal of Production Research*. 2023;**61**(19):6336–6355. DOI: 10.1080/00207543.2022.2127962
- [36] Gong Q, Wu J, Jiang Z, et al. An integrated design method for remanufacturing scheme considering carbon emission and customer demands. *Journal of Cleaner Production*. 2024;**476**:143681
- [37] Wang K, Tan R, Peng Q, et al. A systematic problem analysis network for product conceptual design. *Computers and Industrial Engineering*. 2024;**194**:110382
- [38] Cong J, Zheng P, Bian Y, et al. A machine learning-based iterative design approach to automate user satisfaction degree prediction in smart product-service system. *Computers and Industrial Engineering*. 2022;**165**:107939
- [39] Wang J, Xu C, Zhang J, et al. Big data analytics for intelligent manufacturing systems: A review. *Journal of Manufacturing Systems*. 2022;**62**:738–752
- [40] Liedtka J. Perspective: Linking design thinking with innovation outcomes through cognitive bias reduction. *Journal of Product*

Innovation Management. 2015;**32**(6):925–938. DOI: 10.1111/jpim.12163

[41] Micheli P, S WSJ, H BS, et al. Doing design thinking: Conceptual review, synthesis, and research agenda. *Journal of Product Innovation Management*. 2019;**36**(2):124–148. DOI: 10.1111/jpim.12466

[42] Brown T. Design thinking[J]. *Harvard Business Review*. 2008;**86**(6):84–92

[43] Simaei A, Hirschheim R, Schneider H. Idea crowdsourcing platforms for new product development: A study of idea quality and the number of submitted ideas. *Decision Support Systems*. 2023;**175**:114041. DOI: 10.1016/j.dss.2023.114041

[44] Mount M, Round H, Pitsis TS. Design thinking inspired crowdsourcing: Toward a generative model of complex problem solving. *California Management Review*. 2020;**62**(3):103–120. DOI: 10.1177/0008125620918626

[45] Cheng X, Fu S, De Vreede T, et al. Idea convergence quality in open innovation crowdsourcing: A cognitive load perspective. *Journal of Management Information Systems*. 2020;**37**(2):349–376. DOI: 10.1080/07421222.2020.1759344

[46] Chen B, Althuizen N. The effects of exposure to others' ideas and their ratings on online crowdsourcing platforms on the quantity and novelty of subsequently generated ideas. *Journal of Product Innovation Management*. 2022;**39**(5):643–661. DOI: 10.1111/jpim.12621

[47] Chen L, Wang M, Cui L, et al. Experience base, strategy-by-doing and

new product performance. *Strategic Management Journal*. 2021;**42**(7):1379–1398. DOI: 10.1002/smj.3262

[48] Pedersen S. Staging negotiation spaces: A co-design framework. *Design Studies*. 2020;**68**(5):58–81. DOI: 10.1016/j.destud.2020.02.002

[49] Rodríguez-Calero I, R DS, Burleson G, et al. Prototyping strategies to engage stakeholders during early stages of design: A study across three design domains. *Journal of Mechanical Design*. 2023;**145**(4):041413. DOI: 10.1115/1.4056815

[50] Vasconcelos L, Zahn J, Trevisan D, et al. Engagement by design cards: A tool to involve designers and non-experts in the design of crowdsourcing initiatives. *International Journal of Human-Computer Studies*. 2024;**182**:103166

[51] Ji Y, Jiang Z, Li X, et al. A multitask context-aware approach for design lesson-learned knowledge recommendation in collaborative product design. *Journal of Intelligent Manufacturing*. 2023;**34**(4):1615–1637. DOI: 10.1007/s10845-021-01889-7

[52] Das M, Yang MC. Assessing early stage design sketches and reflections on prototyping. *Journal of Mechanical Design*. 2022;**144**(4):041403. DOI: 10.1115/1.4053463

[53] Shafiee S, Haug A, Shafiee Kristensen S, et al. Application of design thinking to product-configuration projects. *Journal of Manufacturing Technology Management*. 2021;**32**(1):219–241. DOI: 10.1108/JMTM-04-2020-0137

[54] Ball LJ, Christensen BT. Advancing an understanding of design cognition and design metacognition: Progress and

prospects. *Design Studies*. 2019;**65**: 35–59. DOI: 10.1016/j.destud.2019.10.003

[55] M SE, E RA, R DS, et al. Problem framing and cognitive style: Impacts on design ideation perceptions. *Design Studies*. 2021;**74**:101015

[56] Zheng P, Xia L, Li C, et al. Towards Self-X cognitive manufacturing network: An industrial knowledge graph-based multi-agent reinforcement learning approach. *Journal of Manufacturing Systems*. 2021;**61**:16–26

[57] Bakici T. Comparison of crowdsourcing platforms from social-psychological and motivational perspectives. *International Journal of Information Management*. 2020;**54**:102121. DOI: 10.1016/j.ijinfomgt.2020.102121

[58] Johnson BP, Dayan E, Censor N, Cohen LG. Crowdsourcing in cognitive and systems neuroscience. *The Neuroscientist*. 2022;**28**(5):425–437. DOI: 10.1177/10738584211017018

[59] Mordacchini M, Passarella A, Conti M, et al. Crowdsourcing through cognitive opportunistic networks. *ACM Transactions on Autonomous and Adaptive Systems*. 2015;**10**(2):1–29. DOI: 10.1145/2733379

[60] Wang Z, Liang X, Li M, et al. Towards cognitive intelligence-enabled product design: The evolution, state-of-the-art, and future of AI-enabled product design. *Journal of Industrial Information Integration*. 2025;**43**:100759

[61] Gong X, Jiao R, Jariwala A, et al. Crowdsourced manufacturing cyber platform and intelligent cognitive assistants for delivery of manufacturing

as a service: Fundamental issues and outlook. *The International Journal of Advanced Manufacturing Technology*. 2021;**117**(5):1997–2007. DOI: 10.1007/s00170-021-07789-7

[62] Goncalves J, Feldman M, Hu S, et al. Task routing and assignment in crowdsourcing based on cognitive abilities. In: proceedings of the 26th international conference on world wide web companion (WWW '17); [Accessed: 3-7 April 2017; Perth. Republic and Canton of Geneva: International World Wide Web Conferences Steering Committee; 2017. p. 1023–1031

[63] D DR, A EJ, Addepalli S, et al. Cognitive digital twin: An approach to improve the maintenance management. *CIRP Journal of Manufacturing Science and Technology*. 2022;**38**:613–630

[64] El Kalach F, Yousif I, Wuest T, et al. Cognitive manufacturing: Definition and current trends. *Journal of Intelligent Manufacturing*. 2025;**36**:3695–3715

[65] H AJA, Gaffinet B, Panetto H, et al. Cognitive systems and interoperability in the enterprise: A systematic literature review. *Annual Reviews in Control*. 2024;**57**:100954

Chapter 7

Perspective Chapter: Crowdsourcing - Innovations in Digital Collaboration in Africa

Lenny Phulong Mamaro and Ntomolane Lobisa Matsoma

Abstract

It is projected that the potential of Sub-Saharan Africa's crowdfunding market will reach 2.5 billion dollars by 2025. Crowdfunding in Africa differs due to the volatile but young macro-environment, which enables offline backer contributions and project success. Crowdfunding is a viable means of funding the Sustainable Development Goals (SDGs). Online finance does not include the provision of economic assistance to intermediaries, for example, banks, from contributions by users whose incentive may be in exchange for some reward and/or altruism. Blockchain and smart contracts enhance and enable crowdfunding websites by eliminating intermediary third parties, allowing users to better see how their money is being allocated, and opening a ledger for all transactions. This chapter aims to contribute to the scientific literature on information technologies for sustainable development by constructing a bibliometric study to determine the most efficient contributors and the most impactful authors, countries, publishers, institutions, and journals on blockchain to address SDGs using crowdfunding; to construct a system of classification that organises research into categories and sub-categories representing the state of the art; and to determine the most important results and a research agenda for the future in each research category and sub-category. This research has highlighted the digital divide as one of the most probable crowding-out drivers for crowdfunding growth in Africa. Rather than waiting for empirical verification of this theory, home governments can act to further decrease the digital divide in their nations to launch the crowdfunding sector more effectively into flight in Africa.

Keywords: Sustainable Development Goal, crowdfunding, entrepreneur, startup, Africa

1. Introduction

Small and medium-sized enterprises (SMEs) and startups in Africa face a significant financing gap of approximately US\$140 billion, which prevents them from developing innovative solutions to climate change, social disparities, and economic issues. Crowdfunding is a cheaper substitute for venture capital and bank finance, enabling projects to raise funds from numerous small financiers instead

of a few big financiers [1]. Crowdfunding is rapidly becoming an extremely potent means of funding sustainability projects, such as those for rural development. Recent studies examine how crowdfunding platforms integrate sustainability goals and how that strategy can empower rural communities [2]. It allows local entrepreneurs, SMEs, and communities to raise funds directly from a wide pool of supporters, including the African diaspora, thus democratizing access to capital and encouraging community-led solutions to urgent issues. Crowdfunding knowledge and resources are requested from a geographically dispersed crowd through digital platforms. Crowdfunding is one specific sub-type that seeks monetary support from a large crowd of people, usually through online intermediaries. In contrast to conventional means of funding from a small cohort of large-scale financiers, crowdfunding re-allocates small clusters of money from numerous funders, rendering finance an inclusive and collaborative digital process.

This chapter seeks to address a fundamental research question: How can crowdfunding be an innovation and sustainable development driver in Africa? The objective is to explore how various crowdfunding models, particularly reward-based, donation-based, and equity crowdfunding, can bridge financing gaps and propel Africa's attainment of the United Nations Sustainable Development Goals (SDGs), particularly Goal 8 (Decent Work and Economic Growth), Goal 9 (Industry, Innovation, and Infrastructure), and Goal 17 (Partnerships for the Goals).

Globally, there is a consensus on the need to mobilise both domestic and international resources to achieve the SDGs [3]. The goal is to attain sustainable socioeconomic progress, that is, enhance social and economic advancement while at the same time preventing environmental degradation, enhancing the efficiency of resource use, building more sustainable lifestyles, reducing poverty, promoting the shift towards low-emitting carbon green economies, and enhancing the quality of justice and public health [4]. In African financial inclusion, where challenges exist, crowdfunding is one way to achieve entrepreneurial finance in line with these objectives.

In recent years, crowdfunding has emerged as a transformative financial mechanism for fostering innovation and entrepreneurship, particularly in regions with limited access to traditional funding sources. In Africa, where financial inclusion remains a challenge, crowdfunding presents a viable alternative for mobilising resources to support startups, social enterprises, and sustainable development initiatives [5]. The continent's growing digital penetration, youthful population, and entrepreneurial spirit create a fertile ground for crowdfunding platforms to thrive, bridging the gap between innovative ideas and much-needed capital [6].

Foundations and philanthropic organisations play a crucial role in Africa's development landscape, yet their potential to leverage crowdfunding for sustainable impact remains underexplored. By integrating crowdfunding into their funding models, foundations can amplify their reach, democratize access to finance, and support grassroots innovations that align with the United Nations SDGs [7]. Moreover, the collaborative nature of crowdfunding fosters community engagement, ensuring that development initiatives are demand-driven and locally relevant [8].

This chapter examines how crowdfunding can serve as a catalyst for innovation in Africa, unlocking the untapped potential of foundations to drive sustainable development. It analyses successful case studies and existing challenges, and the study highlights strategies for maximising the impact of crowdfunding in fostering inclusive growth across the continent. This chapter adds to sustainability-focused crowdfunding literature in practice and theory. It develops theoretical crowdfunding

knowledge beyond the conventional finance theory by emphasising its contribution to SDG achievements. The complete bibliometric analysis demonstrates emerging fields of research and voids in the literature, offering a clear-cut research direction for scholars in further research. While recent research has helped in the build-up of a noteworthy contribution to current scholarship on crowdfunding in driving sustainability [9, 10], there remain imperative gaps in terms of its long-term effect on a wide range of SDGs.

1.1 Literature review: Crowdfunding and innovation in Africa – unlocking grassroots potential for sustainable development

The increase in restrictions on access to finance due to the unavailability of finance is a growing concern for new SMEs and entrepreneurship after the global financial crisis. Crowdfunding has increased in growth and popularity towards the disintermediation of the finance market. This contributes to access to finance for SMEs due to a lack of finance. Crowdfunding has emerged as a route of alternative financing in Africa because bank loans and venture capital are not accessible to the majority of entrepreneurs, especially at the grassroots level [6]. A boom in mobile money and internet-based platforms has driven the development of crowdfunding models, that is, donation-based, reward-based, equity-based, and peer-to-peer lending. Africa's digitally active, young population and rising internet penetration have also spurred the growth of crowdfunding as an innovation driver and economic empowerment tool. Four prominent categories of crowdfunding include donation-based, reward-based, equity-based, and debt-based [8, 11].

- Donation-based crowdfunding involves the practice of donors contributing money towards funding a cause or project without receiving any tangible reward.
- Reward-based crowdfunding offers non-monetary rewards, such as goods or services, to backers.
- Equity-based crowdfunding offers the possibility for contributors to become co-owners (shareholders).
- Debt-based crowdfunding (or peer-to-peer lending) allows backers to lend money to entrepreneurs in the hope of being repaid with interest.

Donation- and reward-based forms are the norm in the African context because of regulatory limits, low investor consciousness, and immature capital markets [12]. This is accompanied by the emergence of platforms like ThundaFund (South Africa), StartSomeGood (Nigeria), and M-Changa (Kenya) as principal promoters of local innovation and growth. However, for all the promise that it holds, African adoption of crowdfunding remains uneven. Digital illiteracy, weak regulatory frameworks, and inconsistent investor protection are the primary hurdles to widespread application [48].

1.2 Crowdfunding as a catalyst for grassroots innovation

Historically, African cultures have had collective fundraising systems such as Ghana's susu, Kenya's harambee, and South Africa's stokvels, which set the cultural

precedent for contemporary crowdfunding platforms that focus on communal financial support for social impact initiatives [11]. African traditional banks prefer established companies and avoid lending capital to startups or SMEs because they consider them risky and lacking collateral. Consequently, very few African SMEs have access to credit or bank loans. Crowdfunding websites fill this void, stepping in to rescue entrepreneurs who would otherwise have to rely on word-of-mouth or personal financing [13].

Crowdfunding is the raising of funds from a large number of investors, traditionally carried out online. It has been credited as a top ten invention of the twenty-first century. It offers an alternative form of financing compared to traditional forms, for example, bank loans and equity financing. The advantages of crowdfunding over traditional means of financing are that one can quickly reach many potential investors, benefit from opportunities for instant interaction and information exchange with crowdfunding stakeholders, leverage market perceptions ('crowd wisdom'), and require a very low level of bureaucracy.

The worth of funds raised by means of crowdfunding amounted to US\$940.9 million in 2020. That is expected to continue growing in the future at a rate of 5.8%. Crowdfunding investment globally is projected to amount to \$93 billion in 2025, according to the World Bank Report. Crowdfunding allows entrepreneurs to seek funds directly from a wide pool of supporters at home and abroad. Crowdfunding decentralises finance [11]. This route bypasses the expensive expectations of banks and investors, allowing grassroots innovators more chances to raise money for piloting and incubation of ideas [14].

Most African traditional banks have tight lending standards, demand collateral, and lend to a limited proportion of the population. An estimated 43% of adults in Africa have a bank account, and only 22% of micro- and medium-sized businesses can access loans or utilise credit [15]. Crowdfunding platforms allow micro-enterprises and small businesses to finance their operations directly from a broad base of patrons, bringing capital to individuals who are outside mainstream financial institutions [16]. Most Africans do not have access to mainstream banking services, yet with universal mobile money service penetration (e.g., M-Pesa), individuals can avail themselves of crowdfunding without necessarily needing a bank account. The technology leapfrogging allows remote or under-banked innovators to access funds and finance campaigns.

Crowdfunding has proved to be the primary force in expanding access to capital and limiting the power of legacy gatekeepers, such as banks and venture capitalists [17]. Crowdfunding in Africa promotes innovation by:

- Directing early-stage funds to entrepreneurs without collateral or credit history.
- Experimenting with ideas and getting feedback from potential purchasers [8].
- To form communities within startups and social issues, building trust and transparency.

Multiple studies identify the capacity of crowdfunding in the African innovation landscape. In a study submitted by the African Crowdfunding Association [18], platforms had mobilised more than \$200 million during 2020 alone, with a focus on SDG-based sectors like clean energy, education, healthcare, and food security. For

example, the JumpStart Africa platform has supported innovative initiatives and technological innovations across East Africa and West Africa.

Secondly, crowdfunding is also an informational signal of quality to other investors. Signalling theory [19] suggests that a successful crowdfunding would send a message to subsequent-stage investors that a project is marketable and has social support. In this regard, the integration of foundations in the crowdfunding platform would be an essential parameter for gaining credibility, visibility, and legitimacy for African innovative projects.

Crowdfunding platforms enable entrepreneurs to present their business ideas via the internet to a wide population and mobilise funds from individuals and institutions without necessarily going to traditional banks or venture capitalists [20]. This is very useful in Africa, where bank loans are scarce, and banks are risk-averse. Entrepreneurs expose their ideas to the public to test business ideas and see if people or backers are interested. Successful campaigns also prove demand, which can drive subsequent investment and create early customer loyalty [13].

1.3 Internet penetration in Africa: Key statistics and sources

Internet penetration in Africa has expanded substantially over the last decade, driven by mobile coverage, investment in infrastructure, and low-cost smartphones. Regional disparities remain, though. Here are key statistics and sources:

1.3.1 Overall internet penetration in Africa (2024)

Internet users in Africa: around 570 million (43% internet penetration rate) [21]. Since 2010: over 1,200% rise in internet users [22].

Mobile internet supremacy: more than 90% of Africans are mobile internet users [23].

1.3.2 Internet penetration by region

North Africa: highest rate of penetration (70%), led by Egypt (72%) and Morocco (88%) (Internet World Stats, 2024). Sub-Saharan Africa: ~40% penetration, led by South Africa (72%), Kenya (54%), and Nigeria (55%) [24]. Lowest penetration: Eritrea (12%), Burundi (15%), and Niger (18%) are among the lowest [25].

1.3.3 Use of social media and mobile internet

Active social media users: 435 million (33% penetration) [21].

Best-used platforms: WhatsApp, Facebook, TikTok. Subscriptions to mobile broadband: 50% of the population [23].

1.3.4 Barriers to higher penetration

Affordability: only 25% of Africans can afford 1GB of mobile data [26]. Gaps in infrastructure: rural areas are lagging behind, with 60% of urban populations online compared to just 25% of rural populations [22]. Gender gap: women are 37% less likely to access mobile internet [23].

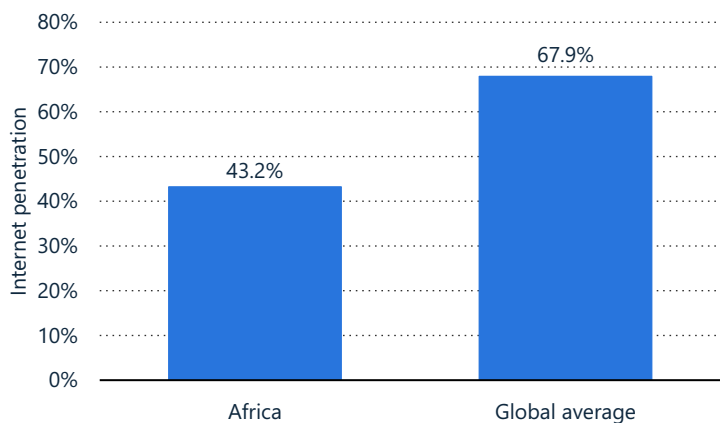


Figure 1.
Internet penetration rate in Africa for the year 2022. Source [24].

Figure 1 indicates the gap in internet penetration in Africa compared to the global average. From the figure, it is clear that internet penetration in Africa is 43.2%, which falls below the global average of 67.9%. This digital gap highlights the persisting issues of infrastructure development, accessibility, and digital literacy on the continent. The comparatively low level of connection directly impacts industries that depend on digital access, including agriculture, finance, and education. In such a research setting, limited internet coverage can hinder the effective rollout and coverage of innovative finance offerings like blended finance, especially in rural and underdeveloped agricultural areas.

1.4 Banking infrastructure in Africa: Key statistics and sources

Africa’s financial infrastructure remains underdeveloped on a global scale, and variations between countries are significant. Some of the key facts about the extent of financial access, online banking, and issues confronting the sector are listed below:

1.4.1 Penetration of traditional banking

A bank account is held by just 48% of Sub-Saharan African (SSA) adults, compared to the world average of 76% [27]. Account ownership is greater in North Africa at 54% but still trails behind other developing regions [27]. The largest banked populations are in Mauritius, Seychelles, and South Africa (over 80%), while the smallest banked populations are in Niger, Chad, and Madagascar (under 20%) [28].

1.4.2 Mobile money and digital banking growth

Africa is the world’s leader in mobile money, with 64% of worldwide mobile money transactions occurring in SSA [23]. Twenty-one percent of African adults have mobile money accounts, compared to only 4% in 2014. The most penetrated markets for mobile money are Kenya, Ghana, and Zimbabwe (over 75% of adults), followed by services such as M-Pesa, MTN Mobile Money, and EcoCash [23].

1.4.3 Bank branch and ATM availability

The Sub-Saharan Africa region has a paltry 5.3 bank branches per 100,000 adults, as opposed to 12.7 in Latin America and 28.5 in developed OECD economies [29]. ATM access is withheld from rural communities, with only 5.1 ATMs per 100,000 persons in SSA, as opposed to 55 per 100,000 in developed economies [25].

1.4.4 Barriers to financial inclusion

Distance to banks: 35% of unbanked Africans identify distance to banks as the primary limitation [28]. High charges: transaction and account-maintenance fees are still out of reach for the low-income population [29]. Documentation requirements: approximately 30% of the unbanked do not possess the required identification or collateral [27].

1.4.5 Fintech and alternative finance expansion

African fintech companies raised more than \$2.7 billion in funding in 2022, led by Nigeria, Kenya, South Africa, and Egypt [30]. Neobanks and digital banks (TymeBank, Kuda, Opay) are expanding very quickly, focusing on underbanked segments [31].

Africa's bottom-up innovators tend to be required to overcome structural impediments, such as inaccessibility to formal finance systems and bureaucratic barriers [32]. Crowdfunding offers an open architecture, which enables innovators to bypass customary gatekeepers and directly transact with an international community of supporters [7]. Literature highlights instances where African businesspeople harnessed platforms such as M-Changa (Kenya), Thundafund (South Africa), and GoFundMe to crowdfund renewable energy ventures, agritech startups, and community-hospitality-based health initiatives [33].

Mollick [8] contends that, aside from finance, crowdfunding is also an experiment with validation, allowing innovators to gauge market viability prior to mass production. This is especially crucial for Africa, considering the resource constraints, which call for lean and agile models of innovation.

2. The role of foundations and institutional support

While grassroots-level crowdfunding is fuelled by peer and community contributions, foundations and development institutions can leverage its potential through strategic partnerships [5]. Certain foundations in Africa, like the African Innovation Foundation (AIF) and the Tony Elumelu Foundation, have started incorporating crowdfunding into their grant-making practices by offering matching funds or technical assistance to grassroots projects [12].

Nonetheless, digital illiteracy gaps, regulatory ambiguity, and some African nations' currency controls hinder the full potential of crowdfunding [34]. In order to prevent such hindrances, scholars recommend policy reforms, capacity development initiatives, and blended finance schemes integrating crowdfunding with conventional grants [35].

3. Research methodology

To properly map and scrutinise the academic landscape with regard to crowdfunding, innovation, and sustainable development in Africa, this study utilised an exhaustive bibliometric analysis. This allows for the determination of trends in research, thematic communities, and knowledge gaps, thus complementing the chapter's objective of sharpening theoretical and practical insights into the role of crowdfunding in driving innovation and attaining the SDGs. The research employed a descriptive bibliometric study design using the convergence of quantitative analysis of publication data and qualitative thematic interpretation of trends. This enables statistical mapping and contextual comprehension of emerging research frontiers.

This chapter offers a greater qualitative examination of effective and ineffective African crowdfunding campaigns, with applied lessons for the practice of crowdsourcing. ThundaFund in South Africa and M-Changa in Kenya case studies reveal that the effectiveness of a campaign largely depends on collaborative dynamics among creators, funders, communities, and platforms. Effective campaigns, including the African Innovation Festival and the Community Water Wells Project, utilised regular updates, included supporter input, mobilised online and offline networks, and tied messaging to indigenous cultures, which allowed them to fundraise above the initial call. Ineffective campaigns like the Green Village Solar Hub and the Youth IT Hub did not succeed because they lacked regular updates, featured poor storytelling, and had low interaction, leading to disappointing funding results. Key findings underscore the need for transparency, active two-way interaction, multi-channel mobilisation, cultural sensitivity, and capacity building for project developers, as a testament that crowdfunding, as a form of crowdsourcing, is dependent on active, ongoing collaboration.

4. Crowdfunding and SDGs

Crowdfunding allows diverse stakeholders to fund projects aimed at addressing significant global issues. Crowdfunding, being flexible and accessible, is best suited to fund projects focused on several SDGs like poverty reduction, gender equality, economic growth, innovation, and partnership. Social mobilisation and sustainable empowerment technologies are the current trends in social movements within grassroots innovations. Climate change is currently one of the biggest challenges in the world. Human activity, such as the burning of fossil fuels and forest waste, is causing climate change through the emission of greenhouse gases (GHGs) [36]. Renewable energy utilisation has the potential to reduce the negative impacts of climate change and environmental degradation. Since renewable technologies are at an embryonic stage, research and developmental exercises for their future exploitation entail considerable investments [10].

4.1 Crowdfunding support for specific SDGs

SDG 1 (No Poverty): crowdfunding allows for support of income-generating projects that empower people and communities to rise above poverty. Agricultural

cooperatives or renewable energy-based campaigns, for instance, offer sustainable livelihood options, enhance food security, and effectively reduce poverty [37]. Its aim is to eradicate all forms of poverty and is among the universally accepted collection of 17 development goals that nations have set for themselves to be met by the year 2030, known as the 2030 Agenda [38]. Therefore, entrepreneurs play an important role in economic activities and growth in developing countries by creating jobs and fostering economic development [39].

SDG 5 (Gender Equality): crowdfunding supports gender equality as it empowers cooperatives and women-owned businesses. Programs such as Angola's Solar Kitchen project empower women by facilitating access to sustainable farming production and renewable energy, enhancing their socioeconomic status and social standing. The minority group, females in particular, and their underrepresentation in the finance market have been a long-time issue for both policy makers and researchers of entrepreneurial finance [40].

The advent of online finance innovations, like crowdfunding, therefore promises more meritocracy in entrepreneurial finance and should easily facilitate female entrepreneurs and minority investors, who are normally in the minority, to be brought into finance [38].

SDG 8 (Decent Work and Economic Growth): crowdfunding facilitates employment and economic growth for entrepreneurship and SMEs. It reduces financial thresholds, increasing entrepreneurship and innovation, which are critical to inclusive economic growth [41]. These factors and more have led to an increased need for financial inclusion. The United Nations enumerated a list of 17 global goals under the SDGs aimed at addressing the multiple social, economic, and environmental issues the world is already battling [42]. 'Decent Work and Economic Growth' is a hallmark describing SDG 8, which strives to enable productive work, inclusive and sustainable economic growth, and decent work for everyone [43].

SDG 9 (Industry, Innovation and Infrastructure): crowdfunding enables local innovators financially to develop new technologies and infrastructure projects [44]. Myanmar's pay-as-you-go home solar systems are another instance of how crowdfunding enables innovative business models that are suited to local conditions. This financial system leverages the use of the internet to combine small amounts of money from many individuals to fund a wide range of purposes, for example, artistic endeavors, product development, and business beginnings [45].

SDG 17 (Partnerships for the Goals): crowdfunding websites connect funders, social entrepreneurs, and communities around the world, creating partnerships that scale impact [46]. Crowdfunding websites are markets that organise donations and investments, bringing together the muscle of citizens, businesses, and governments to drive the SDGs.

4.2 Crowdfunding and the SDGs

Crowdfunding has become a key vehicle to facilitate the attainment of the United Nations SDGs by assisting individuals, organisations, and communities in raising funds to finance projects that promote social, environmental, and economic development. Firstly, crowdfunding is closing the financing gap: financing the 17 SDGs by 2030 will cost trillions of dollars a year, most of which is in developing countries. Crowdfunding provides an alternative and complementary pool of

financing, especially for bottom-up and frontier projects that have little hope of being financed conventionally. Secondly, democratisation of finance: crowdfunding enables anyone, from individuals to institutional investors, to finance SDG-focused projects, creating a global sense of ownership and contribution towards sustainable development. Thirdly, scaling social innovation: by reducing barriers to entry, crowdfunding allows social entrepreneurs and community groups to test and scale SDG solution models, such as clean energy, poverty alleviation, and climate resilience. Lastly, raising awareness and engagement: Campaigns typically raise not only money but also consciousness about key causes, engaging diverse constituencies and raising the profile of the SDGs.

Figure 2 is a world map illustrating crowdfunding revenue by continent. It shows the amount of crowdfunding revenue raised per region: North America: \$17.2 billion (most), Asia: \$10.54 billion, Europe: \$6.48 billion, South America: \$85.74 million, Oceania: \$68.8 million, and Africa: \$24.16 million (least). **Figure 2** illustrates the vast difference in crowdfunding revenue among regions, with developed markets such as North America and Asia performing strongly, while South America and Africa are far behind.

The legal environment, financial infrastructure, and business climate of Africa differ from the principal sources of crowdfunding, such as the USA, Asia, and Europe. As noted previously in Section 4.1, the level of bank account ownership, for instance, is quite low compared to HICs and is highly skewed in African nations. The crowdfunding platforms committed to or with facilities for African projects, therefore, are confronted with heterogeneous or untested challenges [11]. Local crowdfunding platforms are likely to be most aligned with the local infrastructure and accommodate all aspects of crowdfunding, independent of internet connection or the utilisation of formally banked accounts [47]. An example is M-Changa, a Kenyan platform that incorporated more prevalent mobile money technology into

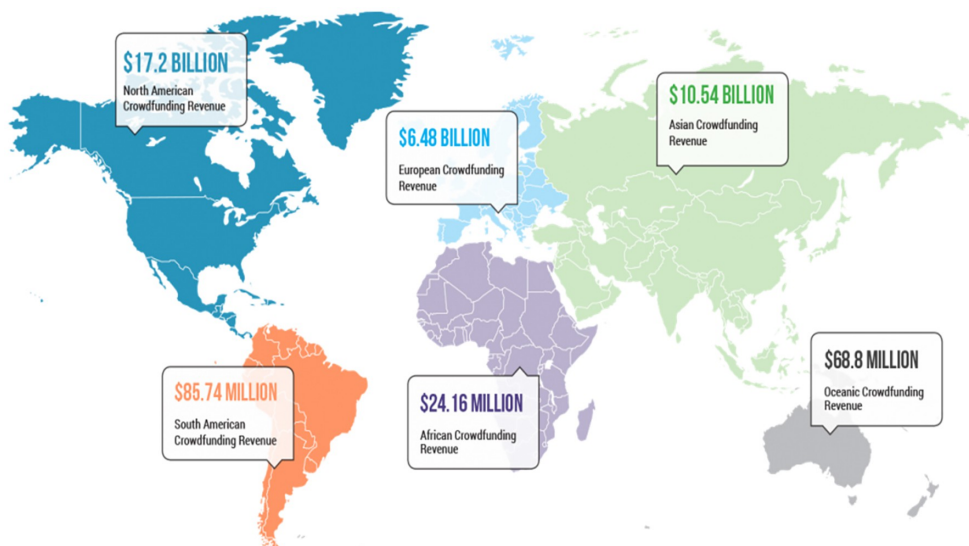


Figure 2.
Crowdfunding activity by region. Source [24].

the product. M-Changa works together with internet payment and mobile money service providers to enable Kenyan families and micro and small businesses to raise funds without having a bank account. The facility to fundraise on mobile can even be given to internet-averse individuals.

Challenges also lie in the guise of weak or nonexistent laws and regulations to safeguard both providers and users of the crowdfunding platforms. A regulatory system is required for loan- and equity-based crowdfunding platforms to secure the rights of backers. A special legal framework for crowdfunding also gives confidence and protection to platforms and businesses that otherwise are running in unregulated, off-the-books markets. Stable and trustworthy systems of laws give the required confidence for crowdfunding platforms to gain footing, invest, and fundraise. Moreover, the lack of legislation discourages the development of the crowdfunding market as a whole.

The previous section discussed the overview of crowdfunding and sustainability in the African continent. Therefore, the current section discusses the drivers of crowdfunding success, particularly in the African continent. Potential backers and investors consider the existing information at their disposal to make a decision on whether to invest or not. The determinants of crowdfunding success are as follows:

Following this view, illustrating the crowdfunding stakeholders during the campaign process, the knowledge and skills developed will likely enhance the chance of success in new projects. The crowdfunding stakeholders are illustrated in **Figure 3**.

The four main parties to crowdfunding transactions include the Entrepreneur, the Backer, the Regulations, and the Crowdfunding platform. Accordingly, in the context of crowdfunding, firstly, *entrepreneurs* or SMEs are defined as any individual or group that issues a public call for funding of a project(s) with a specific purpose (s). The entrepreneur or project creator may benefit from the contributions received as well as market validation results that arise from wide public acceptance and support by engaging in cost-effective access to finance. Secondly, *a crowdfunding platform is an internet program that connects SMEs and potential backers while facilitating trades between them under pre-specified conditions* [49]. Several entrepreneurs in reward-based crowdfunding have been identified as being involved in scams and fraud due to limited regulations, especially in Africa. Thirdly, *regulation* is a set of rules under which crowdfunding models operate in relation to compliance requirements, primarily aimed at protecting both backers and entrepreneurs or fundraisers. In this regard, such authorities have vested interests in supporting new innovative ideas by financing SMEs in their jurisdictions (as job creators and taxpayers), as well as enabling greater public contributions to civic, cultural,

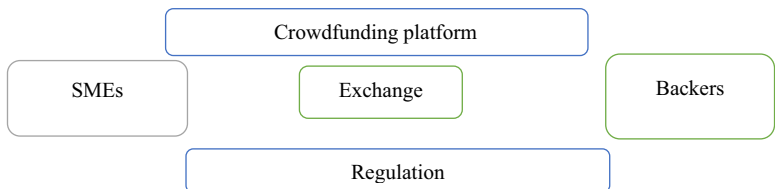


Figure 3.
Crowdfunding stakeholders. Source [48].

educational, and environmental initiatives that may align with a country's government policies. Regulation can be defined as follows: if operations do not already fall under existing securities or banking laws, policymakers have so far taken a wait-and-see approach or implemented a light form of regulation that is to be adapted once regulators have learned more about the functioning of crowdfunding markets [50]. Finally, *backers* can be any individual or organisation that provides finance in response to a public call for the financing of project(s) with specific purpose(s) and are referred to as backers.

Entrepreneurs have to choose funding mechanisms to finance their crowdfunding projects. These can either be *fixed* or *flexible funding mechanisms*. Under the *fixed funding* mechanism, the money contributed is refunded when the crowdfunding project has not been successful (all or nothing). Under the *flexible funding mechanism*, the money contributed to the crowdfunding campaign project is not refunded, irrespective of whether the project has been successful or not (keep it all).

4.3 Experience

The entrepreneur has created crowdfunding projects in the past; his/her experience can help achieve success in obtaining future funding [51]. Therefore, experience plays an important role in attracting potential backers to invest in a campaign. Entrepreneurs who lack such experience might need to rely on other signals to compensate for their lack of credibility, which decreases the likelihood of success. Experience, measured by the entrepreneur's previous successful projects on crowdfunding platforms, is found by [52] to have a positive effect on the success of crowdfunding campaigns. If a founder has previous successful funding experience, sponsors are more likely to believe that he or she will be able to complete the current project.

4.4 Backer

Entrepreneurs seek contributions from the crowd or backers who provide support for a crowdfunding project [53]. Individuals, for example, might support the project by providing funding or promoting the project to raise its visibility. When a potential backer chooses to support a project, they face the challenge of information asymmetry, which is created by the limited information disclosure. According to the findings, the primary motivations for entrepreneurs were to generate finances, obtain confirmation of their abilities, imitate successful experiences of others, and increase project visibility through social media, which enhances the likelihood of success. Backers were primarily motivated by the rewards themselves, the support for an innovative idea, and the contribution to a creative community [54]. The experience of backers has the potential to influence crowdfunding success as it serves as a signal of mutual understanding [55, 56, 57]. Several studies revealed that social factors of the community influence crowdfunding success, in particular the relationship between the entrepreneur and backers, and the importance of offline relationships. The potential backers trust the entrepreneur to use pledged funds to deliver on their promises and trust the crowdfunding platform to conduct pre-screening of projects they post [58].

The following explains the role of crowdfunding.

- Anchor investments and risk reduction: foundations offer seed-stage, non-repayable funding (grants) to crowdfunding campaigns. By acting as anchor investors and making periodic investments in the initial 20–30% of a campaign's target, they reduce the perceived risk to other potential supporters and foster an increased likelihood of successful campaigns.
- Match-funding mechanisms: foundations can leverage the collective effect of crowd-giving through match-funding, in which foundations commit to matching donations up to a specified level from the crowd. This incentivises more individuals to contribute because they are aware that their contributions will be twice as effective. Although foundations are most visible here, match-funding may also be provided by corporations or the public sector.
- Credibility and confidence: the establishment of a good foundation is equivalent to credibility and commitment to the people. If a professionally functioning foundation in social donation provides its endorsement to a campaign, it instills trust among the donors towards the validity and viability of the project.
- Expertise and networking: in addition to financial assistance, foundations also provide impact expertise along with networking opportunities with a wide group of stakeholders. Having them involved can assist project initiators in streamlining their strategy, measuring and tracking impact, and connecting with other partners or supporters.
- Platform partnerships and innovation: some foundations partner with crowdfunding sites or start their own platforms to crowdfund money for particular causes. Such partnerships can mix and match grant-based and investment-based models, developing new forms of SPO financing. Examples include partnerships such as Lendahand with Solidaridad, and building sites like PlusPlus and Energise Africa that bring alternative capital sources and expertise together to fund new and innovative projects in frontier markets.

5. Case studies of African crowdfunding campaigns and platforms

In addition to the bibliometric analysis, this section offers an in-depth discussion of some selected African crowdfunding campaigns and platforms, with an emphasis on cooperative dynamics among funders, project initiators, communities, and platform operators. This places crowdfunding as one of crowdsourcing's sub-types, where value is co-created through collaborative interactions within online spaces. The case studies demonstrate the extent to which such collective processes influence campaign success or failure and provide practical lessons for foundations, policymakers, and practitioners who wish to utilise crowdfunding for sustainable development.

5.1 ThundaFund (South Africa)

ThundaFund is a top South African reward-based crowdfunding platform that finances innovative, social, and entrepreneurial initiatives. Successful example: ‘The African Innovation Festival’.

Collaborative features: ThundaFund supports two-way channels of communication, such as commenting areas, announcements, and social media integration, where project creators can communicate with backers. During the African Innovation Festival campaign, organisers provided regular progress reports, included comments from backers in organising events, established tiered reward systems, and all of this contributed towards increased perceived value.

Outcomes: the campaign was a success in mobilising 140% of the goal, owing not just to local but also to diaspora stakeholders in South Africa. Mutual engagement bred trust, openness, and ownership. Unsuccessful example: ‘Green Village Solar Hub’.

Collaboration challenges: brilliant idea, but little to no communication with supporters after the initial launch, sporadic posting, and not responding to questions eroded supporter trust. The campaign reached only 35% of the target funding.

Lesson: backer maintenance through regular communication and openness is essential to keep energy levels high in collaborative crowdfunding campaigns.

5.2 M-Changa (Kenya)

M-Changa is an online and mobile fundraising platform that marries age-old community-based donations (harambee) with more recent digital-era crowdfunding technologies. Successful example: ‘Community Water Wells Project’.

Collaboration features: M-Changa leverages mobile money channels like M-Pesa, and rural donors can thus be reached. Organisers of campaigns use WhatsApp groups for running day-to-day reports, host sub-drives of fundraising organised by backers, and mark milestones with public recognition.

Outcomes: fundraised 120% of the target, with high engagement from both locals and diaspora communities. Backer-to-backer involvement, sharing the campaign through personal networks, increased reach and funding.

Unsuccessful example: ‘Youth IT Hub’.

Collaboration challenges: even though the concept had initial commitments, inadequate inclusive dialogue among organisers and prospective supporters, as well as limited social media storytelling, led to declining interest.

Insight: the cooperative nature of crowdfunding goes beyond platform abilities; social storytelling and network mobilisation are just as important.

5.3 Cross-platform lessons

Throughout these case studies, the following collaboration trends emerge:

Active and transparent communication – regular, genuine updates create backers’ trust and engagement.

Inclusive engagement – engaging communities in establishing campaign objectives fosters ownership and collective problem-solving.

Leveraging hybrid networks – tapping online spaces, and offline mobilisation (e.g., WhatsApp groups, neighbourhood meetings) optimises campaign reach.

Cultural and contextual alignment – effective campaigns align messages and reward systems with the values and norms of the neighbourhood in order to optimise resonance with target groups.

Responsive adaptation – addressing backer grievances on a continuous basis may optimise campaigns mid-stream for greater effectiveness.

6. Discussion lessons, theory, and policy implications

The findings validate that crowdfunding is both a socio-economic facilitator and a social innovation promoter. Crowdfunding platforms are employed by African entrepreneurs to raise funds, but more importantly, to test ventures, mobilize communities, and build trust. The findings are in line with signalling theory (Spence, 2002), as high-quality information disclosure through the use of photos, videos, and project updates reduces information asymmetry between project initiators and potential supporters.

While crowdfunding encourages innovation, its emergence is constrained by regulatory uncertainty, lack of awareness, and unequal technological infrastructure. Successful adoption in Nigeria, Kenya, and South Africa is an example of where there are enablers in terms of mobile payment integration and favorable policy environments.

From a policy perspective, the creation of strong digital literacy, synchronized crowdfunding laws, and the enhancement of public-private partnerships are critical to fostering innovation-led crowdfunding economies. Governments, development agencies, and financial institutions must recognize crowdfunding as a strategic tool for achieving SDGs by unlocking grassroots entrepreneurship and innovation.

7. Future research directions

Future innovation and crowdfunding research in Africa need to cross the bridge of technology, policy, and grassroots entrepreneurship to realise its full potential towards sustainable growth. Studies can examine the potential of emerging technologies such as blockchain and mobile money to improve transparency, trust, and access to crowdfunding platforms, especially for marginalised rural populations. Additionally, comparative analyses among African nations would be capable of identifying best practices and regulatory frameworks for enhancing innovation while protecting investors and project developers. Policymakers have to collaborate with fintech entrepreneurs and development agencies to craft supportive environments, including financial literacy programs and domestic entrepreneurs' incentives. Additionally, future studies need to place crowdfunding in the broader crowdsourcing and virtual collaborative context more prominently. Key areas are developing new co-operating technologies (i.e., AI, blockchain) to improve trust and efficiency; growing strategies like gamification and interactive storytelling to harness crowd participation; providing support for online communities with ongoing influence after investment; combining crowdfunding with other SDG solution frameworks of crowdsourcing; making platforms adaptable to local cultures; and developing metrics that quantify not only money raised but also the quality and longevity of collaborative networks and sustainability impact.

Nevertheless, the study is limited in its application of secondary data and bibliometric sources, which are less likely to uncover developing informal or community-driven crowdfunding models. Future studies must adopt primary data, including platform analytics and stakeholder interviews, in order to achieve a more contextual understanding.

In conclusion, by accepting and embracing crowdfunding in Africa's development agenda, policymakers and practitioners will be in a position to unlock a huge capacity for innovation, job creation, and sustainable development across the continent.

8. Conclusion

This chapter has examined the revolutionary function of crowdfunding as a new funding tool in Africa, namely in unleashing latent capacity at the grassroots level to spur sustainable development. Through different platforms and models, crowdfunding has emerged as a democratic, inclusive, and affordable tool that empowers entrepreneurs, community drivers, and social innovators to skip conventional financial impediments and leapfrog straight to local and international benefactors.

We have demonstrated that, by being combined with innovation, crowdfunding has the potential to trigger local development through the activation of dormant social capital, energising microenterprises, and powering bottom-up problem-solving. Additionally, it empowers marginalised communities, fosters youth entrepreneurship, and makes it possible for locally led solutions to the SDGs.

But this chapter also recognises the structural and contextual impediments to the optimal potential of African crowdfunding, including regulatory risk, weak digital infrastructure, low financial awareness, and little trust in e-transactions. If these impediments can be mitigated by favourable policies, greater access to digital technology, capacity building, and the development of domestic platforms, then the potential impact of crowdfunding on the continent can be considerably expanded.

In summary, crowdfunding is not just a substitute source of funds; it is a driver of people-driven innovation and sustainable development. It highlights that the largest benefit of crowdfunding is its ability to integrate money mobilisation with such digital collaboration mechanisms as open idea-sharing, stakeholder engagement, and open progress tracking, which retain influence even beyond seed financing stages. Through the implementation of crowdsourcing best practices, foundations and platforms can create robust online communities, improve engagement, and co-create inclusive innovation solutions to Africa's development challenges, thereby contributing to the SDGs.

Acknowledgements

We are indebted to Khethiwe Maraise for the Language editing of the chapter.

Conflict of Interest

“The authors declare no conflict of interest”.

Notes/thanks/other declarations

Nothing to declare

Author details

Lenny Phulong Mamaro* and Ntomolane Lobisa Matsoma
University of South Africa, Pretoria, South Africa

*Address all correspondence to: mamarlp@unisa.ac.za

IntechOpen

© 2025 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Gatti S. Project Finance in Theory and Practice: Designing, Structuring, and Financing Private and Public Projects. 4th ed. Amsterdam: Elsevier; 2023
- [2] Ande T. Crowdfunding platforms and rural community empowerment. *Journal of Sustainable Development Finance*. 2024;**12**(2):112–130
- [3] Gasper D. The road to the sustainable development goals: Building global alliances and norms. *Journal of global ethics*. 2019;**15**(2):118–37
- [4] Jie H, Khan I, Alharthi M, Zafar MW, Saeed A. Sustainable energy policy, socio-economic development, and ecological footprint: The economic significance of natural resources, population growth, and industrial development. *Utilities Policy*. 2023;**81**:101490
- [5] Lehner OM. Crowdfunding social ventures: A model and research agenda. *Venture Capital*. 2013;**15**(4):289–311
- [6] Mitra D. The role of crowdfunding in entrepreneurial finance. *Delhi Business Review*. 2012;**13**(2):67
- [7] Belleflamme P, Lambert T, Schwienbacher A. Crowdfunding: Tapping the right crowd. *Journal of Business Venturing*. 2014;**29**(5):585–609
- [8] Mollick E. The dynamics of crowdfunding: An exploratory study. *Journal of Business Venturing*. 2014;**29**(1):1–16
- [9] Gafni H, Hudon M, Périlleux A. Business or basic needs? The impact of loan purpose on social crowdfunding platforms. *Journal of Business Ethics*. 2021;**173**(4):777–793
- [10] Lam PT, Law AO. Crowdfunding for renewable and sustainable energy projects: An exploratory case study approach. *Renewable and sustainable energy reviews*. 2016;**60**:11–20
- [11] Shneor R, Zhao L, Flåten BT. *Advances in crowdfunding: research and practice*. Springer International Publishing AG; 2020
- [12] Fosu A, Mwabu G. Human development in Africa. *UNDP-HDRO Occasional Papers*. 2010;**7**(2010/8)
- [13] Olafusi TA, Ishola AR, Abimbola BT, Idowu OJ. Development of SMEs in Africa: The role of crowdfunding. *International Journal of Entrepreneurship*. 2022;**26**(5):1–16
- [14] Ravazzoli E, Valero DE. Social innovation: An instrument to achieve the sustainable development of communities. In: *Sustainable cities and communities*. Cham: Springer International Publishing; 2020. p. 605–614
- [15] Asah FT, Louw L, Williams J. The availability of credit from the formal financial sector to small and medium enterprises in South Africa. *Journal of Economic and Financial Sciences*. 2020;**13**(1):1–13
- [16] Paul L, Rena R. The role of digital crowdfunding platforms in democratizing global entrepreneurship. *Journal of Economic Research and Business Administration*. 2024;**149**(3):46–58

- [17] Léon F. Blended Binds: How DFI's support programs stifle bank lending in Africa. *World Development*. 2025;**191**:106998
- [18] Chao EJ, Serwaah P, Baah-Peprah P, Shneor R. Crowdfunding in Africa: Opportunities and challenges. *Advances in crowdfunding: Research and practice*. 2020;**12**:319–39
- [19] Spence M. Signaling in retrospect and the informational structure of markets. *American economic review*. 2002;**92**(3):434–59
- [20] Mamaro LP, Sibindi AB, Godi NJ. The Determinants of Reward-Based Crowdfunding Success in Africa. *Risks*. 2025;**13**(5):94
- [21] Chonka P. Digital governance and security in the Horn of Africa. London: Rift Valley Institute; 2025
- [22] Union T. International telecommunication union. *Yearbook of Statistics 1991–2000*. 2001
- [23] Seck-Sarr SF. Mobile money in sub-Saharan Africa: Innovation and actors' strategies. *Telematics and Informatics Reports*. 2024;**13**:100114
- [24] Nadhom M, Loskot P. Survey of public data sources on the Internet usage and other Internet statistics. *Data in brief*. 2018;**18**:1914–29
- [25] Owusu-Peprah NT. *World Development Report 2022: Finance for an Equitable Recovery*: by World Bank. Washington, DC: World Bank Publications; 2022. p. 267
- [26] Zacher C, Baxter S. Broadband affordability: The metrics that drive and divide us. In: *Proceedings of the TPRC2024 The Research Conference on Communications, Information and Internet Policy*; [Accessed: 2024-August-01]
- [27] Dluhopolskyi O, Pakhnenko O, Lyeonov S, Semenog A, Artyukhova N, Cholewa-Wiktor M, Jastrzębski W. Digital financial inclusion: COVID-19 impacts and opportunities. *Sustainability*. 2023;**15**(3):2383
- [28] Soares F. African Development Bank Group
- [29] Stedman L. The IMF and Capacity Development—Funding Issues. IEO Background Paper No. BP/22-02/13. Washington: International Monetary Fund; 2022
- [30] Tijani B, Oyinlola M, Okoya SA. Digital innovation ecosystem for the circular plastic economy. In: *Digital Innovations for a Circular Plastic Economy in Africa*. Routledge; 2023. p. 76–88
- [31] Ramachandran R, Pillai S, Dahal RK. The transformative Role of AI in advertising and marketing: from data-driven practices to virtual experiences. *Interdisciplinary Journal of Innovation in Nepalese Academia*. 2025;**4**(1):27–45
- [32] Ayalew MM, Xianzhi Z, Hailu DH. The finance of innovation in Africa. *European Journal of Innovation Management*. 2020;**23**(3):348–82
- [33] Kim M. The Myth of Financial Inclusion through FinTech: Focusing on the Digital Credit Industry in Kenya [Doctoral dissertation]. University of East Anglia
- [34] Viseu S. New philanthropy and policy networks in global education governance: the case of OECD's

netFWD. *International Journal of Educational Research*. 2022;**114**:102001

[35] Agyemang F, Castellini M. Hybrid financing models for African startups: Crowdfunding and impact investment. *Development Policy Review*. 2023;**41** (2):189–210

[36] Joshi G, Yenneti K. Community solar energy initiatives in India: A pathway for addressing energy poverty and sustainability?. *Energy and Buildings*. 2020;**210**:109736

[37] Zhou Y, Zhang J, Zeng Y. Borrowing or crowdfunding: a comparison of poverty alleviation participation modes considering altruistic preferences. *International Journal of Production Research*. 2021;**59** (21):6564–78

[38] M Mamaro LP, Sibindi AB. Empowering Africa: The Transformative Impact of Crowdfunding on Sustainable Development. In: *Sustainable Finance and Insurance in Africa*. Cham: Springer Nature Switzerland; 2025. p. 39–61

[39] Ajide FM, Dada JT. Poverty, entrepreneurship, and economic growth in Africa. *Poverty & Public Policy*. 2023;**15**(2):199–226

[40] Agyire-Tettey F, Ackah CG, Asuman D. Gender and returns to entrepreneurship in Africa. *International Journal of Social Economics*. 2018;**45**(12):1609–30

[41] Saher L, Tabák L, Lyeonov S, Vasa L. Inclusive growth: Literature review. *Journal of International Studies*. 2024;**17**(1)

[42] Sharma A, editor. *International Handbook of Skill, Education, Learning,*

and Research Development in Tourism and Hospitality. Springer Nature; 2024

[43] Zehri C, Bendahmane ME, Amina K, Zgarni I, Sekrafi H. Decent work, financial inclusion, and economic growth: Analysis under the SDG 8. *Heritage and Sustainable Development*. 2024;**6**(1):197–218

[44] Fazal A, Ahmed A, Abbas S. Importance of artificial intelligence in achieving sustainable development goals through financial inclusion. *Qualitative research in financial markets*. 2025;**17**(2):432–52

[45] Chalmeta R, Cabezas-Hernando D, dos Santos Silva J. Framework for crowdfunding sustainable development goals projects using blockchain. *Sustainable Development*. 2025;**33** (2):2740–58

[46] Pavlovich K, Markman G. *World scientific encyclopedia of business sustainability, ethics and entrepreneurship: volume 3: spirituality, entrepreneurship and social change*. World Scientific; 2022

[47] Foà C. Crowdfunding cultural projects and networking the value creation: Experience economy between global platforms and local communities. *Arts and the Market*. 2019;**9**(2):235–54

[48] Mamaro LP, Sibindi AB. The drivers of successful crowdfunding projects in Africa during the COVID-19 pandemic. *Journal of Risk and Financial Management*. 2023;**16**(7):332

[49] Shneor R, Munim ZH. Reward crowdfunding contribution as planned behaviour: An extended framework. *Journal of Business Research*. 2019;**103**:56–70

- [50] Zhao L, Ryu S. Reward-based crowdfunding research and practice. *Advances in crowdfunding: Research and practice*. 2020;**12**:119–43
- [51] Wang N, Liang H, Xue Y, Ge S. Mitigating information asymmetry to achieve crowdfunding success: signaling and online communication. *Journal of the Association for Information Systems*. 2021;**22**(3):4
- [52] Liu S, Cheng T, Wang H. Effects of attention and reliability on the performance of online medical crowdfunding projects: The moderating role of target amount. *Journal of Management Science and Engineering*. 2020;**5**(3):162–71
- [53] Szabó RZ, Szász R, Szedmák B. Demand and supply sides of the crowdfunding ecosystem: The case of Kickstarter campaigns and potential Hungarian investors. *Society and Economy*. 2021;**43**(2):165–83
- [54] Hou R, Li L, Liu B. Backers investment behavior on explicit and implicit factors in reward-based crowdfunding based on ELM theory. *Plos one*. 2020;**15**(8)e0236979
- [55] Herd KB, Mallapragada G, Narayan V. Do backer affiliations help or hurt crowdfunding success? *Journal of Marketing*. 2022;**86**(5):117–34
- [56] Fan T, Gao L, Steinhart Y. The small predicts large effect in crowdfunding. *Journal of Consumer Research*. 2020;**47**(4):544–65
- [57] Wei YM, Hong J, Tellis GJ. Machine learning for creativity: Using similarity networks to design better crowdfunding projects. *Journal of Marketing*. 2022;**86**(2):87–104
- [58] Cumming D, Hornuf L, Karami M, Schweizer D. Disentangling crowdfunding from fraudfunding. *Journal of Business Ethics*. 2023;**182**(4):1103–28

The Impact of Project Characteristics on Online Crowdfunding Effectiveness and Its Potential Mechanisms

Yimeng Zhai

Abstract

The information featured on a crowdfunding page is an important source of information for potential project backers about the project and can have a significant impact on backer funding behavior. Crowdfunding information can be divided into two categories: content elements and structural elements, according to their nature and characteristics. Relatively, the former is mainly information that has been artificially edited by the creator, such as project descriptions, project images, progress updates, etc. The latter is objective factual information about the project, such as project category, creator characteristics, target amount, etc. Both types of characteristics show a significant impact on different categories of crowdfunding projects in general, and their persuasive impact on project audiences or funders can be explained by signaling theory, the elaboration likelihood model, and Aristotelian persuasion theory. In addition to the need to further combine multiple research methods, future research should further strengthen the study of the influence of the integration of verbal and non-verbal information, the “double-edged sword” effect of creativity in crowdfunding categories, and the motivation and decision-making mechanisms of different types of investors or audiences in choosing different types of crowdfunding projects.

Keywords: charity, online crowdfunding, reward, creativity, persuasion

1. Introduction

Crowdfunding enables fund collection from diverse contributors, including family, friends, strangers, and businesses. This approach evolved from microfinance and crowdsourcing concepts, with online implementation facilitating broader social media outreach. Schwienbacher and Larralde [1] define crowdfunding as an Internet-based *public appeal* securing financial resources through donations or exchanges for rewards or voting rights supporting defined initiatives. Similarly, Belleflamme et al. [2] characterize crowdfunding as a process of raising capital from numerous contributors, each providing relatively modest amounts, to finance project

development. Building upon this existing scholarship, this study conceptualizes crowdfunding as an innovative financing model whereby project creators leverage Internet platforms to secure relatively small contributions from a large pool of individuals to fund their ventures [3].

Online crowdfunding represents the predominant form and a vital funding channel for businesses and individuals. Compared to traditional mechanisms, it offers low entry barriers, rapid execution, and enhanced diversity. Participants extend beyond enterprises, enabling individuals with innovative ideas to serve as creators or backers. Online crowdfunding encompasses broad project categories, categorized into four types: charity-based, debt-based, reward-based, and equity-based [3]. Reward-based crowdfunding constitutes the most prevalent form, encompassing cultural creativity, agricultural technology, and food industry sectors. Contributors receive non-monetary rewards, including film credits, commemorative items, or exclusive creator meetings. Charity-based contributors receive no returns, representing altruistic consumption that provides psychological satisfaction from philanthropic engagement. These campaigns address healthcare, environmental protection, education, disaster relief, and poverty alleviation. Debt-based projects operate on predetermined return principles, while equity-based crowdfunding enables direct securities investment with profit stakes [4]. Given debt- and equity-based crowdfunding's sophisticated financial behaviors and complex regulatory frameworks, these fall outside this study's scope.

Crowdfunding ecosystems comprise three essential components: platforms, creators, and crowds [5], collectively enabling project implementation. Prominent platforms include Kickstarter, GoFundMe, Facebook, Sina Weibo, and Tencent Charity. Most reward-based platforms operate "all-or-nothing" models, where creators establish funding targets and durations. Meeting predetermined goals by deadlines yields success and full funding; otherwise, projects fail with refunded contributions. Research demonstrates that platforms function as critical catalysts stimulating supporter contributions [6]. Project creators designate registered users with verified credentials to launch campaigns. Creators encompass individuals, legal entities, and organizations, with project-specific roles potentially shifting to donors/supporters. Scholarship has investigated various creator characteristics, including gender [7], project experience [8], educational attainment [9], social prominence, occupation, and professional status. These factors significantly influence outcomes. Borrero-Domínguez et al. [9] showed that gender, experience, and education substantially impact performance. Similarly, García and Welter [10] found that male-initiated projects exhibited higher success rates than female-initiated campaigns. Vismara [11] further revealed that despite comparable abilities to attract supporters, female creators typically secured lower funding amounts relative to their male counterparts. Contemporary research on project funders primarily examines motivational differences across various contributor categories. This body of literature focuses on the diverse funding motivations that drive different types of crowdfunding participants [12–14]. Research indicates that reward-based contributors are predominantly motivated by non-monetary intrinsic factors [15], whereas charity-based participants are driven by altruistic self-fulfillment, social recognition aspirations, and interaction requirements [6, 16, 17].

Academic research predominantly examines crowdfunding projects' inherent characteristics. Substantial attention is given to investigating how descriptions, images, deadlines, target amounts, and observable launch characteristics impact

performance. To elucidate the effects of project characteristics and their underlying mechanisms, this study categorizes the influence of project content elements and structural elements into two distinct dimensions: project appeal and presentation. Content elements correspond closely to advertising appeal-level factors, encompassing primarily human-generated and curated information, including the principal project description, images, and project progress updates. Structural elements consist of objective, fact-based information reflecting fundamental characteristics like project category, contributor numbers, and targets. Given that some platforms directly present creator information, this data is incorporated within the structural element analysis.

This chapter adopts an integrative, theory-driven literature review methodology to synthesize existing knowledge on crowdfunding project features and outcomes. We systematically identified relevant studies through targeted keyword searches (e.g., “crowdfunding success”) across major academic databases and cross-referenced citations of key papers. The selection focused on peer-reviewed articles and conference proceedings that empirically examine how project content elements and project structural elements influence crowdfunding effectiveness. We then employed a concept-centric approach to organize the literature by major themes, grouping findings into content-related versus structural-related factors. Throughout the review process, multiple theoretical frameworks were used as integrative lenses to interpret and connect findings. The theoretical framework diagram is shown in **Figure 1**.

2. Project content elements

2.1 Impact of linguistic information

2.1.1 Project descriptions

For crowdfunding projects, the project description serves a function analogous to advertising copy, typically encompassing project introductions, detailed disclosures, implementation plans, and appeals to potential contributors.

2.1.1.1 Emotional signals in project descriptions

Project creators strategically employ emotionally charged vocabulary in project descriptions as a persuasion mechanism. However, research findings regarding the effectiveness of emotional appeals present conflicting results. Several studies indicate that purely emotional expressions in project descriptions yield no significant impact on crowdfunding outcomes [18, 19]. This finding suggests that contributors in reward-based crowdfunding make funding decisions through rational deliberation driven by return expectations [20], indicating that their investment choices are not readily influenced by the emotional tone of project descriptions. Consistent with this perspective, Ren et al. [18] observed no significant correlation between emotional arousal in project descriptions and crowdfunding performance when examining such vocabulary as external heuristic cues influencing contributions. Conversely, utilizing identical Kickstarter platform data, Chen et al. [21] demonstrated that positive emotional bias in crowdfunding project texts constitutes the most influential factor

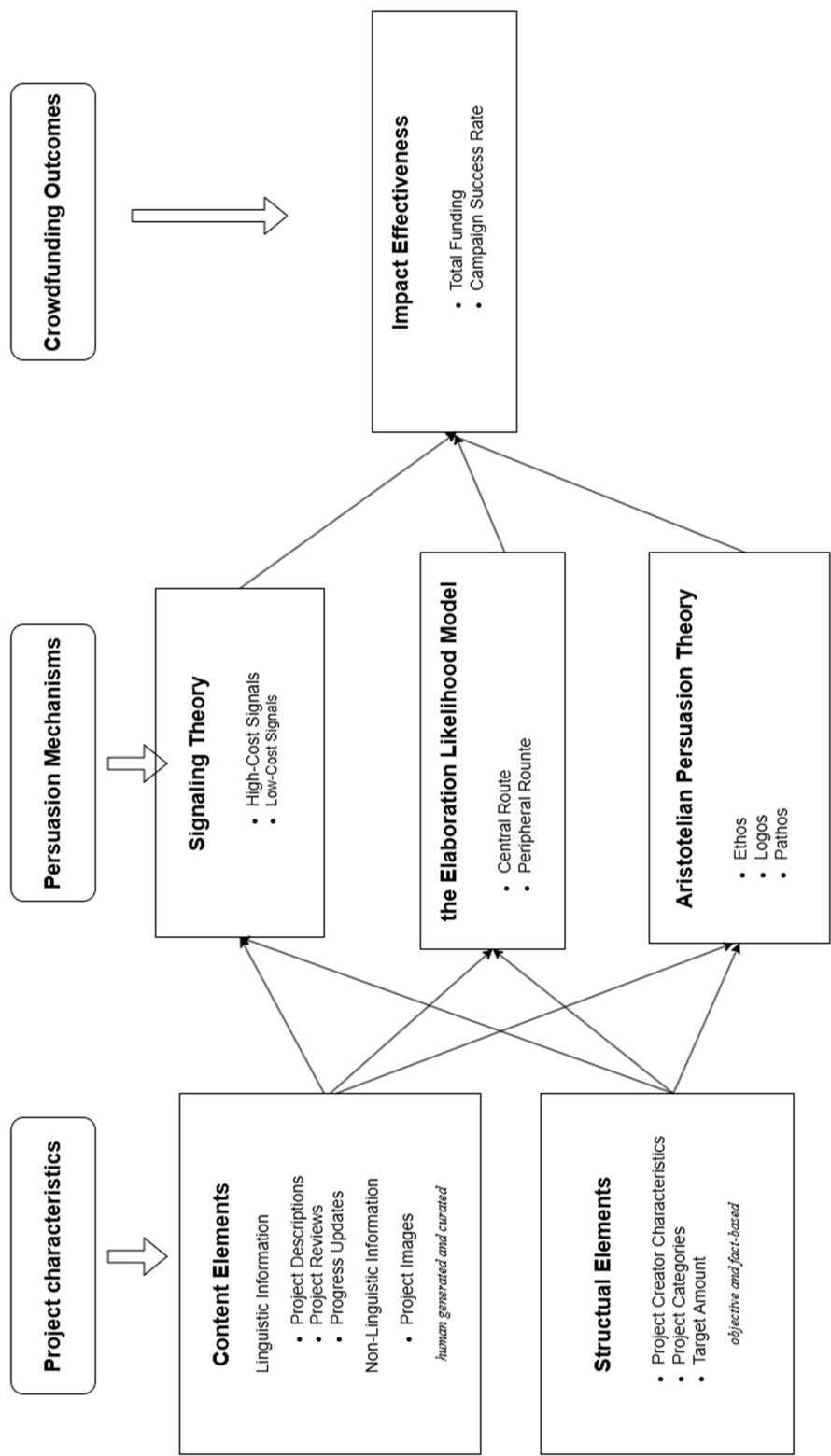


Figure 1.
The theoretical framework of crowdfunding project features and outcomes.

affecting campaign outcomes. According to their findings, emotionally rich textual expressions can bridge the emotional disconnect between crowdfunding contributors and project creators, thereby stimulating contributors' willingness to invest or increase their funding commitments. Anglin et al. [22] conceptualize positive psychological capital as comprising four dimensions: hope, optimism, resilience, and confidence. Incorporating signals reflecting these dimensions in reward-based crowdfunding content communicates the creator's conviction regarding project viability and outcome expectations, thereby more effectively motivating and persuading stakeholders to recognize the project's value proposition. These seemingly contradictory findings can be reconciled by examining the functional role of emotional information embedded in project descriptions. When creators' emotional descriptions serve not merely to express personal sentiments but function as strategic signals conveying positive psychological capital to attract and stimulate favorable stakeholder evaluations, such emotional signals may exert substantial influence on project outcomes.

2.1.1.2 Objectivity in project descriptions

Objective and subjective descriptions constitute two distinct narrative approaches in crowdfunding communications. Objective descriptions align more closely with factual reality [23], emphasizing factual statements, numerical data, statistical evidence, and other verifiable information [24, 25]. In contrast, subjective descriptions resemble evaluative judgments, incorporating emotions, perceptions, personal experiences, assessments, and interpretations, often characterized by greater creativity [26, 27]. As a signal observability mechanism, subjective descriptions enable potential contributors to assess and differentiate project quality; however, they impose higher cognitive processing demands, requiring recipients to expend greater mental effort to interpret the information [25, 28]. Conversely, objective narratives can reduce uncertainty and thereby enhance the likelihood of contributor funding decisions [19, 29]. Hamelin [30] demonstrated that emotional narratives facilitate more rapid attitudinal changes, whereas cognitive statements promote deeper comprehension and enhanced memory retention. Existing research indicates that subjective linguistic styles provide greater advantages than objective approaches in project titles, project descriptions, and creator introductions. Objective language proves more effective for project summaries and reward statements. However, optimal project descriptions should integrate both subjective and objective linguistic strategies, presenting factual information initially, followed by subjective elements to maximize persuasive impact.

2.1.1.3 Trigger cues in project descriptions

Project descriptions incorporating specific contextual cues may generate targeted psychological responses, thereby enhancing the probability of crowdfunding success. For instance, Goff et al. [31] investigated the influence of monetization information in project descriptions on prosocial behavior and charitable contributions, finding that control groups without monetary incentives demonstrated greater willingness to contribute to environmental charity-based crowdfunding campaigns. Conversely, information regarding ecosystem service valuation – specifically, the assignment of monetary worth to non-monetary

resources – negatively affected pro-environmental behavior. This phenomenon likely results from monetary information triggering cognitive priming effects that activate recipients' self-interested motivations and promote rational consumption patterns rather than civic engagement, consequently diminishing the perceived intrinsic value of prosocial activities [32, 33]. Within charity-based campaigns, the potential consequences of non-contribution constitute loss-framed cues, whereas the positive outcomes of donating represent gain-framed cues. Research demonstrates that loss-framed cues produce superior donation outcomes compared to equivalent gain-framed appeals. Studies indicate that narrative frameworks employing loss-framed messaging achieve enhanced fundraising performance relative to those utilizing exclusively gain-framed appeals or purely factual presentations [34].

2.1.1.4 Narrative perspective in project descriptions

The narrative style employed in project descriptions significantly influences campaign persuasiveness [35]. Research examining reward-based crowdfunding demonstrates that first-person narratives enhance textual affinity and reduce psychological distance between creators and readers, while second-person narratives increase reader engagement and interactivity [21]. Positive emotional experiences among project supporters during crowdfunding campaigns can cultivate altruistic tendencies and generate empathetic responses [36, 37]. Robiady et al. [37] investigated the influence of narrative voice in story-driven project descriptions, revealing that when incorporating quoted material within storytelling frameworks, direct quotations employing a first-person perspective evoked more intense emotional responses and produced superior crowdfunding outcomes compared to indirect quotations utilizing third-person narration.

2.1.1.5 Project description word count

The elaboration likelihood model (ELM) represents a widely utilized theoretical framework in consumer psychology, advertising, and marketing communications research, providing valuable insights into individual attitude formation and change [38]. This model conceptualizes information processing through two distinct pathways: the central route and the peripheral route. The central route is characterized by rational cognition and systematic logical evaluation, whereas the peripheral route facilitates information processing when recipients possess limited interest or cognitive capacity. Bi et al. [39] theorize that project description length functions as a quality signal, operating as a central route indicator within the ELM framework. They subsequently evaluated its influence on crowdfunding investment decisions. Within reasonable parameters, increasing description length enables audiences to access more comprehensive project information, thereby reducing information asymmetries and enhancing stakeholder trust. However, Moy, Chan, and Torgler [40] observed that excessive information provision negatively affects fundraising processes and engagement intentions, with project descriptions exceeding optimal word limits typically experiencing diminished success rates. Empirical research utilizing GoFundMe platform data demonstrates that projects featuring descriptions of 600–900 words achieve the highest success probabilities [41].

2.1.2 Project reviews

Project reviews encompass both verbal commentary in interpersonal interactions and online customer reviews (OCR). The latter primarily refers to consumer-generated evaluations of products or services based on direct usage experience. These reviews are typically disseminated online through textual content and numerical ratings, frequently incorporating descriptions of product characteristics (quality or attribute features), user experiences, consumer sentiments, and recommendation guidance [42, 43]. As a critical component of electronic word-of-mouth communication, these reviews often influence audience behavior and significantly impact purchasing decisions among potential users.

2.1.2.1 Comment volume

The volume of comments on crowdfunding projects reflects the degree of public attention they receive and serves as an indicator of supplementary information availability for potential contributors [44]. According to attention economy principles, substantial comment activity can enhance project visibility and differentiation [44]. Comments function as social signals, indicating others' interest in and engagement with a project. Increased comment volume not only provides potential contributors with more comprehensive project information but also enables them to assess project viability based on collective opinions and attitudes [8]. When evaluating projects, individuals are subject to direct and indirect social influence from other group members, reflecting conformity behavior patterns. Research demonstrates that conformity effects can amplify prosocial behaviors, including charitable donations [45, 46]. Consequently, elevated comment activity can stimulate participation in charity-based crowdfunding campaigns. Bao and Huang [47] argue that the number of project comments, update frequency, and visual presentation constitute critical components of impression management strategies. These elements can influence crowdfunding contributors through peripheral processing mechanisms, enhancing their perceptions of project credibility and consequently improving campaign outcomes [39].

2.1.2.2 Comment sentiment

Potential contributors not only consider the volume of comments but also examine existing commentary to assess collective attitudes and opinions. The sentiment embedded within project comments serves as a signal indicating the attitudes of other potential supporters. Under social conformity influences, positive sentiment conveyed through comments can diminish potential contributors' risk perceptions, thereby enhancing their willingness to participate in crowdfunding campaigns or make charitable donations. Conversely, negative sentiment amplifies uncertainty and perceived risk [8]. Wang et al. [48] demonstrated that projects characterized by predominantly negative commentary – indicating widespread dissatisfaction among existing supporters – partially counteract the beneficial effects of comment volume on crowdfunding success.

2.1.3 Progress updates

Updates serve to maintain continuous communication with contributors regarding project advancement, enabling project creators to provide real-time information about ongoing developments. Timely status updates not only demonstrate creators' proactive engagement [47] but also signal smooth project progression, thereby reducing contributors' perceived risk of project failure [49]. Liu et al. [44] contend that project updates function as indicators of project reliability and credibility. Frequent updates enable stakeholders to monitor crowdfunding progress in real time, enhance project transparency, and ultimately cultivate greater stakeholder trust.

Project updates typically manifest as textual communications encompassing various dimensions, including appeal sharing, progress reports, new concept announcements or disclosures, deadline reminders, interactive Q&A sessions, reward introductions, and contributor acknowledgments. These updates are generally accessible through web crawling technologies and are commonly employed as control variables in contemporary crowdfunding research [19, 25, 50, 51]. Xu et al. [52] demonstrated that progress updates exert greater influence on project success than initial project descriptions, exhibiting stronger correlations with success rates. Updates pertaining to deadline reminders and new reward offerings produced the most substantial impact on crowdfunding outcomes.

2.2 Impact of non-linguistic information: Project images

The influence of non-linguistic information in crowdfunding projects primarily centers on the role of visual imagery in campaign performance. Project images function as non-textual descriptive elements and visual representations within crowdfunding campaign pages, serving as distinct communicative tools separate from textual content. Crowdfunding platforms typically accompany each heading section with relevant project images to further illustrate project details, enhance page content richness, and effectively capture visitors' attention. Scholarly research investigating this phenomenon [4, 19, 44, 47, 51] has demonstrated that certain characteristics of project images – including their emotional signals and volume – significantly influence campaign outcomes and success rates.

2.2.1 Emotional signals in project images

The emotions evoked or conveyed through project imagery significantly influence potential contributors' donation decisions and behavioral responses. When potential supporters perceive sadness in visual content, it more readily triggers empathetic responses compared to joyful emotions, thereby increasing the probability of donation decisions and charitable behaviors [53]. From a theoretical perspective, negative framing in charity-based crowdfunding campaigns is more likely to evoke individual anxiety, capturing the attention and emotional resonance of potential donors [54]. Indeed, Lee and Park [4] validated this hypothesis through deep learning and econometric analysis of projects from a Korean public welfare crowdfunding platform, demonstrating that positive emotions evoked by project images can suppress potential donors' empathetic responses. However, potential

contributors may experience emotional fatigue from repeated exposure to negative images across multiple projects. Consequently, in certain circumstances, project images that convey or evoke negative emotions may fail to enhance donation intentions or promote charitable behavior. The emotional content expressed in project imagery affects different crowdfunding categories differentially. In contrast to charity-based campaigns, positive emotions displayed in reward-based crowdfunding project images are more effective than negative emotions in triggering investment decisions or behaviors [51]. Furthermore, facial emotions depicted in project imagery exhibit an inverted U-shaped relationship with investment decisions [51]. Moderate emotional expression can encourage contributor investment; however, the influence of facial emotional contagion does not increase indefinitely. This limitation occurs because highly intense emotional displays are perceived as irrational [55], generating skepticism regarding project authenticity and credibility. Consequently, when emotional intensity reaches its peak, it can produce counterproductive effects on investment decisions. While both happy and sad facial expressions promote investment decisions in reward-based crowdfunding, sad expressions demonstrate smaller impacts on total investment amounts and reach their inflection point earlier than happy expressions [51].

2.2.2 Number of images

Compared to textual content, imagery and video content provide greater visual impact and persuasive efficacy, enabling audiences to intuitively comprehend a project's scope and influence. Previous research demonstrates that appropriately integrated text-image combinations enhance audiences' cognitive and emotional processing capabilities, increasing preference for products or services and strengthening purchase intentions [56]. Furthermore, dynamic media formats (such as video or animated images) elicit significantly more robust interactive responses than static media formats (such as text alone) [19, 57]. The influence of project image quantity manifests through two primary mechanisms: first, images supplement and corroborate textual content, thereby enhancing perceived project credibility and reliability [44]; second, they serve aesthetic and attention-capturing functions, attracting and sustaining audience engagement [19, 47]. Concerning optimal image quantity, existing research indicates that within certain parameters, increased image volume produces more pronounced positive effects. However, empirical studies have not yet established the precise threshold or optimal range that maximizes campaign effectiveness.

3. Project structural elements

3.1 Project creator characteristics

Crowdfunding platforms, such as Kickstarter, incorporate dedicated sections for creator information, displaying relevant biographical details and communication channels. These creator characteristics constitute a fundamental project structural element, prominently featured on campaign webpages. Given that reward-based crowdfunding involves anticipated returns, and many platforms implement an “all-or-nothing” funding model, project contributors place

substantial emphasis on campaign success probability. Consequently, creator characteristics are likely to emerge as significant determinants in project investment decision-making processes.

3.1.1 Project initiation experience of the creator

Project initiation experience serves as a significant indicator of creators' capacity to successfully implement campaigns [58]. Experienced creators who have launched multiple projects can leverage insights from both successful and unsuccessful ventures to enhance their entrepreneurial capabilities, better understand investor requirements, and reduce information asymmetries or knowledge gaps during project implementation [8, 59]. Compared to novice creators, experienced practitioners possess a deeper comprehension of the prerequisites for successful fundraising and reward fulfillment [22]. This expertise enables them to develop comprehensively detailed strategic plans and optimize tactical approaches during the initial phases of new campaigns [8], thereby facilitating more efficient project execution. Borrero-Domínguez et al. [9] empirically demonstrated that project initiation experience significantly increases the probability of achieving minimum funding targets and enhances perceived project credibility. Furthermore, creators with greater crowdfunding experience demonstrate enhanced risk mitigation capabilities, resulting in higher campaign success rates.

3.1.2 Creator's gender

Due to the influence of gender stereotypes and gendered perceptions of competence, creator gender significantly affects crowdfunding campaign outcomes. During project evaluation processes, individuals may perceive female creators as possessing lower risk management capabilities, consequently placing greater trust in male-initiated projects and demonstrating a stronger propensity to support such ventures. This differential treatment contributes to higher success rates for male-initiated campaigns [10]. For female creators, project contributors exhibit heightened emphasis on physical appearance characteristics. Duan et al. [7] employed machine learning-based facial detection technology to measure four indicators of facial trustworthiness: inner brow ridge angle, chin width, facial roundness, and lip-nose distance. Their findings revealed that project funders assigned significantly greater importance to facial credibility metrics for female creators compared to their male counterparts.

3.1.3 Support experience of project creators

Project creators develop social networks through mutual support across different campaigns [8]. In reward-based crowdfunding contexts, the number of projects supported by a creator serves as an indicator of their accumulated social capital [22, 47], representing resources acquired through social connections established during previous project implementations. Zheng et al. [60] identified a reciprocity mechanism operating among project creators within and across platforms: when creators receive funding support from other project creators on a particular platform, they experience a sense of obligation or responsibility to assist creators who had previously supported their campaigns. However, comparative analysis

reveals that creator initiation experience exerts significantly greater influence on crowdfunding project success than creator support experience.

3.2 Project categories

Charity-based crowdfunding projects are typically classified into several primary thematic categories: poverty alleviation and disaster relief, medical treatment, educational assistance, and environmental protection. While these categories share common charitable objectives, they demonstrate distinct performance characteristics [8]. Empirical evidence from Tencent GongYi, China's largest charity-based crowdfunding platform, illustrates these categorical variations: medical treatment projects represent the most prevalent category yet exhibit the lowest success rate (21.7%); conversely, environmental protection projects constitute the smallest category but achieve the highest average donation amount (¥60,391) and maintain a relatively elevated success rate (50%) [61]. Despite these notable performance disparities across charitable crowdfunding categories, existing literature demonstrates a significant research gap regarding the underlying factors that drive these differential outcomes.

Compared to charity-based crowdfunding, reward-based crowdfunding encompasses significantly more diverse project categories, each addressing distinct consumer requirements and preferences. Within reward-based crowdfunding contexts, project categories frequently function as moderating variables that indirectly influence contributor investment decisions. For example, Bi et al. [39] demonstrated that investors evaluating agricultural technology crowdfunding projects prioritize project quality signals over reputation information, whereas reputation assumes greater importance when assessing entertainment and arts crowdfunding campaigns. Reward-based crowdfunding projects can be classified into hedonic and utilitarian categories based on the fundamental nature of the crowdfunded product or service. Hedonic projects primarily address emotional and experiential needs, while utilitarian projects provide functional convenience and practical benefits. Ren et al. [18] found that emotional arousal embedded in project descriptions exerts significantly greater impact on crowdfunding success for hedonic projects compared to utilitarian ventures. Reward-based crowdfunding can also be categorized into tangible product and intangible service crowdfunding [19, 47]. Furthermore, scholars have developed alternative taxonomies distinguishing between tangible product and intangible service crowdfunding [19, 47]. For instance, Bao and Huang [47] categorized cultural and creative projects within reward-based crowdfunding into tangible publications and intangible audiovisual productions. They argued that due to spatial limitations in publication formats, reward feedback mechanisms appear more valuable to contributors, resulting in heightened investment willingness for tangible publication projects and consequently superior success rates. These findings collectively demonstrate that project categories constitute significant determinants of crowdfunding performance outcomes.

3.3 Target amount

When initiating crowdfunding campaigns, creators establish a target amount to facilitate potential contributors' understanding of required funding levels and enable

real-time progress monitoring. While this target amount is subjectively determined by creators and could be considered a content element, its primary function is to reflect the costs necessary for project completion, thereby serving as an objective indicator of implementation complexity. Consequently, this analysis provisionally categorizes target amounts as structural elements.

Target amounts exert substantial influence on campaign outcomes, with project success significantly dependent on the rationality of goal-setting strategies. Research presents competing perspectives on optimal target levels. Some scholars argue that lower target amounts enhance contributor engagement by appearing more attainable [44, 62]. Conversely, others contend that higher targets present greater challenges that can evoke stronger empathetic responses, particularly in medical crowdfunding contexts, thereby increasing willingness to contribute to ambitious campaigns [63]. According to goal-setting theory, motivation derives from challenging objectives, with performance enhancement correlating positively with goal difficulty. However, empirical evidence reveals complex relationships between target amounts and crowdfunding outcomes across different project categories. For disease or health-related crowdfunding campaigns, the beneficial impact of project visibility – particularly social engagement metrics such as shares and comments – diminishes progressively as target funding amounts increase [44]. Conversely, environmental projects demonstrate a nonlinear relationship between target amounts and donation outcomes, wherein low-to-medium targets exert minimal influence on project success, while high-target configurations potentially generate more substantial positive effects [63].

Given that strategic goal-setting can stimulate motivation and provide strong incentive effects, project creators may benefit from strategically employing the anchoring heuristic [64]. By establishing high-value goals as cognitive reference points or psychological anchors, creators can potentially maximize contributors' willingness to participate and their motivational engagement, thereby enhancing the overall performance of crowdfunding campaigns.

4. Persuasion mechanisms of content and structural elements

4.1 Signaling theory

Signaling theory was initially formulated by Spence [65] to elucidate how job applicants reduce information asymmetries with prospective employers through observable characteristics and behaviors. Subsequent scholarly investigations have extensively examined how effective signaling mechanisms can mitigate such informational disparities across various contexts. The theoretical framework posits that signal effectiveness is determined by two fundamental factors: signal cost and signal observability.

In crowdfunding campaigns, signal costs manifest in the prevention of competitors from forging or imitating comparable signals. High-cost signals establish effective separation mechanisms between high-quality and low-quality projects [66], constituting what is termed “hard information.” These signals primarily encompass project structural elements – including creator characteristics, project categories, target amounts, and beneficiary counts – which function as critical indicators of project quality and authenticity. Displayed factually on campaign

webpages, this “hard information” cannot be manipulated by creators and proves difficult for competitors to replicate, thereby qualifying as legitimate high-cost signals that effectively communicate project credibility.

Low-cost signals possess diminished value compared to high-cost signals due to their susceptibility to imitation and replication. Project content elements encompass signals such as project titles, descriptions, and visual images – all creator-defined components. These signals constitute “soft information” that reflects creators’ strategic positioning and promotional attitudes during campaign development [8]. Project creators can transmit these signals through strategic design choices when launching campaigns, including suggesting positive psychological capital through text [22], incorporating objectification cues within abstracts and reward statements [25], evoking emotional responses through narrative perspective manipulation [37], or utilizing imagery of distressed beneficiaries to elicit empathetic responses [4]. Despite their classification as low-cost signals within crowdfunding contexts, these content elements retain significant capacity to stimulate financial contributions from project backers.

Signal observability facilitates project quality differentiation and enables investors to accurately assess campaign characteristics. Wang et al. [25] investigated signal observability mechanisms, demonstrating that accurate signal perception enables receivers to comprehend signal content effectively. Regarding content elements, subjective descriptions impose higher cognitive processing demands, requiring greater interpretive effort from signal receivers. Information presentation that deviates from objectivity represents a double-edged phenomenon: while it may reflect project creativity and innovation, fictionalized or embellished descriptions can simultaneously diminish signal observability and clarity. Within information-asymmetric environments characterized by high noise levels, both signal categories can experience moderation effects [22]. Consequently, both content characteristics (low-cost signals) and structural characteristics (high-cost signals) exert significant influence on crowdfunding campaign performance outcomes.

4.2 The elaboration likelihood model

The elaboration likelihood model constitutes a comprehensive theoretical framework for explaining attitude formation and change, frequently employed in consumer psychology and behavioral research. This model conceptualizes two distinct pathways for information processing: the central route and the peripheral route. In advertising contexts, emotional cues and heuristic shortcuts are employed to facilitate purchase intentions. In essence, the central route involves systematic, rational cognition and logical evaluation, whereas the peripheral route facilitates information processing when recipients possess limited interest or cognitive resources.

Structural elements in crowdfunding contexts can effectively characterize project quality and credibility. However, the structural and content elements of crowdfunding campaigns do not exhibit a straightforward correspondence with the central and peripheral routes within ELM theory. Certain content elements may theoretically align more closely with peripheral route processing, including vivid images or visually striking presentations designed to capture audience attention, as well as emotional appeal strategies and affective cues embedded within project descriptions. Conversely, substantive content elements – such as comprehensive

supporting images that provide detailed project information or extensive project descriptions that offer thorough explanations – could be categorized as facilitating central route processing. The majority of structural elements, given their factual nature and role as quality indicators, predominantly correspond to central route processing mechanisms.

The influence mechanisms underlying crowdfunding processes can be effectively explained through the ELM framework. Crowdfunding campaign pages function as persuasive communications strategically designed to attract potential contributors and stimulate financial support. Since investors must process and evaluate project information before making funding decisions, project creators deploy comprehensive strategies to capture and maintain audience attention [38]. Given the relatively low complexity and financial risk associated with charity-based crowdfunding – which fundamentally differs from traditional consumer purchasing behavior – the ELM demonstrates greater theoretical relevance and empirical utility specifically within reward-based crowdfunding research contexts [38].

4.3 Aristotelian persuasion theory

Aristotle delineated three fundamental persuasion modes in *Rhetoric*: ethos, logos, and pathos. Ethos involves demonstrating knowledge, moral character, competence, and integrity to establish psychological identification and audience trust. Logos requires persuasive discourse to withstand logical scrutiny for credibility. Pathos necessitates evoking audience emotions through affective elements. This classical framework profoundly influenced Western persuasion theory, establishing foundational principles for contemporary research.

In crowdfunding, creators assume persuader roles, while contributors serve as target audiences. Structural information is presented as verifiable data on platform webpages. Creator experience reflects accumulated social and human capital [22], while substantial supporter bases can attract additional participants through herding effects [63]. These elements indirectly demonstrate professionalism and reliability through reputation mechanisms, establishing psychological identification and trust among contributors, exemplifying ethos-based persuasion. Content elements encompass both linguistic and non-linguistic information that facilitate logos and pathos persuasion. When structuring text, creators employ logical expressions (connective devices) or present verifiable objective information, including facts, statistical data, and empirical evidence [19, 24]. These approaches reduce cognitive processing demands, enabling efficient comprehension of project details through logos-based persuasion mechanisms. Both verbal and non-verbal elements can facilitate pathos-based persuasion strategies. Through strategic emotional cues, creators leverage emotional contagion effects to encourage potential contributors to mirror, respond to, and internalize these emotional states [51], cultivating empathetic responses toward campaign emotional appeals.

4.4 Theoretical contributions of the integrated framework

The integrated framework makes two key theoretical contributions to the crowdfunding literature. First, it reconciles seemingly contradictory findings in existing research. Previous studies using single theories have produced inconsistent results regarding the effects of project characteristics. For example, emotional

descriptions enhanced performance in some studies [21] but showed negligible or negative effects in others [18, 19]. Our framework reveals that the effectiveness of emotional appeals depends on the project category (charity vs. reward-based), emotional valence, and backers' processing mode (central vs. peripheral route), thus clarifying the boundary conditions.

Second, the framework provides a dynamic, context-sensitive explanatory model. Rather than seeking universal determinants, it demonstrates that the effects of project characteristics are embedded within a complex causal network, shaped by multiple theoretical mechanisms whose relative weights vary across contexts. This dynamic perspective better captures the complex reality of crowdfunding and offers a more nuanced analytical framework.

5. Research prospects

5.1 Deepening the impact of linguistic and non-linguistic information integration on crowdfunding outcomes

Dual-coding theory posits that linguistic and non-linguistic information operate through distinct cognitive systems: verbal systems process linguistic and abstract content, while imagery systems handle perceptual and concrete matters, functioning as independent yet interconnected mechanisms [67]. Project descriptions and visual imagery in crowdfunding represent different symbolic modalities, triggering distinct cognitive processes when contributors evaluate campaigns. However, limited research has systematically examined descriptions and visuals jointly to investigate their combined impact on funding decisions and interactive mechanisms. Literature suggests high visual-textual congruence enhances cognitive and emotional processing, strengthening consumer preferences and purchase intentions [56]. Additionally, textual-visual relevance exerts pronounced influences on cognitive processing among field-dependent audiences [68]. Future research should systematically investigate text-image integration strategies in crowdfunding communications, focusing on optimal matching mechanisms, contextual moderation effects, and differential impacts across contributor segments.

5.2 Exploring the influence of different investor categories on various types of crowdfunding projects

Previous research predominantly examined outcomes from crowdfunding information disclosure formats. However, factors influencing strategic disclosure decisions have received limited attention. Consequently, investigating disclosure format antecedents represents valuable future research. Investor characteristics may function as critical antecedent variables affecting campaign disclosure strategies. To optimize engagement and stimulate investment intentions, strategic element combinations on project pages require systematic examination. Communicative element effectiveness varies according to audience cultural familiarity. Research indicates text-dominant descriptions demonstrate superior effectiveness for culturally unfamiliar audiences, while image-dominant presentations prove more effective for culturally familiar audiences [69]. Investigating which projects attract specific investor segments or personality profiles constitutes another valuable

research domain. Self-determination theory [70] encompasses intrinsic and extrinsic motivational dimensions. Alternatively, motivation can be categorized as self-directed or other-directed orientations [71]. This motivational framework generates four distinct crowdfunding contributor typologies: angelic backers, reward hunters, avid fans, and tasteful hermits [17]. For creators, effective dissemination requires anticipating audience characteristics and developing tailored strategies aligning with diverse investor profiles to enhance success rates. Future research should systematically investigate audience-strategy alignment mechanisms, examining how different typologies respond to varied information formats and persuasion approaches across crowdfunding categories.

Funding

This research did not receive external funding from any agencies.

Ethical statement

Not applicable.

Conflict of Interest

The authors declare no conflict of interest.

Author details

Yimeng Zhai
School of Psychology, Nanjing Normal University, Nanjing, China

*Address all correspondence to: yimeng.zhai@hotmail.com

IntechOpen

© 2025 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Schwienbacher A, Larralde B. Crowdfunding of small entrepreneurial ventures. In: Cumming D, editor. *The Oxford Handbook of Entrepreneurial Finance*. Oxford: Oxford University Press; 2012. p. 369–391
- [2] Belleflamme P, Lambert T, Schwienbacher A. Crowdfunding: Tapping the right crowd. *Journal of Business Venturing*. 2014;**29**(5): 585–609
- [3] Mollick E. The dynamics of crowdfunding: An exploratory study. *Journal of Business Venturing*. 2014;**29**(1): 1–16
- [4] Lee D, Park J. The relationship between a charity crowdfunding project's contents and donors' participation: An empirical study with deep learning methodologies. *Computers in Human Behavior*. 2020;**106**: 106261
- [5] Zhang H, Chen W. Backer motivation in crowdfunding new product ideas: Is it about you or is it about me? *Journal of Product Innovation Management*. 2019;**36**(2):241–262
- [6] Bagheri A, Chitsazan H, Ebrahimi A. Crowdfunding motivations: A focus on donors' perspectives. *Technological Forecasting and Social Change*. 2019;**146**:218–232
- [7] Duan Y, Hsieh T, R WR, et al. Entrepreneurs' facial trustworthiness, gender, and crowdfunding success. *Journal of Corporate Finance*. 2020; **193**: 01693
- [8] Jiang C, Han R, Xu Q, et al. The impact of soft information extracted from descriptive text on crowdfunding performance. *Electronic Commerce Research and Applications*. 2020;**43**:101002
- [9] Borrero-Domínguez C, Cordón-Lagares E, Hernández-Garrido R. Analysis of success factors in crowdfunding projects based on rewards: A way to obtain financing for socially committed projects. *Heliyon*. 2020;**6**(4):e3744
- [10] D GM, Welter F. Gender identities and practices: Interpreting women entrepreneurs' narratives. *International Small Business Journal: Researching Entrepreneurship*. 2013;**31**(4):384–404
- [11] Vismara S. Equity retention and social network theory in equity crowdfunding. *Small Business Economics*. 2016;**46**(4):579–590
- [12] Kim MJ, Hall CM. What drives visitor economy crowdfunding? The effect of digital storytelling on unified theory of acceptance and use of technology. *Tourism Management Perspectives*. 2020;**34**:100638
- [13] Sasaki S. Majority size and conformity behavior in charitable giving: Field evidence from a donation-based crowdfunding platform in Japan. *Journal of Economic Psychology*. 2019;**70**:36–51
- [14] Strohmaier D, Zeng J, Hafeez M. Trust, distrust, and crowdfunding: A study on perceptions of institutional mechanisms. *Telematics and Informatics*. 2019;**43**:1–21
- [15] H AT, C DB, C SJ, et al. Crowdfunding in a prosocial microlending environment: Examining

the role of intrinsic versus extrinsic cues. *Entrepreneurship Theory and Practice*. 2015;**39**(1):53–73

[16] Jian L, Shin J. Motivations behind donors' contributions to crowdfunded journalism. *Mass Communication and Society*. 2015;**18**(2):165–185

[17] Ryu S, Kim Y. A typology of crowdfunding sponsors: Birds of a feather flock together? *Electronic Commerce Research and Applications*. 2016;**16**:43–54

[18] Ren J, Raghupathi V, Raghupathi W. Exploring the subjective nature of crowdfunding decisions. *Journal of Business Venturing Insights*. 2021;**15**:e233

[19] Tafesse W. Communicating crowdfunding campaigns: How message strategy, vivid media use and product type influence campaign success. *Journal of Business Research*. 2021;**127**:252–263

[20] Agrawal A, Catalini C, Goldfarb A. Some simple economics of crowdfunding. *Innovation Policy and the Economy*. 2014;**14**(1):63–97

[21] Chen J, Liang H, Qian C. Studying investment decisions of rewarded crowdfunding users with emotional distance and text analysis. *Data Analysis and Knowledge Discovery*. 2021;**5**(4):60–71

[22] H A, C SJ, Drover W, et al. The power of positivity? The influence of positive psychological capital language on crowdfunding performance. *Journal of Business Venturing*. 2018;**33**(4):470–492

[23] Boudana S. A definition of journalistic objectivity as a

performance. *Media, Culture and Society*. 2011;**33**(3):385–398

[24] H AT, C DB, W WJ, et al. Persuasion in crowdfunding: An elaboration likelihood model of crowdfunding performance. *Journal of Business Venturing*. 2017;**32**(6):707–725

[25] Wang W, He L, J WY, et al. Signaling persuasion in crowdfunding entrepreneurial narratives: The subjectivity vs objectivity debate. *Computers in Human Behavior*. 2021;**114**:106576

[26] González Rey F. The topic of subjectivity in psychology: Contradictions, paths and new alternatives. *Journal for the Theory of Social Behaviour*. 2017;**47**(4):502–521

[27] Thompson NA. Imagination and creativity in organizations. *Organization Studies*. 2018;**39**(2-3):229–250

[28] Paas F, Renkl A, Sweller J. Cognitive load theory and instructional design: Recent developments. *Educational Psychologist*. 2003;**38**(1):63–71

[29] Parhankangas A, Renko M. Linguistic style and crowdfunding success among social and commercial entrepreneurs. *Journal of Business Venturing*. 2017;**32**(2):215–311

[30] Hamelin N, Thaichon P, Abraham C, et al. Storytelling, the scale of persuasion and retention: A neuromarketing approach. *Journal of Retailing and Consumer Services*. 2020;**55**:102099

[31] Goff SH, Waring TM, Noblet CL. Does pricing nature reduce monetary support for conservation?: Evidence

from donation behavior in an online experiment. *Ecological Economics*. 2017;**141**:119–126

[32] Ovaskainen V, Kniivilä M. Consumer versus citizen preferences in contingent valuation: Evidence on the role of question framing. *The Australian Journal of Agricultural and Resource Economics*. 2005;**49**(4):379–394

[33] Whillans AV, Dunn EW. Thinking about time as money decreases environmental behavior. *Organizational Behavior and Human Decision Processes*. 2015;**127**:44–52

[34] Metzger L, Günther I. Is it what you say or how you say it? The impact of aid effectiveness information and its framing on donation behavior. *Journal of Behavioral and Experimental Economics*. 2019;**83**:101461

[35] Manning S, Bejarano TA. Convincing the crowd: Entrepreneurial storytelling in crowdfunding campaigns. *Strategic Organization*. 2017;**15**(2):194–219

[36] Pansari A, Kumar V. Customer engagement: The construct, antecedents, and consequences. *Journal of the Academy of Marketing Science*. 2017;**45**(3):294–311

[37] Robiady ND, Windasari NA, Nita A. Customer engagement in online social crowdfunding: The influence of storytelling technique on donation performance. *International Journal of Research in Marketing*. 2021;**38**(2):492–500

[38] Wang Z, Yang X. Understanding backers' funding intention in reward crowdfunding: An elaboration likelihood perspective. *Technology in Society*. 2019;**58**:101149

[39] Bi S, Liu Z, Usman K. The influence of online information on investing decisions of reward-based crowdfunding. *Journal of Business Research*. 2017;**71**:10–18

[40] Moy N, Chan HF, Torgler B. How much is too much? The effects of information quantity on crowdfunding performance. *PloS One*. 2018;**13**(3): e192012

[41] C HH, L CC, Mansumittrchai S, et al. The influence of signals on donation crowdfunding campaign success during COVID-19 crisis. *International Journal of Environmental Research and Public Health*. 2021;**18**(14):7715

[42] Chatterjee P. Online reviews: Do consumers use them? *Association for Consumer Research*. 2001;**28**:129–134

[43] Chen Y, Xie J. Online consumer review: Word-of-mouth as a new element of marketing communication mix. *Management Science*. 2008;**54**(3):477–491

[44] Liu S, Cheng T, Wang H. Effects of attention and reliability on the performance of online medical crowdfunding projects: The moderating role of target amount. *Journal of Management Science and Engineering*. 2020;**5**(3):162–171

[45] Goette L, Tripodi E. Social influence in prosocial behavior: Evidence from a large-scale experiment. *Journal of the European Economic Association*. 2021;**19**(4):2372–2398

[46] Wei Z, Deng X, Zhao Z. The effect of conformity tendency on prosocial behaviors. *Advances in Psychological Science*. 2021;**29**(3):531–539

- [47] Bao Z, Huang T. External supports in reward-based crowdfunding campaigns: A comparative study focused on cultural and creative projects. *Online Information Review*. 2017;**41**(5):626–642
- [48] Wang N, Li Q, Liang H, et al. Understanding the importance of interaction between creators and backers in crowdfunding success. *Electronic Commerce Research and Applications*. 2018;**27**:106–117
- [49] Liu Z, Peng B, Ma C. Can Descriptive Information in Reward-Based Crowdfunding Affect Financing Performance? *Foreign Economics and Management*. 2018;**40**(09):84–95
- [50] Ba Z, C ZY, Zhou L, et al. Exploring the donation allocation of online charitable crowdfunding based on topical and spatial analysis: Evidence from the Tencent GongYi. *Information Processing and Management*. 2020;**57**(6):102322
- [51] Raab M, Schlauderer S, Overhage S, et al. More than a feeling: Investigating the contagious effect of facial emotional expressions on investment decisions in reward-based crowdfunding. *Decision Support Systems*. 2020;**135**:113326
- [52] Xu A, Yang X, Rao H, et al. Show me the money! An analysis of project updates during crowdfunding campaigns. *Proceedings of the SIGCHI conference on human factors in computing systems*. 2014
- [53] Small DA, Verrochi NM. The face of need: Facial emotion expression on charity advertisements. *Journal of Marketing Research*. 2009;**46**(6): 777–787
- [54] Heng S, Zhao H, Xiong J, et al. The relationship between facial emotion expression and online charity donation: A mediated moderation model. *Studies of Psychology and Behavior*. 2020;**18**(1):92–99
- [55] Cheshin A, Amit A, Van Kleef GA. The interpersonal effects of emotion intensity in customer service: Perceived appropriateness and authenticity of attendants' emotional displays shape customer trust and satisfaction. *Organizational Behavior and Human Decision Processes*. 2018;**144**: 97–111
- [56] Jaud DA, Melnyk V. The effect of text-only versus text-and-image wine labels on liking, taste and purchase intentions. The mediating role of affective fluency. *Journal of Retailing and Consumer Services*. 2020;**53**:101964
- [57] Tafesse W. Content strategies and audience response on Facebook brand pages. *Marketing Intelligence and Planning*. 2015;**33**(6):927–943
- [58] Courtney C, Dutta S, Li Y. Resolving information asymmetry: Signaling, endorsement, and crowdfunding success. *Entrepreneurship Theory and Practice*. 2017;**41**(2):265–290
- [59] Davies WE, Giovannetti E. Signalling experience & reciprocity to temper asymmetric information in crowdfunding evidence from 10,000 projects. *Technological Forecasting and Social Change*. 2018;**133**:118–131
- [60] Zheng H, Li D, Wu J, et al. The role of multidimensional social capital in crowdfunding: A comparative study in China and US. *Information and Management*. 2014;**51**(4):488–496
- [61] Yang S, Zhang C, Sang W. An analysis on charitable crowdfunding in an authoritarian regime. *Proceedings of*

the Association for Information Science and Technology. 2019;**56**(1):499–503

[62] Briers B, Pandelaere M, Warlop L. Adding exchange to charity: A reference price explanation. *Journal of Economic Psychology*. 2007;**28**(1):15–30

[63] Yang J, Liu L, Yin C. A non-linear decision model for green crowdfunding project success: Evidence from China. *International Journal of Environmental Research and Public Health*. 2019;**16**(2):187

[64] Simon M, J SS, D TJ, et al. A multi-method study of social ties and crowdfunding success: Opening the black box to get the cash inside. *Journal of Business Research*. 2019;**104**:206–214

[65] Spence M. Job market signaling. *Quarterly Journal of Economics*. 1973;**87**(3):355–379

[66] Bergh DD, Connelly Jr BL, K DJ, et al. Signalling theory and equilibrium in strategic management research: An assessment and a research agenda. *Journal of Management Studies*. 2014;**51**(8):1334–1360

[67] Li W, Zhang H. The comparison of recognizing pictures, Chinese characters and English words. *Acta Psychologica Sinica*. 1993;**25**(1):24–30

[68] Fei G, Wang X, Gong G. An eye movement study about the effect of the illustration-text relativeness on the reading of college students with different cognitive styles. *Acta Psychologica Sinica*. 2013;**45**(7):783–789

[69] Kim D, Jang SS. Ethnic food advertising formats and consumers' responses: Picture-dominant or text-dominant? *International Journal of Hospitality Management*. 2019;**82**:5–12

[70] Deci EL, Ryan RM. The general causality orientations scale: Self-determination in personality. *Journal of Research in Personality*. 1985;**19**(2):109–134

[71] Hemetsberger A. Fostering cooperation on the Internet: Social exchange processes in innovative virtual consumer communities. *ACR North American Advances*. 2002;**29**(1):354–356

Chapter 9

Crowdsourcing Career – Current Research on Career in a Boundaryless Field

Dennis Heinrich

Abstract

Digitalization and technological progress have enabled new forms of work and organizational concepts, such as crowdsourcing, clickworking, and the gig economy. New forms of work are also emerging in career management and research, particularly in discussions about concepts such as the “boundaryless career” and the “protean career.” Central aspects of the boundaryless career, such as self-control of career paths and network formation beyond traditional organizations, are reflected in the forms of platform work. However, platform work is often considered to be precarious or to involve the segmentation of work. So, from the perspective of career management or career research, particularly the boundaryless career concept, how can crowdsourcing be viewed? What is the current state of research in this area? What added value does it offer companies (clients and platform providers) and contractors? These questions will be answered by conducting a narrative literature review. Companies benefit from global access to skilled workers, innovation potential, and flexible work design by using crowdsourcing. Platform providers can promote the qualification and retention of crowdworkers through systematic training and networking opportunities. New development opportunities and a better work-life balance are opening up for employees, but risks exist due to algorithmic control, lack of social security, and high levels of self-marketization pressure. Therefore, the research concludes that new HR and management concepts must be introduced to ensure the sustainable use of the opportunities offered by platform work and guarantee fair career prospects. Overall, the combination of platform work and boundaryless careers creates potential for career management but also presents challenges. This contribution’s added value lies in defining digital work as a transformative context for career research.

Keywords: career research, career management, boundaryless career, platform economy, platform work, crowdworking, crowdsourcing, career path, career boundaries, clickworking, autonomy, self-selection

1. Introduction

Digitalization and technological progress have led to the emergence of new forms of work, such as crowdsourcing, clickworking, and the gig economy [1, 2]. These

forms of new work organization are now used in a very varied way [1, 2]. In essence, the focus is on the delegation of work steps or work packages via digital platforms, which are either location-independent, that is, online, or location-specific, that is, offline [2]. Examples of the gig economy include driving services and food delivery, which provide short-term services based on location. Crowdfunding and clickworking refer to the distribution of tasks such as data annotation, translations, and creative micro-orders online on platforms. These tasks are carried out by a large, mostly global crowd, independent of location [2].

From the perspective of career management and research, these roles offer opportunities for flexibility and autonomy, along with potential challenges such as precariousness, limited development prospects, and uncertainty [3, 4]. This chapter provides a balanced and well-informed analysis of the opportunities and risks associated with this approach.

Platform work is frequently linked to concepts such as “boundaryless career” and “protean career” because it offers high flexibility, autonomy, and the opportunity for self-directed career development [5–8].

The three core questions to answer in this contribution are as follows:

So, how can crowdsourcing be viewed from a career management or career research perspective, particularly from the boundaryless career concept?

What is the current state of research in this area?

What added value does it already offer for companies (clients and platform providers) and contractors?

The majority of literature focuses on the technological implementation details and their potential applications. From the perspectives of human resources and career research, comparatively little attention is paid to platform work [6, 9]. The objective of this paper is twofold: firstly, to provide an overview of the current state of research in this field by conducting a narrative literature review; and secondly, to identify practical uses and areas for further research.

2. Method and research design

2.1 Narrative literature reviews

Narrative literature reviews serve to address broader and more abstract questions than individual empirical studies [10]. The various objectives of such reviews range from theory development and evaluation, descriptive overviews of the state of research, problem identification, to historical accounts of theory development.

The aim of this chapter is to provide an overview of the extent to which platform work, in particular crowdworking, appears in the discourse on boundaryless careers and can be linked to this concept in order to obtain guidance on how to deal with this context-related career.

The narrative review process begins with a structured literature search for keywords. The key concepts are converted into precise keywords [10–12]. The terms *platform economy*, *crowdworking*, *crowdsourcing*, *clickworking*, and *boundaryless career*, especially their combinations, are used here. The ABI/INFORM Collection and ECONBIZ databases, along with the Google Scholar search engine, were searched for this purpose.

2.2 Inclusion criteria and selection process

In order to obtain as broad a view as possible of the topic of crowdworking in the context of boundaryless careers, no specific inclusion or exclusion criteria have been defined. The only important factor for this chapter is that the articles have been published in peer-reviewed journals. Both empirical studies and theoretical-conceptual articles and discussions in English and German are included. Publications from 2005 onwards are considered for the platform concepts. Publications from 2010 onwards are reviewed for the combination of boundaryless careers and crowdworking. Most publications on the boundaryless career concept date from the 1990s onwards. Literature that provides references to career-related arguments is added manually. This may also include some practice-oriented literature.

3. Different forms of platform work

Since around the middle of 2000, new forms of platform work have been established, such as crowdworking or the gig economy [2]. However, the field of types of platform work has become even more diverse. Therefore, the most important types are briefly defined below.

3.1 Gig economy

The gig economy is the provision of (partly app-based) short-term, location-based offline work [1, 13]. These forms of work are often found in cleaning, mobility, or delivery. The platforms act as intermediaries, setting quality standards and controlling selection and performance evaluation. Also characteristic of this area is the "just-in-time" provision of workers, who are only paid for the period in which they actually work. Flexibility for companies and contractors is high, but there is a high risk of precarious modification of work.

3.2 External crowdworking/crowdsourcing

Crowdworking or crowdsourcing includes work activities that are carried out via online platforms, regardless of location. An unlimited number of organizations and individuals are networked via the platforms, thus enabling worldwide order completion [1, 9, 13]. Some of these activities are fragmented micro-activities (microtasks), which are often monotonous or repetitive but require human judgment (e.g., photo tagging, surveys, smaller creative tasks). Crowdworking can also include larger, more complex services, such as designing logos or developing websites, designs, or strategies. Payment is often project- or task-related. The term was significantly coined by the journalist Howe [14, 15].

3.3 Clickworking

Clickworking is understood as a special form of crowdworking in which simple, repetitive activities (click work) are carried out via platforms that do not require any special knowledge or extensive skills [16]. The tasks are small-scale, sometimes

repetitive, and often monotonous. Examples include writing articles or categorizing content. The volume of work is captured and handled through digital clicks, often with minimal face-to-face interaction. In some cases, tasks can also be completed based on location [2].

3.4 Internal (enterprise) crowdsourcing

As described above, external crowdworking occurs through public platforms where the crowd consists of external, mostly anonymous (and worldwide) workers. Internal crowdworking, on the other hand, refers to the use of crowdworking methods within a company, that is, the distribution of tasks to a company's own crowd or to internal employees who network virtually [9, 17]. Internal crowdworking allows employers or clients to have greater control over the work done and is characterized by less anonymity due to the organizational involvement of the workforce [17]. Internal crowdworking uses the existing knowledge, skills, and resources of a company's internal workforce in a targeted and flexible manner, which is particularly advantageous when there is a shortage of skilled workers [9, 18, 19]. It also enables more efficient and cost-effective use of organizational human resources through the self-determined selection of tasks (self-selection mechanism) and standardization of tasks [20]. However, there are also risks of being overwhelmed by work structures that are too flexible, social isolation, and competitive pressure among employees, which can put a strain on cooperation and the working atmosphere [21].

In summary, crowdworking is primarily online-based, often small-scale work carried out by many distributed contractors, while the gig economy provides short-term, often location-based services via apps. Clickworking is a particularly repetitive, click-based, small-scale form of crowdworking. Internal crowdwork processes differ from external crowdworking in that the workforce belongs to the company and is subject to stronger control mechanisms. With the exception of internal crowdworking, you are not employed in any form and are not involved in the client's organization [17].

4. Career research – boundaryless career

The concept of a boundaryless career describes careers that are no longer tied to traditional, company-internal careers but are characterized by high mobility, self-control, and flexibility [22].

The boundaryless career emphasizes psychological and physical mobility across organizational boundaries, as well as the aspects of personal responsibility and network orientation [23–25].

The boundaryless career differs from the traditional, hierarchically structured corporate career and is often viewed in connection with the concept of "protean career," which emphasizes self-control and orientation toward individual values. However, empirical studies indicate that the distinction between protean and boundaryless careers is less clear than initially assumed; rather, both concepts can be traced back to a common overarching aspect of proactive career orientation [26].

In the following, typical identified properties of a boundaryless career will be highlighted in order to further connect them with the logic of crowdworking.

Essentially, the term "boundaryless career" describes a paradigm shift, that is, the path from the traditional, hierarchical, company-related career to dynamic, open careers that are no longer fundamentally linked to long-term corporate loyalty. Employees often see their membership in the company as temporary [26, 27].

Behind this paradigm shift is, on the one hand, the positive attitude of employees toward change, learning, and individually responsible development outside of an organization [28, 29].

On the other hand, this is associated with a certain psychological mobility. This type of mobility represents the inner willingness and motivation to learn new skills and take on new challenges [27]. Openness to new experiences and the willingness to get involved in changing tasks and roles are also relevant here [6, 23].

In addition to psychological mobility, high physical and organizational mobility play a role in a boundaryless career. The career, therefore, runs across organizational boundaries, not hierarchically within a company. An independent and flexible career design is characteristic [30, 31]. Changes, therefore, take place between organizations, industries, or projects, while remaining in a single company is not planned according to the boundaryless understanding [23, 28, 29].

As part of the boundaryless career, individuals no longer strive exclusively for hierarchical advancement in the company but rather for personal development and self-realization. Careers are, therefore, also characterized by independent career planning [26, 30]. This also includes so-called self-control. Career planning and development are independent and separate from organizations or employers [6, 28, 32]. Actively shaping your own career is also accompanied by a high level of adaptability to change [29].

External networking addresses another important property of a boundaryless career. The development and use of professional networks outside an organization and across company boundaries are central because there is a lack of a permanent circle of colleagues. Your own marketability and self-marketization are maintained [25, 28, 33]. Due to this fact, success and identity are defined not only by the current organization but also by external recognition [23].

Overall, a boundaryless career is characterized by mobility, personal responsibility, network orientation, and a proactive, adaptable attitude toward careers and changes.

5. Career management in the sense of a boundaryless career

As previously explained, the concept of a boundaryless career describes careers that break away from traditional organizational boundaries, hierarchical structures, and linear career patterns. Instead, it is characterized by frequent transitions between companies, industries, and professional fields, the development of diverse networks, and the ongoing development of skills in the sense of lifelong learning.

How can this understanding of a boundaryless career be implemented in career management?

Employees with a boundaryless career orientation are increasingly taking control of their careers themselves, taking initiative in their career planning, and looking for development opportunities beyond traditional predetermined hierarchies [59, 35, 36]. In view of this, career management should create offers that open up individual career paths and support job crafting and self-directed learning [59, 35, 36]. In addition to flexible and more diverse career paths that enable vertical as well as

horizontal and project-related development [37], options that arise from cooperation with other companies are also conceivable [38, 39].

Promoting individual career skills is important because it is usually the individual's responsibility to plan and develop them further. These include the development of "knowing-why" (motivation), "knowing-how" (skills), and "knowing-whom" (networks) skills [38, 40, 41]. As a company, it is advisable to offer targeted training, network platforms, and mentoring programs to promote these skills [37, 40]. The advantage for companies is that they can at least partially promote staff retention. Studies show that personnel development can be a crucial factor for employee satisfaction and retention [42, 43].

Classic, company-centered career planning is becoming less important. Overall, career management is being given a new role. Career management itself should network individual, organizational, and external resources [35, 40], with most of the responsibility attributed to individuals [6]. Career and talent management should, therefore, be thought of on several levels: at the level of the individual, the network, the organization and, if necessary, the sector, career management should be considered in a holistic way [6, 35].

The focus on boundaryless careers also increases the importance of employability and external mobility [42–44, 60]. This means that it is no longer just about succession planning. Career management should, therefore, focus on promoting adaptability, lifelong learning, and complementary external career options [40, 45].

Particular risks and challenges arise from the tension between the emphasis on external career options and the staff retention necessary from an organizational perspective. Emphasis on individual responsibility can lead to insecurity and a lack of attachment [6, 40, 34]. For this reason, companies should create a balance between flexibility and organizational identification [6, 46, 47, 59]. Leadership work is important here. Managers can promote this balance by conveying meaning and direction (visions, values) to employees through targeted "sensegiving." This supports the balance between individual flexibility needs and identification with the organization [48]. Establishing stable, comprehensible roles and expectations can additionally reduce uncertainty when changes occur and create security that acts as a counterweight to flexibility.

As becomes obvious in this section, boundaryless careers and company career management are in tension. However, opportunities for innovation and competitiveness can also be identified through contemporary adjustments. Companies that adapt their career management to the needs of modern, unlimited careers can better promote and retain employees and increase their attractiveness as employers.

These statements are initially recommendations for career management, derived from the boundaryless career understanding, without any specific reference to platform work. The connection to this occurs in the following section.

6. Boundaryless career in crowdsourcing – opportunities and risks

As described above, crowdworking is a new digital form of work organization in which tasks are delegated to a large, external community (external crowdsourcing). Since the crowd is not directly integrated into the company hierarchy in external crowdworking, new dynamics arise in the coordination, management, and control of work processes. This also opens up new opportunities for employees to organize

their careers flexibly, for example, through the flexible selection of projects and tasks according to their own interests, time availability, and respective skills.

In this section, the characteristics of boundaryless careers are combined with the possibilities and logic of crowdworking based on the current state of research. This creates opportunities and risks when designing careers that need to be taken into account. These opportunities and risks are partly relevant for the career designers themselves but also for clients on the platforms. These connections can also be helpful for target groups who are considering using crowdworking as a job placement tool in the future and are asking themselves career-related questions. First of all, we will focus on the opportunities and added value for boundaryless careers that can be addressed through crowdworking. **Table 1** shows a summary of the characteristics of the boundaryless career by category and how they are addressed in the context of crowdworking, as well as the opportunities and risks that may arise in practice.

When it comes to the aspect of self-determination, autonomy, and flexibility in a boundaryless career, crowdworking people can freely choose tasks, working hours, and locations. On the one hand, this reflects the boundaryless properties of self-control and mobility [49–51]. Crowdworking enables a high degree of self-organization and flexibility [50]. The results of the study by Reimann & Abendroth [52] suggest that when crowdworkers use flexibility in time and tasks, they experience less conflict between work and private life, fewer somatic health symptoms, and greater life satisfaction, although this does not apply to flexible work locations. However, the relationship between flexible working and well-being is partly mediated by experiences of conflict between work and private life.

The ability to work for different clients and platforms at the same time can meet the need for physical and psychological mobility [5, 53]. On crowdworking platforms, there is a physical distance from the clients and potential colleagues. However, crowdworkers actively build networks, exchange ideas with others via the platforms' means of communication, and use these contacts for new orders and support. This is another central element of a boundaryless career [49, 53].

The quality of personal responsibility can also be addressed through crowdworking. Crowdworkers shape their careers independently by selecting tasks, developing skills, and, if necessary, diversifying their work profiles across several platforms [49, 53, 54]. In a sense, this creates new job profiles independently, which is closely related to job crafting. Crowdworkers have to manage their own careers and develop skills. This may be particularly successful in the case of highly qualified platform workers, as their specialized skills may enable them to be more mobile and make profitable use of this flexibility [6].

In the subsequent course, selected risks of a career without boundaries through crowdworking will be addressed.

Platforms use algorithmic control, which can potentially limit the autonomy and development opportunities of crowdworkers. This contradicts the ideal boundaryless career, as algorithmic boundaries and lack of transparency can create new latent barriers [5]. These limits can, for example, affect, on the one hand, access to tasks or, on the other hand, the evaluation of solutions.

Responsibility for career development lies almost exclusively with the individual, as classic HR structures and company support are missing [5, 53]. This is initially in the spirit of the boundaryless career. However, this lack of institutional support from an organization promotes the pressure to market one's own workforce [55]. Platforms create individual visibility for workers by creating profiles and thus establish

Boundaryless career characteristics	Crowdworking connection	Opportunities for career	Risks and challenges for career
High mobility (psychological and physical across organizational boundaries).	Crowdworkers work across different clients and platforms, enabling flexible physical and psychological mobility.	Enables diverse work experience, project variety, and adaptability.	Career uncertainty due to short-term orders and inconsistent demand.
Self-control and independent career planning.	Crowdworkers choose tasks, working hours, locations, and develop skills independently.	High autonomy, flexible work organization, enhanced work-life balance.	Algorithmic control and platform rules limit true autonomy (autonomy paradox).
Network orientation external to company.	Crowdworkers build professional networks via platform communications for new tasks and support.	Supports continuous career opportunities and self-marketing beyond a single employer.	Limited face-to-face interaction; reliance on digital networks can be isolating.
Personal responsibility and proactive career attitude.	Crowdworkers manage and craft their own careers and skill development across platforms.	Encourages skill diversification and entrepreneurial career management.	Pressure to market oneself and compete intensively; lack of institutional support.
Adaptability and openness to new challenges.	Crowdworkers must adapt to diverse tasks and changing platform demands.	Enhances lifelong learning capabilities.	Lack of structured learning pathways and uncertainty about career progression.
Psychological mobility (willingness to learn and change).	Crowdworkers embrace continuous skill development and new project challenges.	Motivates personal growth and career crafting.	Risk stress due to constant pressure and lack of support.
Paradigm shift from long-term company loyalty.	Crowdworking detaches careers from fixed employers; it is seen as temporary membership.	Flexibility to design one's career freely, without being bound to hierarchical advancement.	Precarious income, career instability, and difficulty transferring crowdwork experience to traditional jobs.
Network orientation for marketability.	Crowdworkers use external recognition and platform ratings to define career success.	Enhances personal brand awareness and market position.	Constant competition and visibility pressure, leading to self-exploitation risks.
Physical and organizational mobility across projects, industries, companies.	Crowdwork involves multi-client and multi-platform engagement.	Freedom from organizational constraints and the possibility of cross-sector experience.	Fragmented career path and lack of formal progression opportunities.

Table 1.

Summary of boundaryless career characteristics, their relevance in the context, and the resulting opportunities and risks (own illustration).

a connection between personal work and competition in a small space, which leads to high pressure on crowdworkers [55]. Ultimately, this lack of formal support systems and structured learning or advancement opportunities can also make it difficult to develop career skills [6] if earning a living is primary and the long-term career perspective can only be secondary due to the pressure situation described. It is also conceivable that (self-)exploitation dynamics are more likely to occur [56].

Despite the flexibility targeted, career development often remains uncertain and possibly characterized by short-term orders via the crowdworking platform [5, 49, 53], which makes a career that is based solely on the platform very precarious. Either the career must be structured in such a way that it is designed for several platforms and is therefore diversified, or it must be associated with a certain foresight that compensates for temporary losses in orders.

When crowdworking is used within organizations, there are usually few interactions directly with customers. Feedback opportunities, which may be career-enhancing, are also limited. Classic opportunities for advancement are usually replaced by platform dynamics and their remuneration systems [9]. If employees already work on external platforms, transitions into traditional dependent employment relationships are more difficult because the skills and experiences of platform employees are often not very transferable or recognized [6]. This, in turn, limits the flexibility of the career mentioned above.

The above-mentioned aspect of autonomy, which is addressed through crowdworking, can also turn negative if mechanisms located under the concept of the autonomy paradox take effect [57]. In this context, the autonomy paradox includes the contradictory situation in which, within boundaryless careers, crowdworking formally provides a high level of autonomy and self-determination, but at the same time, this autonomy is limited by various control mechanisms, such as the algorithmic control mentioned above, evaluation logics, or market constraints (pressure to use one's own labor market), which can restrict it [5].

Internal crowdsourcing can be an important building block for pursuing boundaryless careers. It creates the conditions for cross-border, self-directed career paths, promotes collaboration and innovation, and supports modern, agile career management under appropriate conditions.

However, the diffuse responsibility between platforms, clients, and workers for career management sometimes leads to a lack of supportive HRM practices. Neither platforms nor clients feel responsible for promoting the careers of employees [6], so there is self-marketization pressure on employees.

Based on the aspects above, it is recommended that companies and platform operators establish a common and self-organized HRM. Shared HRM, in the form of network models, is proposed as a solution [6]. Platforms and customers could jointly provide feedback, training, and networking opportunities. In contrast, platform employees in self-organized online communities can support each other, exchange knowledge, discuss, and provide development resources.

7. Added value and implications for employees, clients, and platform providers

The concrete added value and implications of crowdsourcing in the context of a boundaryless career differ for companies (clients and platform operators) and employees.

7.1 For clients

Companies can use crowdsourcing as a whole to access the innovation potential and diverse skills of a broad audience.

Digitalization and global access to crowdsourcing platforms allow companies to access global pools of knowledge and work. This leads to heterogeneous teams that work together on a project-related basis and can replace classic team structures.

Internal crowdsourcing can influence cooperation and corporate culture as new forms of collaboration and co-determination emerge. However, the roles of works councils and the representation of the interests of crowdworkers need to be rethought and possibly expanded.

By adding crowdworking, companies can create internal career paths based on actual skills and experience. By participating in (internal) crowdsourcing projects, the skills and commitment of employees can also become visible (company-wide). This makes it easier for HR departments and managers to identify and, if necessary, specifically promote talent.

Platforms offer the ability to provide a flexible, scalable workforce that responds quickly to fluctuations in demand, thereby reducing costs.

The boundaryless career concept can help platforms identify career boundaries that affect the development of platform employees and, thus, the operation of the platform, and develop solutions – for example, through joint HRM with customers.

7.2 For platform operators

Ideally, crowdworkers with a boundaryless career orientation bring in a wide range of skills and networks, which increases the dynamism and innovative strength of platform work and allows the platform to distinguish itself as a flexible mediation model, as skills can be available flexibly across different platforms and projects.

Boundaryless careers promote the idea that platforms can respond more easily to changing demand because crowdworkers link multiple orders from different platforms in a mobile and self-organized manner. This reduces dependencies and risks for operators and creates better scalability.

Platform operators can improve the qualification and retention of crowdworkers through structured feedback, further training, and networking offers, which, in turn, can increase the quality and satisfaction of clients. However, platforms should offer systematic training or development measures, which can enable the use of potential and sustainable career development. The development of transfer skills (knowing-how, knowing-whom, knowing-why) among crowdworkers supports their long-term loyalty and success on the platform, which allows operators to ensure more stable supply chains and higher quality.

7.3 For employees

Participation in crowdsourcing projects can be considered an important component of individual career development, as it offers learning and development opportunities that go beyond, sometimes, traditional continuing training measures. In principle, employees can use the platforms to try out different activities and organize their work independently, which potentially promotes the development of their own career.

Internal crowdsourcing gives employees the opportunity to actively participate in innovation and change processes within companies. This participation can also serve as a springboard for their own careers, as employees gain experience outside of their traditional roles and build networks. Employees can recommend themselves for further tasks or positions through their contributions.

Platform work offers formal flexibility, for example, in the choice of working time, location, and assignment. This makes it easier to combine work and private life, and physical and psychological mobility can be achieved through several platforms and clients at the same time. However, this can only be achieved if the skills for self-control are developed.

However, the real added value for many employees is limited because HRM support (e.g., training, feedback, career opportunities) is often missing, and there are limits to advancement and job changes. Through shared or self-organized HRM in communities of practice, platform workers can develop competencies, build networks (knowing-whom), and strengthen motivation/identity (knowing-why), which improves their chances of intra and interorganizational mobility.

Crowdsourcing opens up new career paths for individuals that are less linear. At the same time, however, uncertainties arise regarding social security, remuneration, and long-term development opportunities. Crowdworkers sometimes receive low remuneration in the microtask sector. For career research, the question therefore arises as to how sustainable, stable careers can be designed in flexible, platform-based working models. Companies must also ensure that crowdsourcing is not misused to simply siphon off ideas, but rather offers real development opportunities for participants.

Algorithmic control and limited institutional career support can result in restrictions on autonomy and increased uncertainties (e.g., precariousness, lack of social security). Responsibility for career development lies almost exclusively with the individual, which leads to high self-marketing pressure and can make long-term development more difficult.

The combination of a boundaryless career and crowdsourcing enables employees to have more flexibility and self-directed career development. Above all, platform operators will have new opportunities to increase quality and competition. Innovative forms of collaboration and the aspect of talent development should be highlighted for clients. Equally, it should be taken into account that the challenges cited, such as precariousness, lack of institutional promotion, and algorithmic control, can be addressed with new HR and management concepts to ensure sustainable and fair career opportunities on platforms, in the spirit of a boundaryless career.

8. Conclusion

The combined consideration of theory and practice, the boundaryless career concept, and crowdworking show that although crowdworking structurally offers the prerequisites for boundaryless careers and there are some obvious similarities in coverage, there are actually many arguments that make such careers more difficult and limit the long-term acquisition of career skills.

In summary, by conducting this narrative literature review, it can be said that crowdsourcing influences careers by enabling new forms of work and career, can support individual career orientations, and promotes innovative skills. At the same time, it presents career management with challenges in terms of self-marketing pressure, security, and sustainable development opportunities.

Platform work offers companies and crowdworkers new opportunities or even synergies but is associated with significant challenges for sustainable, that is,

long-term careers. The research stresses the need for new management and HR concepts in order to exploit the potential of these forms of work and minimize risks [6]. What exactly these can look like and to what extent they are actually possible in the context of a boundaryless career without the advantages being mitigated is unclear. More transparency, fair rating systems, and new HR strategies are also required to enable sustainable careers in platform work [6, 58]. However, up to this point, the identified opportunities and risks of crowdworking in the context of the boundaryless career can be useful in practice.

Boundaryless career is a central concept in modern career research that emphasizes flexibility and personal responsibility. It offers opportunities for individual development but is not universally applicable and faces methodological and conceptual challenges. Even though the narrative literature review cannot provide a systematic overview of the research, it becomes clear that crowdworking is not frequently considered in the context of boundaryless careers but is nevertheless worthy of discussion. This calls for further research in various areas.

Future research should take greater account of the diversity of career boundaries and contexts. Overall, future research in the field of careers should focus more strongly on digital career contexts in order to generate insights into the interactions between people and digital platforms.

For an even more specific analysis, it is necessary to consider the respective regional or national economic and legal area, because, for example, the social security systems in the countries can significantly influence the conditions of platform work, which leads to different forms of precarious work [59]. Qualitative research could contribute to a better conceptual foundation for careers in the digital context, while more detailed standardized surveys on platforms could provide generalizable findings on career perceptions, career conditions, or boundaries in digital working contexts. Studies similar to those conducted by Haq et al. [60] would be useful, for example, to systematically capture the tension between autonomy and structural platform constraints.

Conflict of Interest

The author declares no conflict of interest.

Author details

Dennis Heinrich
University of Hamburg, Hamburg, Germany

*Address all correspondence to: dennis.heinrich@uni-hamburg.de

IntechOpen

© 2025 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Pongratz HJ. Die digitale Beschäftigungsindustrie als global expandierende Branche. WSI-Mitteilungen. 2021;74(4):263–273
- [2] Schmidt FA. Arbeitsmärkte in der Plattformökonomie: Zur Funktionsweise Und den Herausforderungen von Crowdwork Und Gigwork. Bonn: Friedrich-Ebert-Stiftung, Abteilung Wirtschafts-und Sozialpolitik; 2016
- [3] Satzger B, Psailer H, Schall D, Dustdar S. Auction-based crowdsourcing supporting skill management. Information Systems. 2013;38:547–560. DOI: 10.1016/j.is.2012.09.003
- [4] Hünefeld L, Meyer SC, Backhaus N. Digitalization of employment: Working via online platforms. Flexible Working Practices and Approaches: Psychological and Social Implications. 2021;167–190
- [5] Duggan J, Sherman U, Carbery R, McDonnell A. Boundaryless careers and algorithmic constraints in the gig economy. The International Journal of Human Resource Management. 2021;33(22):4468–4498
- [6] Kost D, Fieseler C, Wong SI. Boundaryless careers in the gig economy: An oxymoron? Human Resource Management Journal. 2020;30(1):100–113
- [7] Lo Presti A, Pluviano S, Briscoe JP. Are freelancers a breed apart? The role of protean and boundaryless career attitudes in employability and career success. Human Resource Management Journal. 2018;28(3):427–442
- [8] Omar N, Jamil R. The shift from traditional jobs to gig work: Rethinking career development in a flexible economy. International Journal of Research and Innovation in Social Science. 2025;9(4):4936–4946
- [9] Heinrich D, Schramm F. New perspective on platform work-internal crowdworking as an instrument to facilitate strategic human resources management. International Journal of Work Innovation. 2022;3(1):48–68
- [10] Baumeister RF, Leary MR. Writing narrative literature reviews. Review of General Psychology. 1997;1(3):311–320
- [11] Ferrari R. Writing narrative style literature reviews. Medical Writing. 2015;24(4):230–235
- [12] Juntunen M, Lehenkari M. A narrative literature review process for an academic business research thesis. Studies in Higher Education. 2021;46(2):330–342
- [13] De Stefano V. The rise of the just-in-time workforce: On-demand work, crowdwork, and labor protection in the gig-economy. Comparative Labor Law & Policy Journal. 2015;37:471
- [14] Howe J. The rise of crowdsourcing. Wired Magazine. 2006;14(6):176–183
- [15] Greef S, Schroeder W, Sperling HJ. Plattformökonomie und Crowdworking als Herausforderungen für das deutsche Modell der Arbeitsbeziehungen. Industrielle Beziehungen. Zeitschrift Für Arbeit, Organisation Und Management. 2020;27(2):13–14

- [16] Leist D, Hießl C, Schlachter M. Plattformökonomie - Eine Literaturlauswertung. (Forschungsbericht/ bundesministerium Für Arbeit Und Soziales, FB499). Berlin: Bundesministerium für Arbeit und Soziales; Universität Trier, Institut für Arbeitsrecht und Arbeitsbeziehungen in der Euro päischen Union (IAAEU); 2017. Available from: <https://nbn-resolving.org/urn:nbn:de:0168-ss0ar-55486-2> [Accessed: 2026-January-4]
- [17] Zuchowski O, Posegga O, Schlagwein D, Fischbach K. Internal crowdsourcing: Conceptual framework, structured review, and research agenda. *Journal of Information Technology*. 2016;**31**(2):166–184
- [18] Hetmank L. A synopsis of enterprise crowdsourcing literature. *Proceedings of the European Conference on Information Systems (ECIS) 2014*, Tel Aviv, Israel, June 9-11.
- [19] Leimeister JM, Zogaj S, Durward D, Bretschneider U. Neue Geschäftsfelder durch Crowdsourcing: Crowd-basierte start-ups als Arbeitsmodell der Zukunft. In: Hoffmann R, Bogedan C, editors. *Arbeit der Zukunft. Möglichkeiten Nutzen - Grenzen Setzen*. Frankfurt am Main: Campus Verlag GmbH; 2015. p. 141–158
- [20] Blohm I, Zogaj S, Bretschneider U, Leimeister JM. How to manage crowdsourcing platforms effectively? *California Management Review*. 2018;**60**(2):122–149
- [21] Pfeiffer S, Kawalec S, Held M, Held V. Crowdfunding und Leistungsgerechtigkeit. *HMD Praxis der Wirtschaftsinformatik*. 2019;**56**(4): 748–765
- [22] Briscoe JP, Hall DT. The interplay of boundaryless and protean careers: Combinations and implications. *Journal of Vocational Behavior*. 2006;**69**(1): 4–18
- [23] Sullivan S, Arthur M. The evolution of the boundaryless career concept: Examining physical and psychological mobility. *Journal of Vocational Behavior*. 2006;**69**: 19–29
- [24] Rodrigues R, Guest D, Budjanovcanin A. Bounded or boundaryless? An empirical investigation of career boundaries and boundary crossing. *Work, Employment and Society*. 2016;**30**(4):669–686
- [25] Briscoe J, Hall D, Demuth R. Protean and boundaryless careers: An empirical exploration. *Journal of Vocational Behavior*. 2006;**69**:30–47
- [26] Hall DT. Protean careers of the 21st century. *Academy of Management Perspectives*. 1996;**10**(4):8–16
- [27] Arthur MB. The boundaryless career: A new perspective for organizational inquiry. *Journal of Organizational Behavior*. 1994;**15**: 295–306
- [28] Chan K, Ho M, Chernyshenko O, Bedford O, Uy M, Gomulya D, Sam Y, Phan W. Entrepreneurship, professionalism, leadership: A framework and measure for understanding boundaryless careers. *Journal of Vocational Behavior*. 2012;**81**:73–88
- [29] Uy MA, Chan KY, Sam YL, Ho MHR, Chernyshenko OS. Proactivity, adaptability and boundaryless career attitudes: The mediating role of entrepreneurial

alertness. *Journal of Vocational Behavior*. 2015;**86**:115–123

[30] Arthur MB, Rousseau DM, Eds. *The Boundaryless Career: A New Employment Principle for A New Organizational Era*. New York: Oxford University Press; 2001

[31] Volmer J, Spurk D. Protean and boundaryless career attitudes: Relationships with subjective and objective career success. *Zeitschrift Für ArbeitsmarktForschung*. 2011;**43** (3):207–218

[32] Wiernik B, Kostal J. Protean and Boundaryless Career Orientations: A Critical Review and Meta-Analysis. *Journal of Counseling Psychology*. 2018;**66**:280–307

[33] DeFillippi R, Arthur M. The boundaryless career: A competency-based perspective. *Journal of Organizational Behavior*. 1994;**15**: 307–324

[34] Nikandrou I, Galanaki E. Boundaryless career and career outcomes: The mediating role of individual career management behaviours. *Zagreb International Review of Economics and Business*. 2016;**19**:71–98

[35] Crowley-Henry M, Benson ET, Al Ariss A. Linking talent management to traditional and boundaryless career orientations: Research propositions and future directions. *European Management Review*. 2019;**16**(1):5–19

[36] Kundi Y, Hollet-Haudebert S, Peterson J. Linking protean and boundaryless career attitudes to subjective career success: A serial mediation model. *Journal of Career Assessment*. 2020;**29**:263–282

[37] Gerli F, Bonesso S, Pizzi C. Boundaryless career and career success: The impact of emotional and social competencies. *Frontiers in Psychology*. 2015;**6**:1304

[38] Koster F. HR innovation through inter-organizational HR collaboration. *Innovation & Management Review*. 2024;**21**(2):123–136

[39] Helfen M, Sydow J, Wirth C. Inter-organisational human resource management and network orientation of worker representatives: A practice-based perspective. *Transfer: European Review of Labour and Research*. 2024;**30**(2):181–206

[40] Jo H, Park M, Song JH. Career competencies: An integrated review of the literature. *European Journal of Training and Development*. 2023;**48** (7/8):805–832

[41] Eby LT, Butts M, Lockwood A. Predictors of success in the era of the boundaryless career. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior*. 2003;**24** (6):689–708

[42] Ferdiana S, Khan Z, Ray S. Investigating the impact of career development, organizational commitment, and organizational support on employee retention. *Journal of Management Studies and Development*. 2023;**2**(02):117–128

[43] Jena L, Nayak U. Organizational career development and retention of millennial employees: Role of job satisfaction, organizational engagement and employee empowerment. *International Journal of Organization Theory & Behavior*. 2023;**26**(1/2):115–131

- [44] Colakoglu SN. The impact of career boundarylessness on subjective career success: The role of career competencies, career autonomy, and career insecurity. *Journal of Vocational Behavior*. 2011;**79**(1):47–59
- [45] Redondo R, Fabra ME, Sáenz-Diez R. Examining reciprocal relationships between boundaryless career orientations and perceived employability. *Journal of Career Development*. 2024;**51**(3):370–389
- [46] Inkson K, Gunz H, Ganesh S, Roper J. Boundaryless Careers: Bringing back boundaries. *Organization Studies*. 2012;**33**:323–340
- [47] Franke F, Felfe J. Commitment und identifikation in organisationen: Ein empirischer vergleich beider konzepte. *Zeitschrift Für Arbeits- Und Organisationspsychologie A&O*. 2008;**52**(3):135–146
- [48] Herber G. Organisationale Identität: Messung der Veränderung Am Beispiel Einer Fusion Und Transformation (Doctoral dissertation, Johannes Kepler Universität Linz). 2019. (In German)
- [49] Deng XN, Joshi KD. Why individuals participate in micro-task crowdsourcing work environment: Revealing crowdworkers' perceptions. *Journal of the Association for Information Systems*. 2016;**17**(10):711–736
- [50] Cho H, Jung H. Job autonomy and job satisfaction of crowdworkers: Mediating effects of self-efficacy and meaningfulness of work. *SAGE Open*. 2025;**15**(2):1–14
- [51] Wu W, Yang Q, Gong X, Davison R. Understanding sustained participation in crowdsourcing platforms: The role of autonomy, temporal value, and hedonic value. *Information Technology & People*. 2022;**36**:734–757
- [52] Reimann M, Abendroth AK. Flexible working and its relations with work-life conflict and well-being among crowdworkers in Germany. *Work* (Reading, Mass.). 2023;**74**(2):609–620
- [53] Idowu A, Elbanna A. Digital platforms of work and the crafting of career path: The crowdworkers' perspective. *Information Systems Frontiers*. 2022;**24**(2):441–457
- [54] Taylor J, Joshi K. Joining the crowd: The career anchors of information technology workers participating in crowdsourcing. *Information Systems Journal*. 2018;**29**:641–673
- [55] Krzywdzinski M, Gerber C. Plattformarbeit und soziale Ungleichheit in Deutschland und den USA. In: Baur Nina, Beyer Jürgen, editors. *Wirtschaft Und Soziale Ungleichheit*. Wiesbaden: Springer Fachmedien Wiesbaden; 2024. p. 139–169
- [56] Fieseler C, Bucher E, Hoffmann CP. Unfairness by design? The perceived fairness of digital labor on crowdworking platforms. *Journal of Business Ethics*. 2019;**156**(4):987–1005
- [57] Mazmanian M, Orlikowski WJ, Yates J. The autonomy paradox: The implications of mobile email devices for knowledge professionals. *Organization Science*. 2013;**24**(5):1337–1357
- [58] Rani U, Furrer M. Digital labour platforms and new forms of flexible work in developing countries: Algorithmic management of work and workers. *Competition & Change*. 2021;**25**(2):212–236

[59] Krzywdzinski M, Gerber C.
Unterschiedlich prekär. Die sozialen
Sicherungssysteme prägen die
Plattformarbeit in Deutschland und den
USA. WZB Mitteilungen H.
2021;172:43–46

[60] Haq SU, Sulbout J, Pichault F.
From anchors to scripts: Reframing
career theory for the microtasking era.
Career Development International.
2025;30(6):581–596

Digital Bridges: Enabling Cross-Border Research Collaboration in Southern African Universities

Joseph Zuva and Pinias Chikuvadze

Abstract

The digital tools have the transformative potential to foster cross-border research collaborations within the universities in Southern Africa. Thus, they offer avenues for shared knowledge and innovation. A systematic review approach guided the definition of themes, setting the inclusion criteria, conducting literature searches, assessing quality, extracting data, and synthesising findings. It is in this regard that this chapter aims to explore how digital technologies are reshaping the dynamics of research in universities. This calls for the interrogation of challenges and opportunities faced by universities in leveraging digital technologies for an interconnected research ecosystem within the region. Additionally, this chapter delves into the impact of these technologies on nurturing inclusivity by bridging the gap between historically deprived and well-resourced universities. Furthermore, ethical issues, data privacy concerns, and the significance of impartial partnerships are critically dissected to guarantee the sustainability and veracity of these collaborative efforts in universities. In conclusion, this chapter presents case studies and success stories of digitally-enabled research collaborations within Southern African universities. Thus, these serve as a proposal for overcoming challenges and taking full advantage of cross-border research collaborations. Therefore, this chapter illuminates the transformative impact of digital tools on research collaborations in universities in Southern Africa. Hence, it offers actionable insights and strategic recommendations for universities, academics, and policymakers. It is in this context that this chapter underscores the significance of embracing digital tools as a catalyst for bridging universities in Southern Africa as they advance their collaborative research agenda in innovation and knowledge production.

Keywords: cross-border, digital bridges, research collaboration, Southern Africa, universities

1. Introduction

The Fourth Industrial Revolution (4IR) in this twenty-first century has deeply transformed research in universities in Southern Africa [1]. Thus, it has offered

unprecedented opportunities for collaboration, resource optimisation and knowledge exchange. In this case, digital technologies have aided universities in transcending physical limitations to vast online repositories, sophisticated data analysis tools, and virtual collaboration spaces [2]. In addition, cloud computing, artificial intelligence, and blockchain-based research authentication instruments are increasingly influential in how academics conduct their research, share results, and engage with global academic communities [3, 4]. This shift towards digital tools not only quickens the pace of research but also enhances accessibility and inclusivity, making universities more dynamic and consistent.

It is significant to acknowledge that there have been fruitful research collaborations between universities [5]. However, many academics have struggled with bureaucratic constraints, restricted access to international research links, and irregular funding mechanisms. In addition, cross-border research collaborations in universities have been inhibited by discrepancies in institutional resources, infrastructural restrictions, and geographic remoteness [6–8]. Therefore, digital technologies in universities across the region are protagonists in bridging gaps prompted by resource disproportions, technological constraints, and physical separation.

Despite growing interest in regional academic infusion, Southern Africa's universities face persistent challenges to cross-border research collaboration, including uneven digital infrastructure, limited institutional support, and fragmented policy environments. These challenges hinder the formation of sustainable research networks and restrict access to shared knowledge resources. Addressing the digital divide through strategic digital bridges is essential to unlocking the region's collaborative potential and fostering inclusive academic development. Hence, this chapter aims to critically examine how digital bridges facilitate cross-border research collaboration among universities in Southern Africa. It seeks to identify challenges and opportunities for digital inclusion, assess the impact of digital connectivity on academic partnerships, and examine the socio-economic and cultural dimensions in university research collaborations. This book chapter provides a critical examination of how digital bridges can transform cross-border research collaboration in Southern Africa, thereby contributing to the discourse on impartial digital transformation in universities across the region.

2. Methodology

In the context of the above-mentioned background, this chapter adopted a systematic review methodological approach to enable cross-border research collaboration among Southern African universities. Peer-reviewed literature sources from 2010 onwards were sourced using databases such as Scopus, Directory of Open Access Journals (DOAJ), Web of Science, Elsevier, and Google Scholar. Inclusion criteria focused on relevance to digital collaboration, regional scope, and academic rigour. The targeted sources were screened and appraised using PRISMA guidelines. Thematic synthesis guided analysis, identifying key enablers, barriers, and emerging trends. This ensured replicability, transparency, and a comprehension of how digital bridges are shaping regional academic partnerships and knowledge exchange.

3. Digital technologies reshaping cross-border research collaboration

In this chapter, digital bridges refer to technological infrastructures, platforms, and initiatives that connect people, institutions, or regions across physical, cultural, or institutional divides, especially in contexts where access to digital tools and connectivity is uneven. The concept is used interchangeably with terms such as digital inclusion and digital research collaboration. In Southern African universities, these serve as enablers of collaboration, communication, and inclusion in the digital age [9]. Thus, they have transformed cross-border research collaborations, despite the existence of numerous hindrances. This has facilitated a seamless exchange of knowledge, enabling cross-border research collaboration regardless of one's terrestrial position. For instance, through the influence of open-access repositories, cloud computing, and virtual research networks, researchers can effectively segment resources, co-develop knowledge, and enhance the impact of their output [10]. Thus, digital technologies have torn apart traditional challenges, nurturing inclusivity and widening access to transformative cross-border research collaboration opportunities. In this case, digital technologies are considered the cornerstone of modern cross-border research collaborations without physical presence.

In addition, platforms such as Academia.edu, Open Researcher and Contributor ID (ORCID), and ResearchGate enable researchers to exchange findings, connect, and engage in discussions with peers across universities or countries [11]. It is significant to note that cloud-based collaboration tends to enhance cross-border research collaborations through the provision of decentralised storage and real-time access to relevant resources. Thus, to guarantee that researchers are able to work on documents simultaneously, services like Dropbox, Google Drive, and Microsoft OneDrive minimise delays and streamline data sharing [12]. In other instances, specialised research environments like Jupyter Notebooks and Google Colab have the potential to promote co-authoring of computational studies and analyse large datasets collaboratively [13].

It should be highlighted that, historically, access to intellectual knowledge has been circumscribed by patented journal subscriptions and institutional borders. The availability of open-access repositories and digital libraries has emerged as a solution to the democratisation of research accessibility for universities within the region. Hence, platforms like the DOAJ, PubMed Central, arXiv, etc., are enabling researchers in universities within the region to stay updated on global research developments [14]. This repository network within the region fosters research visibility and promotes collaborative engagement. In addition, through these platforms, researchers from different national and regional universities have access to a vast range of academic publications. Furthermore, initiatives like the South African National Research Foundation's (NRF) Open Access Portal further facilitate knowledge dissemination nationally and regionally [15]. This empowers universities to cultivate academic excellence despite financial challenges.

Video conferencing tools like Zoom, Microsoft Teams, and Google Meet have redefined how researchers from universities within the region exchange knowledge and interact [16]. For researchers to securely store, archive, and share datasets nationally and regionally, universities adopted data-sharing platforms like Zenodo and Figshare [17]. These platforms create an environment that promotes transparency and reproducibility in research. In addition, there are tools like Mendeley, Zotero, and EndNote, which can facilitate collaborative writing, literature

synthesis, and citation management, thereby enhancing the research process [18]. This, in academic research, augments data security, ensures the veracity of research collaborations, and thwarts unauthorised adjustments of shared results. Therefore, the adoption of these digital technologies advances research collaboration, which bridges university disparities within the region. In other words, it nurtures an equitable research ecosystem, thereby empowering universities within the region to co-develop solutions to societal problems [19]. All these transformative research collaborations are made possible through the interaction of big data analytics, decentralised research infrastructure, and artificial intelligence. Hence, for the region to embrace these technologies, there is an absolute need for universities to create a more cohesive and globally competitive research landscape to propel academic excellence.

4. Challenges and opportunities in leveraging digital technologies

It is relevant to highlight that the effectiveness of digital research networks depends on researchers' ability to navigate advanced software for data analysis, online knowledge sharing, and interdisciplinary collaboration [20]. However, it is at times not possible since many researchers in the region are mostly grounded in traditional research methodologies. This calls for specific training in cybersecurity, virtual collaboration platforms, open-access publishing, and data management. Hence, at both regional and national echelons, universities are progressively prioritising deliberate capacity-building initiatives aimed at connecting digital tools to reinforce research collaborative ecosystems [21]. These exertions are considered to foster trans-institutional collaboration, augment knowledge discussion, and intensify the conspicuousness, approachability, and influence of research outputs across diverse university communities.

This is against the backdrop that many Southern African universities operate under shoestring budgets, thereby limiting their ability to invest in open-access collaborative research repositories and digital infrastructure [22]. Hence, there is a need for government institutions and funding agencies to be at the centre of enabling contributions to the adoption of cloud-based management, international research collaborations, and digital projects. This should be grounded in national and regional policy frameworks, which encourage intellectual property protections in digital galaxies, ethical guiding principles for online collaborative research activities, and remote research collaborations [23]. Hence, the need to fortify the national and regional regulatory and financial structures such that universities can have a firm underpinning for the development of digitally-enabled collaborative research links.

This chapter considers infrastructure as one of the challenges inhibiting the adoption of digital technologies in collaborative research nationally and regionally. Some of the universities in the region struggle with outdated technologies, unreliable electricity supply, and limited bandwidth in their quest to ground collaborative research in digital technologies [24]. Therefore, this discrepancy in digital infrastructure hurts digital research collaboration across the region. This creates an uneven playing field where underfunded universities face challenges in infusing digital tools into their research collaborations, while well-resourced universities can effortlessly partake in this drive. This disparity can be addressed through national and regional investment in cloud storage solutions, accessible research databases,

and broadband connectivity [25]. Hence, collaborative research efforts through communal resources can bridge this gap and increase inclusivity in digital research collaborations.

In spite of the above-mentioned challenges faced, it can be acknowledged that digital technologies present transformative prospects for research collaboration within the region. Thus, the effective adoption of digital collaborative research environments facilitates researchers in universities to engage in research activities without terrestrial limitations and to advance interdisciplinary links. This facilitates real-time data exchange, thereby allowing researchers to co-author publications, interrogate large datasets, and carry out joint experiments collaboratively [26]. Therefore, these advancements accelerate knowledge production, create a dynamic research ecosystem, and enhance research efficiency. This generates a podium for researchers to contribute implicitly to both national and regional research efforts while addressing contemporary issues [27].

In addition, it can be highlighted that digital research collaboration serves as a conduit to diminish inequalities between historically deprived and well-funded universities across the region [28]. In other words, shared digital repositories and open-access initiatives have the potential to guarantee that knowledge is accessible to all researchers across the region. This can be achieved through the adoption of decentralised knowledge-sharing platforms, cross-institutional projects, and virtual networking events to empower all researchers, irrespective of the status of their universities [29]. This enhances institutional synergy, allowing researchers to leverage harmonising proficiency and develop solutions to persistent national and regional socio-economic challenges. By addressing these challenges, national and regional universities are likely to unlock the full potential of digital technologies, thereby creating an interconnected research ecosystem grounded in knowledge sharing and innovation. The **Table 1** summarises some of the challenges and opportunities related to digital bridges for cross-border research collaboration in universities.

Category	Challenges	Opportunities
Infrastructure	Uneven access to high-speed internet (limited cloud computing capacity)	Investment in regional cloud infrastructure (expansion of broadband access)
Platform compatibility	Incompatible software systems across universities	Standardisation of digital research frameworks (adoption of open-source platforms)
Digital literacy	Technological proficiency gaps among researchers	Regional digital training programs (capacity-building initiatives)
Access to research outputs	Limited access to subscription-based journals	Open data repositories (e.g., University of Cape Town's Open Data Project) enhance transparency
Cultural and linguistic inclusion	Underrepresentation of Indigenous knowledge systems	AI-driven tools for language preservation (e.g., Stellenbosch's Digital Humanities)
Global engagement	Risk of dependency on external universities	Strategic partnerships with global research networks (knowledge transfer and mentorship)

Table 1.
Challenges and opportunities in leveraging digital technologies in universities.

The table underscores the dual landscape of digital research collaboration in Southern Africa's universities, where promising innovations co-exist with persistent structural and operational challenges. By strategically addressing these barriers and leveraging the outlined opportunities, universities can transform digital bridges from isolated efforts into cohesive, sustainable networks that advance regional academic infusion and global research relevance.

5. Inclusivity in cross-border universities research networks

In addressing disparities between well-resourced and disadvantaged universities in Southern Africa, cross-border research networks have been advocated by researchers [30]. It is against this background that most universities in the region struggle to compete in digital research networks. This is mainly due to limited access to cutting-edge digital tools, a dearth of high-speed internet, and financial restrictions. On the other hand, well-funded universities have invested in international research collaborations, contemporary research services, and cutting-edge digital libraries [31]. It is in this context that the region has put in place strategies to foster an equitable research collaboration model to encourage capacity-building and resource allocation across universities. This is done with the view of bridging the digital gap between the underprivileged and well-resourced universities within the region [32]. Hence, there is a need for initiatives like shared access to digital repositories, collaborative research hubs, and joint research funding pools to generate synergy for meaningful research in an inclusive and balanced manner.

Regardless of a university's background, equitable access to digital resources is acknowledged as a vital cog for ensuring that researchers can engage in high-quality collaboration in knowledge production [33]. Hence, this unequal research platform is leveled through the engagement of cloud-based research tools, data-sharing arrangements, and open-access publishing platforms. It is in this context that researchers from underprivileged universities should be exposed to specialised training workshops, academic exchange opportunities, and mentorship programmes to enable them to upgrade themselves to the expected research competence levels.

This has been made possible through digital collaboration initiatives that promote inclusivity in Southern African research networks, such as the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) [34]. These initiatives have leveraged digital platforms to link researchers from different universities, enabling multiparty studies in areas such as sustainable development and food security. In addition, the South African NRF and the Africa Open Science Platform advocate for transparent data-sharing, collaborative research, and open access to repositories to nurture knowledge-sharing among universities [35]. This is illustrated by **Figure 1**.

This is an example of how digital technologies can be employed strategically to strengthen regional research collaboration. As shown in **figure 1** this digital bridge conceptual framework illustrates how interconnected digital infrastructure, cloud computing, collaborative platforms, open data initiatives, and high-speed internet access collectively enable cross-border research collaboration in Southern Africa. These components function synergistically to overcome geographic, financial, and institutional barriers, fostering inclusive academic partnerships. Cloud-based tools support data-intensive research, while open repositories democratize access to

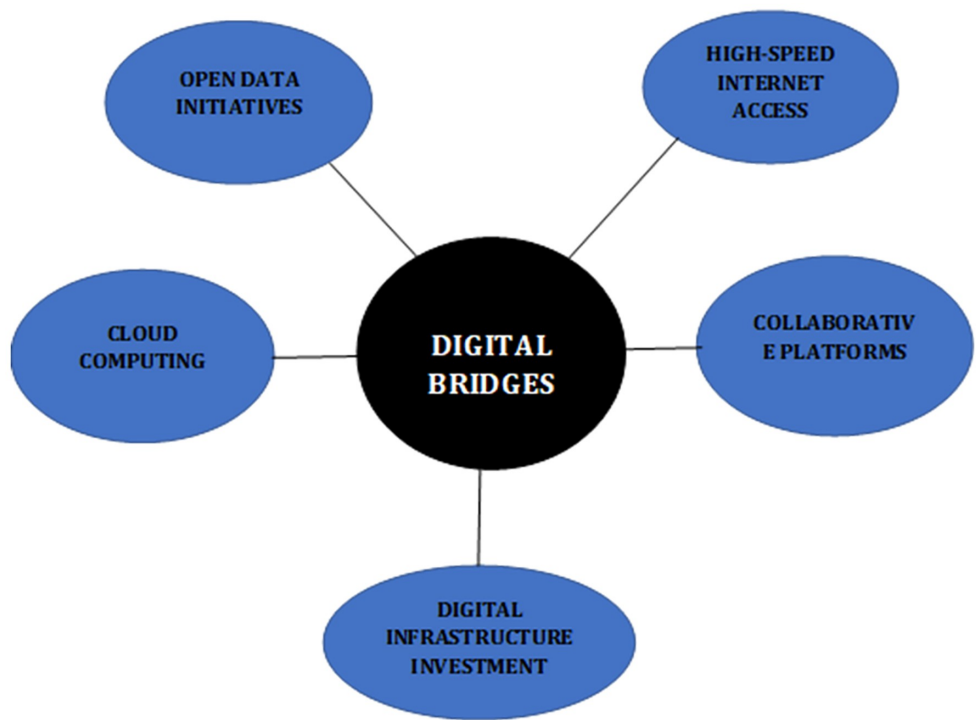


Figure 1.
Mapping cross-border research networks in Southern African universities.

knowledge. Collaborative platforms enhance real-time engagement, and standardised digital systems mitigate compatibility issues. High-speed connectivity remains foundational, requiring sustained investment. Together, these elements form a resilient digital ecosystem that empowers universities to participate in global research networks and address regional challenges through shared innovation. It is against this background that digital inclusivity remains a priority in research collaborations nationally and regionally. Therefore, by adopting digital inclusion, universities in the region can cooperatively connect their academic investments to boost innovation, support all-inclusive knowledge production, and tackle regional problems. Below is a diagrammatic presentation of the digital research collaboration process in Southern African universities.

Figure 2 above illustrates the digital collaboration process provides a structured view of how Southern African universities can build effective cross-border research networks through digital bridges. The process begins with digital infrastructure, which includes broadband connectivity, cloud servers, and institutional hardware. This foundational layer is critical, as disparities in infrastructure across the region often determine the extent to which universities can participate in collaborative research. Next, technological tools such as collaborative platforms, data repositories, and virtual communication systems enable researchers to engage across borders. However, the effectiveness of these tools depends on their interoperability and accessibility, which must be addressed through inclusive design and regional standardisation.

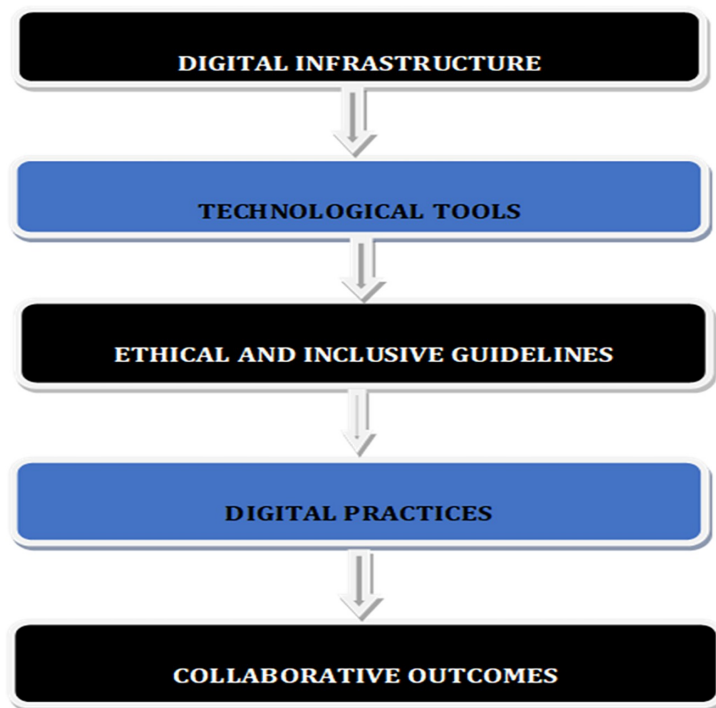


Figure 2.
Digital collaboration process in Southern African Universities.

The third stage, ethical and inclusive guidelines, plays a pivotal role in shaping responsible digital collaboration. These guidelines ensure that research practices respect data privacy, intellectual property, and cultural sensitivities. They also promote equitable participation, especially for under-resourced institutions and marginalised communities. Following this, digital practices refer to the actual implementation of collaborative activities, such as co-authoring publications, sharing datasets, and conducting joint analyses. This phase reflects the operationalisation of prior investments and ethical commitments, and its success depends on researchers’ digital literacy and institutional support. Finally, collaborative outcomes represent the tangible results of digital research partnerships, including joint publications, policy innovations, and shared knowledge products. These outcomes should be accessible, inclusive, and reflective of diverse contributions across the region.

Throughout the process, inclusivity and ethics are not standalone elements but embedded principles that guide each stage. By integrating these values into infrastructure, tools, and practices, universities can ensure that digital bridges are not only functional but transformative, advancing regional academic integration, fostering innovation, and contributing meaningfully to global research agendas. This framework offers a roadmap for sustainable, equitable, and impactful digital collaboration in Southern Africa.

6. Socio-economic and cultural dimensions in universities research collaborations

This section examines the intersection of digital research collaboration and socio-economic development in Southern Africa, which has the potential to address both national and regional challenges such as climate change, public health, and more. Digital platforms can enable researchers (scientists, sociologists, economists, and policymakers) to combine their competencies and generate holistic solutions to contemporary problems bedevilling the region. This is further supported by the inclusion of digital technologies like remote sensing, AI-driven policy analysis, and data modelling in collaborative research [36]. These technologies can be utilised by researchers to develop approaches that strengthen health systems, foster sustainable economic growth, and mitigate climate hazards. Consequently, when researchers collaborate across borders, it ensures that results are contextually responsive and relevant to the unique socio-economic circumstances within the region.

It is significant to highlight that Southern African communities have a long-standing Indigenous Knowledge System (IKS) that can be harnessed to strengthen digital research collaborations. In other words, IKS can offer treasured insights into public health practices, justifiable resource management, and ecological preservation. Therefore, Geographical Information System (GIS) mapping for indigenous land-use practices, online forums for knowledge discussion, and open-access knowledge repositories are some of the approaches that can be used to infuse indigenous views into research collaborations [37]. This can facilitate collaborations between universities and local societies, which guarantee that IK is well-kept and infused into scientific procedures. Therefore, this reassures inclusivity and improves the quality of collaborative research outputs, since the entire process is grounded in local communities' lived experiences.

In the past, the underprivileged societies' abilities to contribute meaningfully to knowledge generation were restricted, as it was a preserve of the elite universities [38]. These institutions had the leeway to contribute towards knowledge generation because they had access to research and policy discussions. This calls for the democratisation of facts through digital inclusion, which is promoted through the dynamism of open-access research databases, virtual conferences, etc. This enables a holistic approach to global research discussions to influence policy decisions. In other words, digital inclusion fortifies democratic participation and ensures that various voices shape the path of the region's collaborative research urgencies [39]. This fosters regional cohesion, strengthens research collaborations, and guarantees that knowledge flows easily across universities and borders. It is important to highlight that digital research collaboration requires the inclusion of ethical reflections, such as Intellectual Property Rights (IPR), research ownership, and data privacy. In this case, policymakers and universities need to develop clear guiding principles to encourage data integrity and ensure open research collaborations.

In addition, digital inclusion has a critical role to play in influencing community engagement with systematic research procedures. For instance, online learning platforms, community-driven digital archives, and indigenous science initiatives allow for knowledge co-creation between the community and researchers [40]. This inspires a participatory research approach, thereby confirming that the findings are associated with social significance and home-grown needs. Therefore, the infusion of diverse

standpoints into digital research collaborations helps the region's capacity to address persistent issues with justifiable, socially agreed-upon resolutions.

7. Ethical considerations and data privacy in universities research collaborations

It is important to acknowledge that the adoption of digital research collaboration in universities creates the need for vigorous ethical contexts. This was brought into the fold with the view to ensure transparent and responsible research collaborations in universities within the region. Thus, ethical digital research collaborations call for the articulation of clear procedures on data privacy protection, integrity, and ownership in cross-border universities with different monitoring values [41]. Hence, there is a need for researchers from various universities across the region to adhere to the standardised research ethics guidelines. Therefore, it is significant to develop governance structures to oversee digital research collaborations nationally and regionally to strengthen transparency and accountability. These can include institutional review boards, ethics committees, and regional policy contexts to guarantee that research practices align with national, regional, and global ethical standards.

According to [42], IPR in digital collaborative research presents authorship attribution, patent protection, and equitable access to knowledge as some of the challenges encountered. It is important to highlight that, as universities move towards open access and cloud-based repositories, safeguarding IP while advancing the ideals of collaborative innovation becomes a critical element. In addition, researchers' contributions can be protected through the enactment of data licensing agreements, research-sharing protocols, and copyright laws [43]. The mechanisms for tracking authorship and acknowledgement of intellectual contributions can be enhanced by digital tools like blockchain for academic publishing. There is a need for enacting policies supporting equitable publishing and open-source data with a view to reducing the frequency of monopolisation of findings by well-resourced universities. This ensures that knowledge remains available to researchers in universities across the region.

According to [44], addressing the influence disparity between universities with diverse echelons of technological and financial resources is another way of creating impartial digital research collaborations. This creates sustainable research networks guided by the principles of mutuality, communal advantage, and impartiality. Under these circumstances, all universities can contribute and improve through collaborative research efforts [45]. Therefore, ethical digital governance should be the focal point in shaping sustainable collaborative research across the region. A commitment to ethical digital collaboration ensures that research efforts drive meaningful societal impact while maintaining trust, transparency, and academic excellence [46].

8. Case studies and success stories in Southern African universities

Southern African universities have increasingly adopted digital technologies to foster cross-border research collaboration, yet the effectiveness of these initiatives varies. The African Data-Intensive Research Cloud, for instance, represents

a promising leap in regional connectivity through cloud-based computing [47]. Its capacity to support data-intensive disciplines like genomics and climate modelling is significant, but its success hinges on equitable access to high-speed internet and institutional investment – areas where disparities persist. Without widespread infrastructure upgrades, its transformative potential remains unevenly distributed. The University of Cape Town's Open Data Project advances transparency and democratizes access to scholarly outputs, particularly benefiting institutions with limited journal subscriptions. However, its impact is constrained by the lack of standardised metadata and interoperability across repositories, which can hinder seamless data integration and reuse. To maximise its utility, regional coordination on open data standards is essential.

Stellenbosch University's Digital Humanities initiative showcases the innovative use of AI and machine learning in preserving indigenous languages [48]. While this effort contributes to cultural heritage and computational linguistics, its scalability across the region is limited by resource intensity and the need for specialised expertise. Broader regional uptake would require targeted capacity-building and shared digital infrastructure. Despite these advances, persistent challenges undermine the sustainability of digital collaboration. Platform incompatibility across universities delays data exchange and reflects a broader lack of harmonised digital research frameworks. Similarly, technological proficiency gaps among researchers slow collaborative momentum, underscoring the need for regionally coordinated digital literacy programs. Without such interventions, digital bridges risk becoming fragmented pathways rather than cohesive networks. Furthermore, while partnerships with global research corporations offer mentorship and access to advanced technologies, they can also reinforce dependency if not strategically managed. Initiatives like the African Research Universities Alliance and the Global Research Council provide valuable platforms for cross-continental engagement, but their long-term impact depends on the ability of Southern African universities to assert agency, adapt global best practices to local contexts, and contribute meaningfully to global research agendas.

9. Conclusion(s)

This chapter underscored the significance of embracing digital tools as a catalyst for bridging universities in Southern Africa as they advance their collaborative research agenda in innovation and knowledge production. This can be made possible through policy interventions targeted at advancing digitally-enabled research collaboration among Southern African universities. Thus, regional policy frameworks, such as those coordinated by the Southern African Development Community (SADC), should encourage research funding models that prioritise digital collaboration, incentivising universities to adopt advanced technological tools for interdisciplinary studies. By institutionalising digital research policies, stakeholders can facilitate seamless knowledge exchange while ensuring ethical compliance and data security in online academic networks. For Southern African universities to fully leverage digital research opportunities, capacity-building initiatives must focus on strengthening digital literacy, infrastructure, and research management competencies. Additionally, technology investment strategies should prioritise expanding digital repositories, establishing virtual research hubs, and

integrating blockchain technology for transparent research validation. Sustainable investment in institutional capacity ensures that universities remain competitive and capable of leading high-impact research collaborations in the digital age. As digital transformation accelerates, Southern African universities must position themselves as leaders in innovative, globally connected research ecosystems. The integration of artificial intelligence, big data analytics, and decentralised research platforms presents new opportunities for advancing regional knowledge production. By embracing long-term digital strategies, the region can secure its place in the evolving landscape of university research.

Conflict of Interest

The authors declare no conflict of interest.

Author details

Joseph Zuva^{1*} and Pinias Chikuvadze²

1 Catholic University of Zimbabwe, Harare, Zimbabwe

2 Bindura University of Science Education, Bindura, Zimbabwe

*Address all correspondence to: jzuva@cuz.ac.zw

IntechOpen

© 2025 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Yende SJ. A transition towards the Fourth Industrial Revolution (4IR) in the South African Education Sector: A perspective from rural-based higher education. *African Journal of Development Studies*. 2021;**11**(2). https://hdl.handle.net/10520/ejc-aa-affrika1_v11_n2_a3
- [2] Omodan BI. Redefining university infrastructure for the 21st century: An interplay between physical assets and digital evolution. *Journal of Infrastructure, Policy and Development*. 2024;**8**(4):3468. DOI: 10.24294/jipd.v8i4.3468
- [3] Bucăța G, Tileagă C. Digital renaissance in education: Unveiling the transformative potential of digitization in educational institutions. *Land Forces Academy Review*. 2024;**29**(1):20–37. DOI: 10.2478/raft-2024-0003
- [4] Tang C, Qiu P, Dou J. The impact of borders and distance on knowledge spillovers-Evidence from cross-regional scientific and technological collaboration. *Technology in Society*. 2022;**70**:102014. DOI: 10.1016/j.techsoc.2022.102014
- [5] Chen G, Yang G, He F, Chen K. Exploring the effect of political borders on university-industry collaborative research performance: Evidence from China's Guangdong province. *Technovation*. 2019;**82**:58–69. DOI: 10.1016/j.technovation.2019.02.001
- [6] Costello MJ, Appeltans W, Bailly N, Berendsohn WG, de Jong Y, Edwards M, Froese R, Huettmann F, Los W, Mees J, Segers H. Strategies for the sustainability of online open-access biodiversity databases. *Biological Conservation*. 2014;**173**:155–165. DOI: 10.1016/j.biocon.2013.07.042
- [7] Hensel NH, editor. *Course-based Undergraduate Research: Educational Equity and High-impact Practice*. New York, NY: Taylor & Francis; 2023. DOI: 10.4324/9781003443704
- [8] Tonkin JD, Altermatt F, Finn DS, Heino J, Olden JD, Pauls SU, Lytle DA. The role of dispersal in river network metacommunities: Patterns, processes, and pathways. *Freshwater Biology*. 2018;**63**(1):141–163. DOI: 10.1111/fwb.13037
- [9] Daniels C, Erforth B and Teevan C. *Africa - Europe Cooperation and Digital Transformation*. London: Taylor & Francis; 2023. DOI: 10.4324/9781003274322
- [10] Rafi N, Ahmed A, Shafique I, Kalyar MN. Knowledge management capabilities and organizational agility as liaisons of business performance. *South Asian Journal of Business Studies*. 2022;**11**(4):397–417. DOI: 10.1108/SAJBS-05-2020-0145
- [11] Knipp R. Digital scholarship from the periphery: Insights from researchers in Chile on Academia. edu and researchgate. *Journal of Interactive Media in Education*. 2024;**2024**(9):1–14 doi:10.5334/jime.856
- [12] Bommana BK. *Towards Reliable User Collaboration over Cloud-based File Synchronization System: Dropbox as a Case Study (Doctoral dissertation)*, University Of Minnesota
- [13] Grodzinski N, Grodzinski B, Davies BM. Can co-authorship networks

be used to predict author research impact? A machine-learning based analysis within the field of degenerative cervical myelopathy research. *Plos One*. 2021;**16**(9):e0256997. DOI: 10.1371/journal.pone.0256997

[14] Grynyshyna M, Boiko T, Boklan M, Husakova N, Pozniak A. Comparative Analysis of Ways to integrate Microsoft Teams, Zoom, Google Meet into the educational process of Higher Education Institutions of Ukraine. *Journal of Higher Education Theory & Practice*. 2023;**23**(2). DOI: 10.33423/jhetp.y23vi2.5806

[15] Onyancha OB, Nwagwu WE, Kwanya T. Knowledge mobilization for maximized research impact in centers of excellence in three countries in sub-Saharan Africa: Insights from content analysis. *Information Development*. 2025;**8**:02666669251336561

[16] Simon P. Reimagining Collaboration: Slack, Microsoft Teams, Zoom, and the post-COVID World of Work. Motion Publishing; 2021

[17] Hurst EJ. Web conferencing and collaboration tools and trends. *Journal of Hospital Librarianship*. 2020;**20**(3): 266–279. DOI: 10.1080/15323269.2020.1780079

[18] Passas I. Bibliometric analysis: The main steps. 2020;**4**(2):1014–1025 DOI: 10.3390/encyclopedia4020065 2024

[19] Zurba M, Petriello MA, Madge C, McCarney P, Bishop B, McBeth S, Denniston M, Bodwitch H, Bailey M. Learning from knowledge co-production research and practice in the twenty-first century: Global lessons and what they mean for collaborative research in Nunatsiavut. *Sustainability Science*.

2022;**17**(2):449–467. DOI: 10.1007/s11625-021-00996-x

[20] Zamiri M, Esmaeili A. Methods and technologies for supporting knowledge sharing within learning communities: A systematic literature review. *Administrative Sciences*. 2024;**14**(1):17. DOI: 10.3390/admsci14010017

[21] Zenkienė L, Leišytė L. Strengthening university capacity in regional innovation ecosystem through the participation in the European Universities initiative. *European Journal of Higher Education*. 2024;**14**(sup1): 88–108. DOI: 10.1080/21568235.2024.2410358

[22] Johnson IM. International assistance and National and Individual contributions in the development of Education for Library, Information and Archival Studies: Some evidence from a case study. *Libri*. 2016;**66**(1):3–12. DOI: 10.1515/libri-2015-0110

[23] Gregson J, Brownlee JM, Playforth R, Bimbe N The future of knowledge sharing in a digital age: Exploring impacts and policy implications for development

[24] Muriithi PM. Academic Research Collaborations in Kenya: Structure, Processes and Information Technologies [Doctoral dissertation]. University of Brighton

[25] Gur BA, Kulesza J. Equitable access to satellite broadband services: Challenges and opportunities for developing countries. *Telecommunications Policy*. 2024;**48**(5):102731. DOI: 10.1016/j.telpol.2024.102731

- [26] Ahmed A. Open access towards bridging the digital divide—policies and strategies for developing countries. *Information Technology for Development*. 2007;**13**(4):337–361. DOI: 10.1002/itdj.20067
- [27] Jacob M, Meek VL. Scientific mobility and international research networks: Trends and policy tools for promoting research excellence and capacity building. *Studies in Higher Education*. 2013;**38**(3):331–344. DOI: 10.1080/03075079.2013.773789
- [28] Stewart HA. Sustainability of Private Historically Black Colleges or Universities [Doctoral dissertation]. Walden University
- [29] Bryant R, Dortmund A, Lavoie B. Social interoperability in research support: Cross-Campus partnerships and the University research enterprise. OCLC Research Report. 6565 Kilgour Place, Dublin, OH: OCLC Online Computer Library Center, Inc; p. 43017. 2020
- [30] Chasi S North-South Partnerships in Public Higher Education: A Selected South African Case Study [Doctoral dissertation]. University of the Witwatersrand, Faculty of Humanities, School of Education
- [31] Okafor IA, Ajagbe AO, Mbagwu SI, Agyei DD, Udokanma EE, Godswill C, Quaye B, Oyeniran OI, Fakorede S. Interdisciplinary Research in Africa: Challenges and Prospects. DOI: 10.20944/preprints202504.1077.v1
- [32] Mojapelo S, Dube L. Library and information services in marginalised and under-resourced communities in South Africa: Ecosystem services and their implications. *Libri*. 2017;**67**(3):215–234. DOI: 10.1515/libri-2016-0069
- [33] Mkhize TR, Davids MN. Towards a digital resource mobilisation approach for digital inclusion during COVID-19 and beyond: A case of a township school in South Africa. *Educational Research for Social Change*. 2021;**10**(2):18–32. DOI: 10.17159/2221-4070/2021/v10i2a2
- [34] Osiru M, Adipala E Responding to key gaps in Africa’s higher agricultural education: Lessons from the Regional Universities Forum for Capacity Building in Agriculture
- [35] Kodua-Ntim K, Fombad M. Challenges and strategies for open access in South Africa: A knowledge management approach. *Information Development*. 2024;**26**:02666669241257188
- [36] Dritsas E, Trigka M. Remote sensing and geospatial analysis in the big data era: A survey. *Remote Sensing*. 2025;**17**(3):550. DOI: 10.3390/rs17030550
- [37] Olson R, Hackett J, DeRoy S. Mapping the digital terrain: Towards Indigenous geographic information and spatial data quality indicators for Indigenous knowledge and traditional land-use data collection. *The Cartographic Journal*. 2016;**53**(4):348–355. DOI: 10.1080/00087041.2016.1190146
- [38] Subotnik RF, Olszewski-Kubilius P, Worrell FC. Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science in the Public Interest*. 2011;**12**(1):3–54
- [39] Helbing D, Mahajan S, Fricker RH, Musso A, Hausladen CI, Carissimo C,

- Carpentras D, Stockinger E, Sanchez-Vaquerizo JA, Yang JC, Ballandies MC. Democracy by design: Perspectives for digitally assisted, participatory upgrades of society. *Journal of Computational Science*. 2023;71:102061. DOI: 10.1016/j.jocs.2023.102061
- [40] Lepore W, Hall BL, Tandon R. The Knowledge for Change Consortium: A decolonising approach to international collaboration in capacity-building in community-based participatory research. *Canadian Journal of Development Studies/Revue Canadienne D'études du Développement*. 2021;42(3):347–370. DOI: 10.1080/02255189.2020.1838887
- [41] Mariam S. Legal and ethical challenges in International Cybersecurity: Addressing Cross-Border data breaches. *Journal of Advances in Cybersecurity Science, Threat Intelligence, and Countermeasures*. 2024;8(12):22–32. <https://polarpublishations.com/index.php/JACSTIC/article/view/3>
- [42] Unnikrishnan A. Analyzing the impact of emerging technologies on intellectual property rights (IPR): A comprehensive study on the challenges and opportunities in the digital age. *Law & World*. 2024;29:66
- [43] Bangani S and Moyo M. Data sharing practices among researchers at South African Universities. *Data Science Journal*. 2019;18(28):1–14. DOI: 10.5334/dsj-2019-028
- [44] Snijder M, Steege R, Callander M, Wahome M, Rahman MF, Apgar M, Theobald S, Bracken LJ, Dean L, Mansaray B, Saligram P. How are research for development programmes implementing and evaluating equitable partnerships to address power asymmetries? *The European Journal of Development Research*. 2023;35(2):351. DOI: 10.1057/s41287-023-00578-w
- [45] Wilmer H, Meadow AM, Brymer AB, Carroll SR, Ferguson DB, Garba I, Greene C, Owen G, Peck DE. Expanded ethical principles for research partnership and transdisciplinary natural resource management science. *Environmental Management*. 2021;68(4):453–467. DOI: 10.1007/s00267-021-01508-4
- [46] Mbah GO. The role of artificial intelligence in shaping future intellectual property law and policy: Regulatory challenges and ethical considerations. *Journal Homepage*. 2024;2582:7421
- [47] Simmonds R, Taylor R, Horrell J, Fanaroff B, Sithole H, van Rensburg SJ, Pretorius B The African data intensive research cloud. In: 2016 IST-Africa Week Conference. 11 May 2016. IEEE; p. 1–8. DOI: 10.1109/ISTAFRICA.2016.7530650
- [48] Mlambo R, Matfunjwa M. The use of technology to preserve indigenous languages of South Africa. *Literator-Journal of Literary Criticism, Comparative Linguistics and Literary Studies*. 2024;45(1):2007. https://hdl.handle.net/10520/ejc-literat_v45_n1_a_2007

Edited by Kyeong Kang

Crowdsourcing – Innovations in Digital Collaboration explores how digital platforms, collective intelligence, and artificial intelligence are transforming the ways people work together, innovate, and solve complex problems. This volume gathers international perspectives on emerging crowdsourcing ecosystems across research, industry, and society. The chapters examine key themes such as AI-enabled Crowdtwork, large language models and collaborative intelligence, strategic crowdsourcing frameworks, digital education platforms, crowdfunding methods, digital labor markets, and global research partnerships. By blending theoretical insights with real-world applications, the book demonstrates how crowdsourcing promotes innovation, knowledge development, and inclusive participation in the digital economy. Researchers, practitioners, policymakers, and students will benefit from the interdisciplinary viewpoints presented in this volume. The book offers valuable insights into the future of digital collaboration and the changing role of crowdsourcing in addressing complex global challenges.

*Taufiq Choudhry,
Business, Management and Economics Series Editor*

Published in London, UK

© 2026 IntechOpen

© Igor Kutyaev / iStock

IntechOpen

ISSN 2753-894X

ISBN 978-1-83634-947-1

